PRACTICE MANUAL

Final Course

PAPER : 5

ADVANCED MANAGEMENT ACCOUNTING

PART-A

BOARD OF STUDIES
THE INSTITUTE OF CHARTERED ACCOUNTANTS OF INDIA

This practice manual has been prepared by the faculty of the Board of Studies. The objective of the practice manual is to provide teaching material to the students to enable them to obtain knowledge and skills in the subject. In case students need any clarifications or have any suggestions to make for further improvement of the material contained herein, they may write to the Director of Studies.

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A WORD ABOUT PRACTICE MANUAL

The Board of Studies (BoS) has undertaken the step of developing Practice Manuals of all subjects to help the students with better understanding of the subject through a mode of questions and answers on different important topics and problems. Practice Manual and Study Material of a particular subject complements each other and all the students are expected to make holistic study of both to gain maximum benefit and acquire in-depth knowledge of the subject. The Practice Manual in the subject of “Advanced Management Accounting” has been developed by BoS taking primary input from question papers of Institute’s earlier examinations over a number of years. It has been divided into sixteen chapters, keeping close correspondence with the chapters of the Study Material so as to make it an effective guidance material by providing clarification / solution to very important topics / issues, both theoretical and practical, of different chapters.

The Practice Manual will serve as a revisionary help book towards preparing for final examination of the Institute and help the students in identifying the gaps in the preparation for the examination and developing strategic plan to bridge it. The Practice Manual contains solutions to the questions which will act as a guide towards developing the skills of students on framing appropriate answer to a question and thereby to help students to improve their performance in the examination. The Practice Manual of “Advanced Management Accounting” has been thoroughly revised to cater the need of home study and distance learning approach in the Chartered Accountancy course. We would like to highlight some of the unique features of this edition of the Practice Manual of the subject “Advanced Management Accounting”.

- ❖ This Practice Manual remains divided into two parts for ease of handling by the students. Part-A contains Chapters 1−9 and Part-B contains Chapters 10−16.
- ❖ Each chapter of the Practice Manual wherever possible has been divided into three sections i.e. Section A: Theory Questions, Section B: Practical Questions and Section C: Scenario Based Questions.
- ❖ This Practice Manual has more than 350 practical questions apart from handpicked theoretical and scenario based questions. All these questions have been compiled in such a manner that it will cover basic concepts, practical concepts and all kinds of adjustments required to address a question for extensive revision of the syllabus.
- ❖ Questions on emerging management accounting concepts like Life Cycle Costing, Just in Time (JIT), Value Chain Analysis, Pricing Strategy, Pareto Analysis, Multinational Transfer Pricing, Profitability Analysis, Balanced Scorecard etc. have been strengthened with introduction of new vivid questions and their solutions.

- As a part of knowledge progression, some simple questions related with the topics like Marginal Costing, Standard Costing etc. are also included in the Practice Manual to enhance the conceptual clarity to have a complete grasp on these topics to enable the students to handle advanced level of questions.
- Important definitions, equations, formulae etc. has been given at the beginning of each chapter for a quick recapitulation.
- Solutions in this Practice Manual have been given in an unhurried and step by step way so that students can understand each problem with the help of self study.
- Presentation is the hallmark of this Practice Manual. Questions and solutions thereof have been presented in a students' friendly approach.

Every effort has been made to make the Practice manual error free, however if inadvertently any error is present and found by readers they may send it to us immediately so that it can be rectified at our end.

For any further clarification/ guidance, students are requested to send their queries at ***deepak.gupta@icai.in***

Happy Reading and Best Wishes!

Paper-5, Advanced Management Accounting

Statement Showing Topic-Wise Distribution of Examination Questions Along With Marks

Chapter/ Topics (Part-A)		Term of Examination															
		May 2012		Nov. 2012		May 2013		Nov. 2013		May 2014		Nov. 2014		May 2015		Nov. 2015	
		Q	M	Q	M	Q	M	Q	M	Q	M	Q	M	Q	M	Q	M
Chapter-1	Developments in the Business Environment	1(d) 3(c) 6(c)	5 5 4	1(c) 6(b) 7(a) 7(e)	10 4 4 4	2(a) 4(b) 7(a)	8 8 4	2(c) 6(a) 7(b)	4 8 4	1(c) 4(a) 7(c)	5 8 4	7(c) 6(a) 7(d)	4 10 4	7(a) 5(a) 7(c) 4(a)	4 8 4 8	1(a) 1(b) 2(a) 6(a) 7(a) 7(e)	5 5 8 8 4 4
Chapter-2	Decision Making using Cost Concepts and CVP Analysis	1(a) 1(c) 4(a) 5(a)	5 5 8 8	1(a) 7(b) 7(c)	5 4 4	1(a) 1(d) 5(a)	5 5 12	1(a) 1(d) 7(d)	5 5 4	5(b) 2(a) 1(a) 1(b)	8 10 5 5	7(b) 3(b) 5(b)	4 8 9	3(a) 1(d) 3(b)	12 5 4	7(d)	4
Chapter-3	Pricing Decisions	3(a)	8	5(a)	12	1(b) 7(c)	5 4	2(a)	4	7(a)	4	1(a) 1(d)	5 5	1(a) 7(d)	5 4	5(b) 7(b)	4 4
Chapter-4	Budget & Budgetary Control	6(a) 7(d)	8 4	4(b)	4	2(b)	8	1(c) 7(e)	5 4	6(a)	7	6(b)	6	2(a)	8	4(a) 7(c)	8 4
Chapter-5	Standard Costing	2(b)	6	3(a)	9	3(b)	8	5(a)	8	3(a)	10	5(a)	7	6(b)	8	3(a)	8
Chapter-6	Costing of Service Sector	7(e)	4	6(a)	7	×	×	3(a) 7(a)	12 4	×	×	7(e)	4	×	×	×	×
Chapter-7	Transfer Pricing	2(a)	10	2(a)	11	7(e)	4	4(a)	12	5(a)	8	4(a)	10	1(c)	5	5(a)	12

Chapter/ Topics (Part-A)		Term of Examination															
		May 2012		Nov. 2012		May 2013		Nov. 2013		May 2014		Nov. 2014		May 2015		Nov. 2015	
		Q	M	Q	M	Q	M	Q	M	Q	M	Q	M	Q	M	Q	M
Chapter-8	**Uniform Costing and Inter-firm Comparison**	×	×	4(c)	4	6(c)	5	3(b)	4	×	×	×	×	×	×	×	×
Chapter-9	**Profitability Analysis**	6(b)	4	×	×	5(b)	4	×	×	6(b) 7(b)	5 4	1(b)	5	7(b)	4	1(d)	5

Note

***'Q'** represents* question numbers as they appeared in the question paper of respective examination.

***'M'** represents* the marks which each question carries.

PART-A

CONTENTS

(Chapters 10 to 16 of Advanced Management Accounting are in PART-B)

Chapter-1: Developments in the Business Environment

Chapter-2: Decision Making using Cost Concepts and CVP Analysis

Chapter-5: Standard Costing

1 Developments in the Business Environment

Basic Concepts

A Bottleneck	A Bottleneck is an activity within the organisation where the demand for that resource is more than its capacity to supply.
A Constraint	A Constraint is a situational factor which makes the achievement of objectives / throughput more difficult than it would otherwise be. Constraints may take several forms such as lack of skilled employees, lack of customer orders or the need to achieve a high level of quality product output.
Activity Based Budgeting	Activity Based Budgeting (ABB) is a process of planning and controlling the expected activities for the organisation to derive a cost-effective budget that meets forecasted workload and agreed strategic goals. An activity-based budget is a quantitative expression of the expected activities of the firm, reflecting management's forecast of workload and financial and non-financial requirements to meet agreed strategic goals and planned changes to improve performance. Thus, the key elements of ABB are: – Type of work / activity to be performed; – Quantity of work / activity to be performed; and – Cost of work / activity to be performed.
Activity Based Costing	Activity Based Costing is an accounting methodology that assigns costs to activities rather than products or services. This enables resources & overhead costs to be more accurately assigned to products & services that consume them. CIMA defines 'Activity Based Costing' as an approach to the costing and monitoring of activities which involves tracing resource consumption and costing final outputs. Resources are assigned to activities, and activities to cost objects based

	on consumption estimates. The latter utilise cost drivers to attach activity costs to outputs.
Activity Based Cost Management	The term Activity Based Management (ABM) is used to describe the cost management application of Activity Based Costing (ABC). CAM-1 defines ABM as 'A discipline that focuses on the management of activities as the route to improving the value received by the customer and the profit achieved by providing this value. This discipline includes cost driver analysis, activity analysis, and performance measurement. Activity-Based Management draws on Activity-Based Costing as its major source of information'.
Activity Cost Pool*	Aggregation of all costs related to a specific activity.
Activity Driver*	Transaction that causes an activity.
Activity Driver Analysis*	Identification and evaluation of the activity drivers used to trace the cost of activities to cost objects.
Activities, Hierarchy*	Classification of activities by level of organisation, for example unit, batch, product sustaining and facility sustaining.
Benchmarking	Benchmarking is the process of identifying and learning from the best practices anywhere in the world. It is a powerful tool for continuous improvement.
Back-flushing	Back-flushing requires no data entry of any kind until a finished product is completed. At that time the total amount finished is entered into the computer system, which multiplies it by all the components listed in the bill of materials for each item produced. This yields a lengthy list of components that should have been used in the production process and which are subtracted from the beginning inventory balance to arrive at the amount of inventory that should now be left on hand. Given the large transaction volumes associated with JIT, this is an ideal solution to the problem.
Batch Level Activities*	Activity (such as setting up machines) where volume varies directly with the number of batches of output but is independent of the number of units in a batch.
Business Process Re-Engineering	Business Process Re-Engineering involves examining business processes and making substantial changes in the day to day operation of the organisation. It involves the redesign of work by changing the activities. A business process

	consists of a collection of activities that are linked together in a coordinated & Sequential manner to achieve goal & objective.
Cost Control	Cost Control implies guidance a reputation of cost by executive action. For this purpose, the executives are provided with some yard stick such as standards or budgets with which the actual costs and performances are compared to ascertain the degree of achievement made. Therefore Cost Control involves continuous comparisons of actual with the standards or budgets to regulate the former. Standards or budgets once set up are not attended during the period or until some mistakes are discovered in standards.
Committed Cost*	Cost arising from prior decisions, which cannot, in the short run, be changed. Committed cost incurrence often stems from strategic decisions concerning capacity with resulting expenditure on plant and facilities. Initial control of committed costs at the decision point is through investment appraisal techniques.
Cost Driver*	Factor influencing the level of cost. Often used in the context of ABC to denote the factor which links activity resource consumption to product outputs, for example the number of purchase orders would be a cost driver for procurement cost.
Cost Management*	Application of management accounting concepts, methods of data collection, analysis and presentation in order to provide the information needed to plan, monitor and control costs.
Cost Reduction	Cost Reduction is the achievement of real and permanent reduction in unit cost of products manufactured. It, therefore, continuously attempts to achieve genuine savings in cost of production distributing, selling and administration. It does not accept a standard or budget as or fined. It rather challenges the standards/budgets continuously to make improvement in them. It attempts to excavate, the potential savings buried in the standards by continuous and planned efforts.
Cost of Appraisal*	Costs incurred in order to ensure that outputs produced meet required quality standards.
Cost of Conformance*	Cost of achieving specified quality standards.
Cost of External Failure*	Cost arising from inadequate quality discovered after the transfer of ownership from supplier to purchaser.

Cost of Internal Failure*	Costs arising from inadequate quality which are identified before the transfer of ownership from supplier to purchaser.
Cost of Non-Conformance*	Cost of failure to deliver the required standard of quality.
Cost of Prevention*	Costs incurred prior to or during production in order to prevent substandard or defective products or services from being produced.
Computer-Aided Manufacturing	The manufacturing process is carried out by a range of machinery that, together with its concomitant software, comes under the collective heading of computer–aided manufacturing (CAM). Maximum elements of CAM are computer numerical control (CNC) and robotics. CNC machines are programmable machine tools. These are capable of performing a number of machining tasks, e.g. cutting, grinding, moulding, bending etc. A program stores all the existing manufacturing activities and set-up instructions for a particular machine or bank of machines, providing facility of changing its configuration in a matter of seconds via the keyboard; changes to existing configurations and new configurations are easily accommodated. CNC therefore offers great flexibility, and reduces set-up times. Human operators will tire and are error prone. CNC machines are able to repeat the same operation continuously in identical manner, with high accuracy level.
Differentiation Advantage	It occurs when customers perceive that a business unit's product offering (defined to include all attributes relevant to the buying decision) is of higher quality, involves fewer risks and/or outperforms competing product offerings. For example, differentiation may include a firm's ability to deliver goods and services in a timely manner, to produce better quality, to offer the customer a wider range of goods and services, and other factors that provide unique customer value.
Executional Cost Drivers	These drivers capture a firm's operational decisions on how best to employ its resources to achieve its goals and objectives. These cost drivers are determined by management policy, style and culture. How well a firm executes its use of human and physical resources will determine its level of success or failure.

Industry Value Chain	Industry Value Chain refers to the series of activities, which add value to the product supplied to the industry. The industry value chain starts with the value-creating processes of suppliers, who provide the basic raw materials and components. It continues with the value creating processes of different classes of buyers or end-use consumers, and culminates in the disposal and recycling of materials.
Just-in-Time (JIT) *	System whose objective is to produce or to procure products or components as they are required by a customer or for use, rather than for stock.
Just-in-Time Production*	Production system which is driven by demand for finished products, whereby each component on a production line is produced only when needed for the next stage.
Just-in-Time Purchasing*	Purchasing system in which material purchases are contracted so that the receipt and usage of material, to the maximum extent possible, coincide.
Just-in-Time System*	Pull system, which responds to demand, in contrast to a push system, in which stocks act as buffers between the different elements of the system such as purchasing, production and sales.
Kaizen Costing	It focuses on the reduction of waste in the production process, thereby further lowering costs below the initial targets specified during the design phase. Kaizen Costing is a Japanese term for a number of cost reduction steps that can be used subsequent to issuing a new product design to the factory floor. Some of the activities in the Kaizen Costing methodology include the elimination of waste in the production, assembly, and distribution processes, as well as the elimination of work steps in any of these areas.
Low-Cost Advantage	A firm enjoys a relative cost advantage if its total costs are lower than the market average. This relative cost advantage enables a business to do one of the two things; price its product or services lower than its competitors in order to gain market share and still maintain current profitability; or match with the price of competing products or services and increase its profitability.
Life Cycle Costing	Life Cycle Costing is different to traditional cost accounting system which report cost object profitability on a calendar basis i.e. monthly, quarterly and annually. Life Cycle Costing involves tracing cost and revenues on a product by product basis over several calendar periods. Costs and revenue can be analysed by time period, but the emphasis

	is on cost revenue accumulation over the entire life cycle of each product.
MRP- II	When the scope of MRP-1 is developed further that includes – Planning of Raw Material; – Planning of Component & Sub- Assemblies; – Compute the Other Resources e.g. Machine or Labour Capacity; – To create a fully integrated Plan for Management then it is known as Manufacturing resources planning (MRP – 2). MRP-II (also written MRP-2) adds the MRP schedule into a capacity planning system and then builds the information into a production schedule. It is also seen as a link between strategic planning and manufacturing control.
Management Accounting*	Management accounting is the application of the principles of accounting and financial management to create, protect, preserve and increase value for the stakeholders of for-profit and not-for-profit enterprises in the public and private sectors. Management accounting is an integral part of management. It requires the identification, generation, presentation, interpretation and use of relevant information to: – Inform strategic decisions and formulate business strategy – Plan long, medium and short-run operations – Determine capital structure and fund that structure – Design reward strategies for executives and shareholders – Inform operational decisions – Control operations and ensure the efficient use of resources – Measure and report financial and nonfinancial performance to management and other stakeholders – Safeguard tangible and intangible assets – Implement corporate governance procedures, risk management and internal controls.
Material Requirements Planning (MRP) *	System that converts a production schedule into a listing of the materials and components required to meet that schedule, so that adequate stock levels are maintained and items are available when needed.

Non-Value-Added Activities (NVA)	The Non-Value-Added Activities (NVA) represents work that is not valued by the external or internal customer. NVA activities do not improve the quality or function of a product or service, but they can adversely affect costs and prices. Non-value added activities create waste, result in delay of some sort, add costs to the products or services and for which the customer is not willing to pay. Moving materials and machine set up for a production run are examples of NVA activities.
Product Life Cycle	Each product has a life cycle. The life cycle of a product vary from a few months to several years. Product life cycle is thus a pattern of expenditure, sales level, revenue and profit over the period from new idea generation to the deletion of product from product range. The life cycle of a product consists of four phases viz., Introduction; Growth; Maturity; Saturation and Decline.
Penetration Pricing Strategy	Penetration Pricing is the strategy of entering the market with a low initial price so that a greater share of the market can be captured. The penetration strategy is used when an elite market does not exist and demand seems to be elastic over the entire demand curve, even during early stages of product introduction. High price elasticity of demand is probably the most important reason for adopting a penetration strategy. The penetration strategy is also used to discourage competitors from entering the market.
Quality	It is a measure of goodness to understand how a product meets its specifications. ISO standard defines quality as 'the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs'. When the expression 'quality' is used, we usually think terms of an excellent product or service that fulfills or exceeds our expectations. These expectations are based on the intended use and the selling price. When a product surpasses our expectations we consider that quality. Thus, it is somewhat of an intangible based on perception.
Quality Assurance	It deals with the present, and concerns the putting in place of systems to prevent defects from occurring.
Quality Control	It is concerned with the past, and deals with data obtained from previous production which allow action to be taken to stop the production of defective units.
Quality Cost	Cost of performing the activities to check failure in meeting

	the quality specification. The 'cost of quality' isn't the price of creating a quality product or service. It's the cost of not creating a quality product or service. Every time work is redone, the cost of quality increases.
Quality Management	It is concerned with the future, and manages people in a process of continuous improvement to the products and services offered by the organisation.
Synchronous Manufacturing	'Synchronous Manufacturing' has been defined as 'an all-encompassing manufacturing management philosophy that includes a consistent set of principles, procedures, and techniques where every action is evaluated in terms of the common global goal of the organisation.
Structural Cost Drivers	Structural Cost Drivers consist of organisational factors that determine the economic structure driving the cost of a firm's products. These cost drivers reflect a firm's long-term decisions, which position the firm in its industry and marketplace.
Skimming Pricing Strategy	Skimming Pricing is the strategy of establishing a high initial price for a product with a view to 'skimming the cream off the market' at the upper end of the demand curve. It is accompanied by heavy expenditure on promotion. A skimming strategy may be recommended when the nature of demand is uncertain, when a company has expended large sums of money on research and development for a new product, when the competition is expected to develop and market a similar product in the near future, or when the product is so innovative that the market is expected to mature very slowly.
Six-Sigma Accuracy	The sigma accuracy means the process is 99.999998% accurate. That is the process will / can produce only 0.002 defects per million. This is the structural meaning of six-sigma. In quality practice, six-sigma means 3.4 parts per million.
Throughput*	Throughput term defined, in work by Goldratt, 'as sales minus material and component costs. Similar to contribution except material is considered the only variable cost'. Goldratt argues that labour costs should be treated as fixed'. In Goldratt's analysis 'operating expense is all non-material costs' and 'inventory cost is defined as the cost of assets employed'.
Throughput	Variable cost accounting presentation based on the definition

Accounting (TA) *	of throughput (sales minus material and component costs). Sometimes referred to as super variable costing because only material costs are treated as variable.
Target Costing	Target Costing has been described as a process that occurs in a competitive environment, in which cost minimization is an important component of profitability. This newer approach of product costing may take into account initial design and engineering costs, as well as manufacturing costs, plus the costs of distribution, sales and services. It can be defined as 'a structured approach to determining the cost at which a proposed product with specified functionality and quality must be produced, to generate a desired level of profitability at its anticipated selling price'.
Throughput Ratios*	Several ratios were defined by Galloway and Waldron based on the definition of throughput. The TA (throughput accounting) ratio is: $\frac{\text{Throughput Per Bottleneck Minute}}{\text{Factory Cost Per Bottleneck Minute}}$ [Note: Galloway and Waldron define factory cost in the same way that Goldratt defines operating expense. See throughput] If the TA ratio is greater than 1 the product in question is "profitable" because, if all capacity were devoted to that product, the throughput generated would exceed the total factory cost. If there was a bottleneck products could be ranked by a variant of the TA ratio (although the ranking is the same as that derived by the use of throughput per bottleneck minute). Other performance ratios suggested include: $\frac{\text{Throughput}}{\text{Labour Cost}}$ and $\frac{\text{Throughput}}{\text{Material Cost}}$
Theory of Constraints (TOC) *	Procedure based on identifying bottlenecks (constraints), maximising their use, subordinating other facilities to the demands of the bottleneck facilities, alleviating bottlenecks and re-evaluating the whole system.

Total Quality Management (TQM)	TQM is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society. CIMA defines 'Total Quality Management' as integrated and comprehensive system of planning and controlling all business functions so that products or services are produced which meet or exceed customer expectations. TQM is a philosophy of business behaviour, embracing principles such as employee involvement, continuous improvement at all levels and customer focus, as well as being a collection of related techniques aimed at improving quality such as full documentation of activities, clear goal-setting and performance measurement from the customer perspective.
Throughput per Bottleneck Minute*	Method of ranking products that share the same (bottleneck) facility. Very similar to the use of contribution per unit of limiting factor.
The Plan–Do–Study–Act Cycle	The 'Plan – Do – Study – Act' Cycle describes the activities a company needs to perform in order to incorporate continuous improvement in its operation. This cycle, is also referred to as the Shewhart Cycle or the Deming Wheel. The circular nature of this cycle shows that continuous improvement is a never-ending process.
Value Analysis*	Value Analysis is a systematic interdisciplinary examination of factors affecting the cost of a product or service in order to devise means of achieving the specified purpose at the required standard of quality and reliability at the target cost.
Value Chain	Porter described the Value Chain as 'internal processes or activities a company performs to design, produce, market, deliver and support its product'. He further stated that 'a firm's value chain and the way it performs individual activities are a reflection of its history, its strategy, its approach of implementing its strategy, and the underlying economics of the activities themselves'. John Shank and V. Govindarajan described the value chain in broader terms. According to them 'the value chain for any firm is the value-creating activities all the way from basic raw material sources from component suppliers through to the ultimate end-use product delivered into the final consumer's hands'. This description views the firm as part of an overall chain of value-creating processes.

Value Engineering (VE)	Value Engineering involves searching for opportunities to modify the design of each component or part of a product to reduce cost, but without reducing functionality or quality of the product.
Value-Added Activities (VA)	The Value-Added Activities are those activities which are indispensible in order to complete the process. The customers are usually willing to pay (in some way) for these services. For example polishing furniture by a manufacturer dealing in furniture is a value added activity.

(*)Source - CIMA's Official Terminology

SECTION - A

The Impact of Changing Environment on Cost and Management Accounting

Question-1

How has the composition of manufacturing costs changed during recent years? How has this change affected the design of cost accounting systems?

Answer

Traditionally, manufacturing companies classified the manufacturing costs to be allocated to the products into (a) direct materials. (b) direct labour and (c) indirect manufacturing costs. In the present day context, characterised by intensive global competition, large scale automation of manufacturing process, computerization and product diversification to cater to the changing consumer tastes and preferences has forced companies to refine their costing systems to provide better measurement of the overhead costs used by different cost objects. Accordingly, manufacturing costs are classified into three broad categories as under:

(i) *Direct cost*: As many total costs relating to cost objects as feasible are classified into direct cost. The objective is to trace as many costs as possible in to direct and to reduce the amount of costs classified into indirect because the greater the proportion of direct costs the greater the accuracy of the cost system.

(ii) *Indirect cost pools*: Increase the number of indirect cost pools so that each of these pools is more homogeneous. In a homogeneous cost pool, all the costs will have the same cause-and-effect relationship with the cost allocation base.

(iii) Use cost-and-effect criterion for identifying the cost allocation base for each indirect cost pool.

The change in the classification of manufacturing costs as above has lead to the development of Activity Based Costing (ABC). Activity Based Costing refines a costing system by focusing on individual activities as the fundamental cost objects. An activity is an event, task or unit of work with a specified purpose as for example, designing, set up, etc. ABC system calculates the costs of individual activities and assigns costs to cost objects such as products or services on the basis of the activities consumed to produce the product or provide the service.

Total Quality Management (TQM)

Question-2

Write a short note on 'Quality Cost'.

Answer

Cost of performing the activities to check failure in meeting the quality specification. *The "cost of quality" isn't the price of creating a quality product or service. It's the cost of not creating a quality product or service.* Every time work is redone, the cost of quality increases. Obvious examples include:

(i) The reworking of a manufactured item.
(ii) The retesting of an assembly.
(iii) The rebuilding of a tool.
(iv) The correction of a bank statement.
(v) The reworking of a service, such as the reprocessing of a loan operation or the replacement of a food order in a restaurant.

In short, any cost that would not have been expended if quality were perfect contributes to the cost of quality.

Quality costs are the total of the cost incurred by;

(i) Investing in the prevention of nonconformance to requirements.
(ii) Appraising a product or service for conformance to requirements.
(iii) Failing to meet requirements, which can be internal failure or external failure.

Question-3

Define "Quality" and explain its important dimensions.

Answer

It is a measure of goodness to understand how a product meets its specifications. ISO standard defines quality as *"the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs."*

When the expression "quality" is used, we usually think terms of an excellent product or service that fulfills or exceeds our expectations. These expectations are based on the intended use and the selling price. When a product surpasses our expectations we consider that quality. Thus, it is somewhat of an intangible based on perception.

Quality has nine important dimensions demonstrated in the table below:

Dimension	Meaning and Example
Performance	Primary product characteristic, such as the brightness of the picture
Features	Secondary characteristic, added features, such as remote control
Conformance	Meeting specifications or industry standards, workmanship
Reliability	Consistency of performance over time, average time for the unit to fail
Durability	Useful life, includes repair
Service	Resolution of problems and complaints, ease of repair
Response	Human-to- human interface, such as the courtesy of the dealer
Aesthetics	Sensory characteristics, such as exterior finish
Reputation	Past performance and other intangibles, such as being ranked first

Question-4

Give 5 examples of Prevention Costs, Appraisal Costs, Internal Failure Costs, and External Failure Costs.

Answer

Prevention Costs	Appraisal Costs	Internal Failure Costs	External Failure Costs
Quality Engineering	Inspection	Scrap	Revenue Loss
Quality Training	Product Acceptance	Rework	Warranties
Quality Audits	Packaging Inspection	Re-Inspection	Discount Due to Defects
Design Review	Field Testing	Re-Testing	Product Liability
Quality Circles etc	Continuing Supplier Verification etc	Repair etc	Warranty etc

Question-5

Explain four P's of quality improvement principles.

Answer

The Four P's quality improvement principles are as below:

(i) **People:** It will quickly become apparent that *some individuals are not ideally suited to the participatory process*. Lack of enthusiasm will be apparent from a generally negative approach. Where these individuals are charged with the responsibility for driving group success then progress will be slow or negligible

(ii) **Process:** It is essential to approach *problem-solving practically* and to regard *the formal process* as a system designed to prevent participants from jumping to conclusions.

(iii) **Problem:** Problems need to be approached in *bite-sized chunks*, with teams tackling solvable problems with a direct economic impact, allowing for immediate feedback together with recognition of the contribution made by individual participants.

(iv) **Preparation:** *Courses on creative thinking* and *statistical processes* are needed in order to give participants a greater appreciation of the diversity of the process. This training must quickly be extended beyond the immediate accounting circle to include employees at supervisory levels and below who are involved at the data input stage.

Question-6

What are the essential requirements for successful implementation of TQM?

Or

What are Six C's of TQM?

Answer

The Six Cs for successful implementation of a Total Quality Management (TQM) process is depicted as follows:

(i) **Commitment:** Quality improvement must be everyone's job. Clear commitment from the top management, steps necessary to provide an environment for changing attitudes and breaking down barriers to quality improvement must be provided. Support and training for this must be extended.

(ii) **Culture:** Proper training must be given to effect changes in culture and attitude.

(iii) **Continuous Improvement:** Recognition of room for improvement continually as a process, and not merely a one-off programme.

(iv) **Cooperation:** Must be ensured by involving employees by resorting to mutually agreeable improvement strategies and associated performance measures.

(v) **Customer Focus:** Perfect service with zero defectives with satisfaction to end user whether external customer or internal customer.

(vi) **Control:** Documentation, procedures and awareness of current practices ensure checking deviation from the intended course of implementation.

Question-7

List out the remedies available for difficulties experienced during implementation of PRAISE.

Answer

Remedies available for difficulties experienced in each step available during implementation of praise:

Step	Activity	Remedies
(i)	Problem Identification	✓ Participative approaches like brainstorming, multi-voting, panel discussion. ✓ Quantification and precise definition of problem.
(ii)	Ranking	✓ Participative approach. ✓ Subordination of individual to group interest.
(iii)	Analysis	✓ Lateral thinking brainstorming.
(iv)	Innovation	✓ Systematic evaluation of all aspects of each strategy.
(v)	Solution	✓ Effective internal communication. ✓ Training of personnel and managers. ✓ Participative approach.
(vi)	Evaluation	✓ Effective control system to track actual feedback system.

Question-8

Discuss the benefits accruing from the implementation of a Total Quality Management programme in an organization.

✍ **Answer**

The benefits accruing from the implementation of a Total Quality Management programme in an organisation are:

(i) There will be increased awareness of quality culture in the organization.

(ii) It will lead to commitment to continuous improvement.

(iii) It will focus on customer satisfaction.

(iv) A greater emphasis on team work will be achieved.

Question-9

What are the universal beliefs in respect of TQM?

✍ **Answer**

Following are the universal Total Quality Management beliefs:

(i) Owner / customer satisfaction is the measure of quality.

(ii) Everyone is an owner/customer.

(iii) Quality improvement must be continuous.

(iv) Analysis of the processes is the key to quality improvement.

(v) Measurement, a skilled use of analytical tools, and employee involvement are critical sources of quality improvement ideas and innovations.

(vi) Sustained total quality management is not possible without active, visible, consistent, and enabling leadership by managers at all levels.

(vii) It is essential to continuously improve the quality of products and services that we provide to our owners/customers.

Question-10

Describe Deming's 14 points.

✍ **Answer**

Deming "14 points"

1.	"Create constancy of purpose towards improvement". Replace short-term reaction with long-term planning.	2	"Adopt the new philosophy". The implication is that management should actually adopt his philosophy, rather than merely expect the workforce to do so.
3.	"Cease dependence on inspection". If variation is reduced, there is no need to inspect manufactured items for defects, because there won't be any.	4.	"Move towards a single supplier for any one item." Multiple suppliers mean variation between feedstock.
5.	"Improve constantly and forever". Constantly strive to reduce variation.	6.	"Institute training on the job". If people are inadequately trained, they will not all work the same way, and this will introduce variation.
7.	"Institute leadership". Deming makes a distinction between leadership and mere supervision. The latter is quota and target-based.	8.	"Drive out fear". Deming sees management by fear as counter-productive in the long term, because it prevents workers from acting in the organisation's best interests.
9.	"Break down barriers between departments". Another idea central to TQM is the concept of the 'internal customer', that each department serves not the management, but the other departments that use its outputs.	10.	"Eliminate slogans". Another central TQM idea is that it's not people who make most mistakes - it's the process they are working within. Harassing the workforce without improving the processes they use is counter-productive.
11.	"Eliminate management by objectives". Deming saw production targets as encouraging the delivery of poor-quality goods.	12.	"Remove barriers to pride of workmanship". Many of the other problems outlined reduce worker satisfaction.
13.	"Institute education and self-improvement".	14.	"The transformation is everyone's job".

Question-11

Write a note on the 'Plan – Do – Study – Act' cycle.

Or

Write a note on 'Shewhart' cycle.

Or

Write a note on 'Deming Wheel'.

Answer

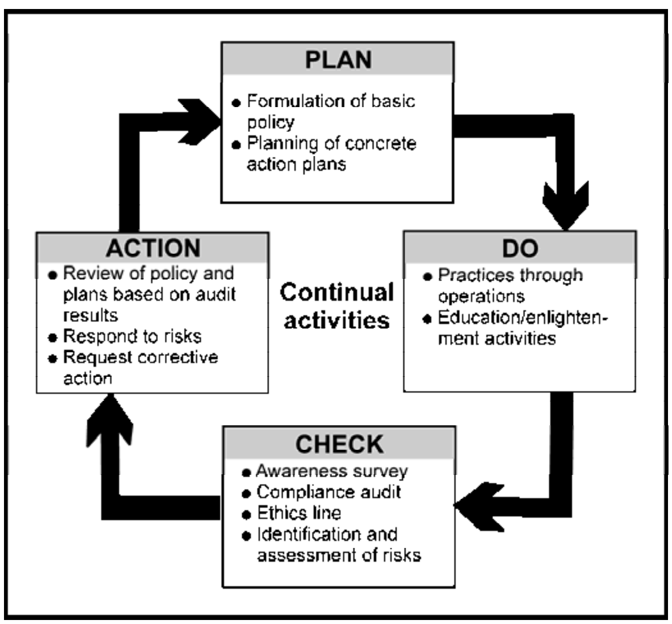
The Plan – Do – Study – Act (PDSA) Cycle describes the activities a company needs to perform in order to incorporate continuous improvement in its operation. This cycle, is also referred to as the *Shewhart cycle or the Deming wheel.* The circular nature of this cycle shows that continuous improvement is a never-ending process. Let's look at the specific steps in the cycle.

(i) **Plan:** The first step in the PDSA cycle is to plan. Managers must evaluate the current process and make plans based on any problems they find. They need to document all current procedures, collect data, and identify problems. This information should then be studied and used to develop a plan for improvement as well as specific measures to evaluate performance.

(ii) **Do:** The next step in the cycle is implementing the plan (do). During the implementation process managers should document all changes made and collect data for evaluation.

(iii) **Study** / **Check:** The third step is to study the data collected in the previous phase. The data are evaluated to see whether the plan is achieving the goals established in the plan phase.

(iv) **Act:** The last phase of the cycle is to act on the basis of the results of the first three phases. The best way to accomplish this is to communicate the results to other members in the company and then implement the new procedure if it has been successful.



Note that this is a cycle; the next step is to plan again. After we have acted, we need to continue evaluating the process, planning, and repeating the cycle again.

Question-12

Write a note on Six Sigma.

Answer

Continuous improvement can be brought into the organisational culture by introducing continuously changing planned targets. One such target can be six-sigma accuracy. The sigma accuracy means the process is 99.999998% accurate. That is the process will/can produce only 0.002 defects per million. This is the structural meaning of six-sigma. In quality practice, six-sigma means 3.4 parts per million.

Six sigma is the statistical measure used to ensure quality of products and services. The six sigma academy has developed a break through strategy consisting of measure, analyze, improve and control, that allows companies to make exceptional bottom-line improvements.

In addition to the material and labour savings, which flow directly to the bottom line, a company engaged in six sigma can expect to see:

(i) Improved customer satisfaction.

(ii) Reduction cycle time.

(iii) Increased productivity.

(iv) Reduction in total defect.

(v) Improved process flow.

Six Sigma Capability Chart

Sigma	Parts per Million
Six Sigma	3.4 Defects per Million
Five Sigma	233 Defects per Million
Four Sigma	6,120 Defects per Million
Three Sigma	66,807 Defects per Million
Two Sigma	3,08,537 Defects per Million
One Sigma	6,90,000 Defects per Million

Question-13

Write a note on "Criticisms of Total Quality Management"

Answer

Some authors, notably Carlzon (1987), Albrecht (1985) and Albrecht and Zemke (1988) have criticised the direction that TQM implementations have tended to take in practice, in particular.

— the focus on documentation of process and ill-measurable outcomes;

— the emphasis on quality assurance rather than improvement; and

— an internal focus which is at odds with the alleged customer orientation.

Carlzon has revived the customer focus with an emphasis on total employee involvement (TEI) culminating in the empowerment of the 'front-line' of customer service troops. The main features of his empowerment thrust has been :

— loyalty to the vision of the company through the pursuit of tough, visible goals;

— recognition of satisfied customers and motivated employees as the true assets of a company;

— delegation of decision-making to the point of responsibility by eliminating hierarchical tiers of authority to allow direct and speedy response to customer needs; and

— decentralisation of management to make best use of the creative energy of the workforce.

Albrecht suggest that TQM may not be appropriate for service based industries, because the standards-based approach of 'industry best practice' ignores the culture of organisations. He recommends a move towards TQS (total quality service), which is more customer oriented and creates an environment to promote enthusiasm and commitment. Albrecht suggests that poor service is associated with sloppy procedures, errors, inaccuracies and oversights and poor co-ordination, all of which represents improvement opportunities which can be achieved through tighter controls.

Activity Based Cost Management

Question-14

What is activity based costing?

Answer

Activity Based Costing is an accounting methodology that assigns costs to activities rather than products or services. This enables resources & overhead costs to be more accurately assigned to products & services that consume them.

CIMA defines *'Activity Based Costing' as an approach to the costing and monitoring of activities which involves tracing resource consumption and costing final outputs. Resources* *are assigned to activities, and activities to cost objects based on consumption estimates. The latter utilise cost drivers to attach activity costs to outputs."*

Question-15

Explain the concept of activity based costing. How ABC system supports corporate strategy?

Answer

"ABC is an accounting methodology that assigns costs to activities rather than products and services. This enables resources and overhead costs to be more accurately assigned to products and services that consume them when compared to traditional methods where either labour or machine hrs are considered as absorption basis over cost centres."

In order to correctly associate costs with products and services, ABC assigns cost to activities based on their resources . It then assigns cost to 'Cost objects', such as products and customers, based on their use of activities. ABC can track the flow of activities in organization by creating a link between the activity and the cost objects. ABC supports corporate strategy in many ways such as:

(i) ABC system can effectively support the management by furnishing data, at the operational level and strategic level. Accurate product costing will help the management to compare the profits of various customers, product lines and to decide on price strategy etc.

(ii) Information generated by ABC system can also encourage management to redesign the products.

(iii) ABC system can change the method of evaluation of new process technologies, to reduce setup times, rationalization of plant lay out in order to reduce or lower material handling cost, improve quality etc.

(iv) ABC system will report on the resource spending.

(v) ABC analysis helps managers focus their attention and energy on improving activities and the actions allow the insights from ABC to be translated into increased profits.

(vi) Performance base accurate feedback can be provided to cost centre managers.

(vii) Accurate information on product costs enables better decisions to be made on pricing, marketing, product design and product mix.

Question-16

Why are conventional product costing systems more likely to distort product costs in highly automated plants? How do activity-based costing systems deal with such a situation?

Answer

The conventional product cost system was in vogue when companies manufactured narrow range of products, overhead costs were relatively small and distortions arising from inappropriate overhead allocations were not significant. It used volume measures like direct labour hours or machine hours for charging overhead costs to products. In the case of a company using highly automated plant, direct labour is a small fraction of cost when compared with overheads (because of higher amount of depreciation). In case where such a company is multi product, overheads which are large in proportion to direct labour are influenced by number of set up, inspection, number of purchases etc. In these circumstances, the volume based method of recovery of overheads is no longer appropriate and such a measure will report inaccurate product costs. Hence, the traditional system of costing was found to over cost high volume products and under cost low volume products. Activity Based Costing (ABC) system aims at refining the costing system used in automated plants in the following manner:

(i) ABC systems trace more costs as direct costs.

(ii) ABC systems create homogeneous cost pools linked to different activities.

(iii) For each activity cost pool, ABC systems seek a cost allocation base that has a causeand- effect relationship with costs in the cost pool.

Question-17

Write the factors prompting the development of ABC system.

Answer

Factors prompting the development of ABC system include:

(i) Growing overhead costs because of increasingly automated production.

(ii) Increasing market competition which necessitated more accurate product costs.

(iii) Increasing product diversity to secure economies of scope & increased market share.

(iv) Decreasing costs of information processing because of continual improvements and increasing application of information technology.

Question-18

State main advantages of Activity Based Costing.

Answer

The main advantages of using Activity Based Costing are:

(i) More accurate costing of products/services, customers, SKUs, distribution channels.

(ii) Better understanding overhead.

(iii) Utilizes unit cost rather than just total cost.

(iv) Integrates well with Six Sigma and other continuous improvement programs.

(v) Makes visible waste and non-value added.

(vi) Supports performance management and scorecards.

(vii) Enables costing of processes, supply chains, and value streams.

(viii) Activity Based Costing mirrors way work is done.

(ix) Facilitates benchmarking.

Question-19

Explain - "ABC: A Decision Making Tool".

Answer

It is a useful tool for many of the management decisions facing companies today. It can bring a picture of the operation to light that may not be obvious through other analysis tools. Specifically, ABC is useful in analyzing specific segments of an organization. This might include a market line, a group of products (even a single product), a customer, or an employee. The ABC is implemented in following decisions:

(i) ABC is a complement to total quality management (TQM). It provides quantitative data that can track the financial impact of improvements implemented as part of the TQM initiative. Some have even suggested that ABC is the most important concept introduced since TQM..

(ii) Wholesale distributors can gain significant advantage in the decision-making process through implementation of ABC concepts. The expansion of line offerings has brought about difficult decisions for the distributor..

(iii) Other decisions that can be assisted by ABC include facility and resource expansion. Often the basis for relocation or opening of a new distribution center is based on cost associations. The ABC model can identify the specific cost elements being targeted, providing a much clearer picture from which management can act.

(iv) Decision support for human resources can be augmented by ABC. Where activity, and therefore cost, can be associated to an individual, new levels of financial performance can be determined.

(v) Companies who wish to determine price based on cost plus markup basis find ABC method of costing very relevant and are able to determine competitive prices for their products.

(vi) Using Traditional absorption costing, overheads may get distributed equally across all product lines. ABC traces costs back to the activity and the consumption of resources by each product. Thus, product line profitability can be determined in more realistic terms.

(vii) Other areas where ABC system can be relevant include market, make or buy decisions, transfer pricing, plant close – down decisions, evaluation of offshore production or outsourcing a process, capital investment decisions, etc.

In summary, activity-based costing is a management decision-making tool. By associating cost to the activity, a clear relationship can be established between sources of activity demand and the related costs. This association can benefit the distributor in determining where costs are being incurred, what is initiating the costs and where to apply efforts to curb inflationary costs. This can be of particular value in tracking new products or customers. It can also provide tracking of logistics costs, one of the fastest growing areas of expense to the distribution operation.

Question-20

Explain which features of the Service organisations may create problems for the application of activity-based costing.

✍ **Answer**

The following may create problem for adoption of ABC system in service organisation –

(i) *Facility sustaining costs* (such as property, rents etc.) represent a significant portion of total costs and may only be avoidable if the organisation ceases business. *It may be impossible to establish appropriate cost drivers.*

(ii) It is often difficult to define products where they are of *intangible nature*. *Cost objects can therefore be difficult to specify.*

(iii) Many service organisations have *not previously had a costing system* and much of the information required to set up a ABC system will be non-existent. Therefore *introduction of ABC may be expensive*.

Question-21

What is the fundamental difference between Activity Based Costing System (ABC) and Traditional Costing System? Why more and more organisations in both the manufacturing and non-manufacturing industries are adopting ABC?

Answer

In the traditional system of assigning manufacturing overheads, overheads are first allocated and apportioned to cost centres (production and support service cost centres) and then absorbed to cost objects (e.g. products). Under ABC, overheads are first assigned to activities or activity pools (group of activities) and then they are assigned to cost objects. Thus, ABC is a refinement over the traditional costing system. Usually cost centres include a series of different activities. If different products create different demands on those activities, the traditional costing system fails to determine the product cost accurately. In that situation, it becomes necessary to use different rates for different activities or activity pools.

The following are the reasons for adoption of ABC by manufacturing and non-manufacturing industries:

(i) Fierce competitive pressure has resulted in shrinking profit margin. ABC helps to estimate cost of individual product or service more accurately. This helps to formulate appropriate marketing / corporate strategy.

(ii) There is product and customer proliferation. Demand on resources by products / customers differ among product / customers. Therefore, product / customer profitability can be measured reasonably accurately, only if consumption of resources can be traced to each individual product / customer.

(iii) New production techniques have resulted in the increase of the proportion of support service costs in the total cost of delivering value to customers. ABC improves the accuracy of accounting for support service costs.

(iv) The costs associated with bad decisions have increased substantially.

(v) Reduction in the cost of data processing has reduced the cost of tracking resources consumption to large number of activities.

Question-22

Point out the differences between activity based costing and traditional absorption costing.

Answer

The points of differences between activity based costing and traditional absorption costing can be enumerated below:

Activity Based Costing	Traditional Absorption Costing
(i) Overheads are related to activities and grouped into activity cost pools.	(i) Overheads are related to cost centers / departments.

(ii) Activities are classified as – (i) Unit Level, (ii) Batch Level, (iii) Product Level and (iv) Facility Level activities.	(ii) Only (i) Unit Level (Variable) and (ii) Facility Level (Fixed) activities are identified.
(iii) Costs are related to activities and hence are more realistic.	(iii) Costs are related to cost centers and hence not realistic of cost behaviour.
(iv) Activity–wise cost drivers are determined.	(iv) Time (Hours) are assumed to be the only cost driver governing costs in all departments.
(v) Activity–wise recovery rates are determined and there is no concept of a single overhead recovery rate.	(v) Either multiple overhead recovery rate (for each department) or a single overhead recovery rate may be determined for absorbing overheads.
(vi) Cost are assigned to cost objects, e.g. customers, products, services, departments, etc.	(vi) Costs are assigned to Cost Units i.e. to products, or jobs or hours.
(vii) Essential activities can be simplified and unnecessary activities can be eliminated. Thus the corresponding costs are also reduced / minimized. Hence ABC aids cost control.	(vii) Cost Centers / departments cannot be eliminated. Hence not suitable for cost control.

Question-23

State Benefits of Activity Based Cost Management.

Answer

Benefits of Activity Based Cost Management

(i) Provision of excellent basis and focus for cost reduction.

(ii) Provides operational management with a clear view of HOW to implement an Activity Based budget.

(iii) Provision of clear understanding of the underlying causes of business processing costs.

(iv) Provision of excellent basis for effectiveness of management decision making.

(v) Identification of key process waste elements, permit management prioritisation and leverage of key resources.

Question-24

What is difference between ABC and ABM?

Answer

The ABC refers to the technique for determining the cost of activities and the output that those activities produce. It is the logical distribution of overhead i.e. overhead should be distributed on the consumption of resources consumed by goods and services. The aim of ABC is to generate improved cost data for use in managing a company's activities.

The ABM is a much broader concept. It refers to the management philosophy that focuses on the planning, execution and measurement of activities as the key to competitive advantage.

Question-25

What are the key elements of Activity Based Budgeting (ABB)?

Answer

The key elements of ABB are:

(i) Type of work/activity to be performed;

(ii) Quantity of work/activity to be performed; and

(iii) Cost of work/activity to be performed.

Question-26

Write a short note on 'Batch Level Activities'.

Answer

The cost of some activities (mainly manufacturing support activities) is driven by the number of batches of units produced. Examples of this are:

(i) Material Ordering – Where an order is placed for every batch of production.

(ii) Machine Set-up Costs – Where machines need resetting between each different batch of production.

(iii) Inspection of Products – Where the first item in every batch is inspected rather than every 100th item quoted above.

Question-27

Give two examples for each of the following categories in activity based costing:

(i) Unit level activities

(ii) Batch level activities

(iii) Product level activities

(iv) Facility level activities

Answer

Examples:

(i)	Unit Level Activities	----	(i)	Use of indirect materials
			(ii)	Inspection or testing of every item produced
			(iii)	Indirect consumables
(ii)	Batch Level Activities	----	(i)	Material ordering
			(ii)	Machine set up costs
			(iii)	Inspection of products–like first item of every batch
(iii)	Product Level	----	(i)	Designing the product
			(ii)	Producing parts to a certain specification
			(iii)	Advertising costs, if advertisement is for individual products
(iv)	Facility Level	----	(i)	Maintenance of buildings
			(ii)	Plant security

Question-28

Differentiate between 'Value-added' and 'Non-value-added' activities in the context of Activity based costing. Give examples of Value-added and Non-value-added activities.

Answer

A value added activity is an activity that *customers perceive as adding usefulness to the product or service they purchase*. In other words, it is an activity that, if eliminated, will reduce the actual utility or usefulness which customers obtain from using the product or service. For example, painting a car in a company manufacturing cars or a computer manufacturing company making computers with preloaded software.

A non-value added activity is an activity where *there is an opportunity of cost reduction without reducing the product's service potential to the customer*. In other words, it is an activity that, if eliminated, will not reduce the actual or perceived value that customers obtain by using the product or service. For example, storage and moving of raw materials, reworking or repairing of products, etc.

Value-added activities enhance the value of products and services in the eyes of the organisation's customers while meeting its own goals. Non-value added activities on the other hand do not contribute to customer-perceived value.

Target Costing

Question-29

What is Target Costing? It is said that implementation of the target costing technique requires intensive marketing research. Explain why intensive marketing research is required to implement target costing technique.

Answer

Target cost is the difference between estimated selling price of a proposed product with specified functionality and quality and the target margin. This is a cost management technique that aims to produce and sell products that will ensure the target margin. It is an integral part of the product design. While designing the product, the company needs to understand what value target customers will assign to different attributes and different aspects of quality. This requires use of techniques like value engineering and value analysis. Intensive marketing research is required to understand customer preferences and the value they assign to each attribute and quality parameter. This insight is required to be developed must before the product is introduced. The company plays within the space between the maximum attributes and quality that the company can offer and the minimum acceptable to target customers. Therefore in absence of intensive marketing research, the target costing technique cannot be used effectively.

Question-30

What is target costing? It is said that target costing fosters team work within the organisation. Explain how target costing creates an environment in which team work fosters.

Answer

Target cost is the difference between the estimated selling price of a proposed product with specified functionality and quality and target margin. This is a cost management technique that aims to produce and sell products that will ensure the target margin. It is an integral part of the product design. While designing the product the company allocates value and cost to different attributes and quality. Therefore, they use the technique of value engineering and value analysis. The target cost is achieved by assigning cost reduction targets to different operations that are involved in the production process. Eventually, all operations do not achieve the cost reduction targets, but the overall cost reduction target is achieved through team work. Therefore, it is said that target costing fosters team work.

Question-31

Discuss, how target costing may assist a company in controlling costs and pricing of products.

Answer

Target costing may assist control of costs and pricing of product as under:

(i) Target costing considers the price that ought to be charged by a company to achieve a given market share.

(ii) Target costing should take life cycle costs in to consideration.

(iii) If there is a gap between the target cost and expected cost, ways and means of reducing or eliminating it can be explored.

(iv) The target cost may be used for controlling costs by comparison.

Question-32

State any 5 advantages of "Target Costing".

Answer

Advantages of "Target Costing are as under:

(i) Target costing ensures proper planning well ahead of actual production and marketing.

(ii) Implementation of Target Costing enhances employee awareness and empowerment.

(iii) Foster partnership with suppliers.

(iv) Minimize non value-added activities.

(v) Encourages selection of lowest cost value added activities.

Question-33

By appropriate presentation show the difference between 'Target Cost' and 'Traditional Costing'

Answer

Target Costing	Traditional Costing
Production Specification ⇩ Target Price and Volume ⇩ Target Profit ⇩ Target Cost ⇩ Product Design	Production Specification ⇩ Product Design ⇩ Estimated Cost ⇩ Target Cost ⇩ Target Price

Question-34

Identify the companies, which seem to benefit most from target costing.

Answer

Some companies, which seem to benefit most from target costing, are those, which maintain the following criteria:

(i) Assembly-oriented industries, as opposed to repetitive-process industries that produce homogeneous products;

(ii) Involved heavily with the diversification of the product lines;

(iii) Use technologies of factory automation, including computer-aided design, flexible manufacturing systems, office automation, and computer-aided manufacturing;

(iv) Have experienced shorter product life cycles where the pay-back for factory automation typically must be achieved in less than eight years;

(v) Must develop systems for reducing costs during the planning, design and development stages of a product's life cycle;

(vi) Are implementing management methods such as just-in-time, value engineering, and total quality control

Question-35

Identify Control Points which should be taken care of in all target costing projects.

Answer

Control Points which should be taken care of in all target costing projects

(i) **Identification of Principal Control Point:** Experience shows that there always comes a point, where the *cost of maintaining the design team exceeds the savings gardened from additional iterations*. It is also necessary that most products should be launched within a reasonably short time or they will miss the appropriate market, where they will beat the delivery of competing products to the market. This emphasis that the principal control points over the course of target costing programme should be properly taken care of.

(ii) **Point of Go / No Go Decision:** If target costing is not reached, management retains power to abandon the design project. There comes a point, when actual performance is very close to expected performance in matter of cost incurrence.

(iii) **Milestone *can be in terms of* Timer or Points:** A milestone can be in terms of time, say one month. It can also be on the points in design process, at which specific activities are completed.

Question-36

Write a short note on 'Kaizen Costing'.

Answer

Kaizen Costing is a Japanese term for a number of cost reduction steps that can be used subsequent to issuing a new product design to the factory floor. Some of the activities in the kaizen costing methodology include the elimination of waste in the production, assembly, and distribution processes, as well as the elimination of work steps in any of these areas. Though these points are also covered in the value engineering phase of target costing, the initial value engineering may not uncover all possible cost savings. Thus, kaizen costing is really designed to repeat many of the value engineering steps for as long as a product is produced, constantly refining the process and thereby stripping out extra costs. The cost reductions resulting from kaizen costing are much smaller than those achieved with value engineering but are still worth the effort since competitive pressures are likely to force down the price of a product over time, and any possible cost savings allow a company to still attain its targeted profit margins while continuing to reduce cost.

Life Cycle Costing

Question-37

What is total-life-cycle costing approach? Why is it important?

Answer

Life cycle costing estimates, tracks and accumulates the costs over a product's entire life cycle from its inception to abandonment or from the initial R & D stage till the final customer servicing and support of the product. It aims at tracing of costs and revenues on product by product basis over several calendar periods throughout their life cycle. Costs are incurred along the product's life cycle starting from product's design, development, manufacture, marketing, servicing and final disposal. The objective is to accumulate all the costs over a product life cycle to determine whether the profits earned during the manufacturing phase will cover the costs incurred during the pre and post manufacturing stages of product life cycle.

Product life cycle costing is important for the following reasons:

(i) When non-production costs like costs associated with R & D, design, marketing, distribution and customer service are significant, it is essential to identify them for target pricing, value engineering and cost management. For example, a poorly designed software package may involve higher costs on marketing, distribution and after sales service.

(ii) There may be instances where the pre-manufacturing costs like R & D and design are expected to constitute a sizeable portion of life cycle costs. When a high percentage of total life cycle costs are likely to be so incurred before the commencement of production, the firm needs an accurate prediction of costs and revenues during the manufacturing stage to decide whether the costly R & D and design activities should be undertaken.

(iii) Many costs are locked in at R & D and design stages. Locked in or Committed costs are those costs that have not been incurred at the initial stages of R & D and design but that will be incurred in the future on the basis of the decisions that have already been taken. For example, the adoption of a certain design will determine the product's material and labour inputs to be incurred during the manufacturing stage. A complicated design may lead to greater expenditure on material and labour costs every time the product is produced. Life cycle budgeting highlights costs throughout the product life cycle and facilitates value engineering at the design stage before costs are locked in.

Total life-cycle costing approach accumulates product costs over the value chain. It is a process of managing all costs along the value chain starting from product's design, development, manufacturing, marketing, service and finally disposal.

Question-38

Explain the essential features of Life-cycle costing.

Answer

Product Life Cycle costing involves:

(i) Tracing of costs and revenue of product over several calendar period- throughout their entire life cycle.

(ii) Emphasis is on Cost and revenue accumulation over the entire life cycle of the product.

(iii) Life cycle costing traces research and design.

(iv) It focuses on development costs, incurred to individual products over their entire life cycles.

(v) Total magnitude of research and development costs are reported and compared with product revenues generated in later periods.

Question-39

What is product life cycle costing? What are the costs that you would include in product life cycle cost?

Answer

Product life cycle costing traces costs and revenues of each product over several calendar periods throughout their entire life cycle. The costs are included in different stages of the product life cycle.

Development Phase – R & D Cost / Design Cost.

Introduction Phase – Promotional Cost / Capacity Costs.

Growth Phase / Maturity – Manufacturing Cost / Distribution Costs / Product Support Cost.

Decline / Replacement Phase – Plants Reused / Sold / Scrapped / Related Costs.

Question-40

Briefly explain the phases in the life cycle of a product.

Answer

Phases in Life Cycle of a Product:

Phase	Characteristics
Introduction	Product is launched. Profits are almost non existent. Competition is almost negligible.
Growth	Sales/ Profits rise rapidly. Competiton enters.
Maturity	Sales increases but at a declining rate. Some firms extend their product lines with new models.
Saturation and Decline	Drop in sales volume, need for product demand disappears. Better and cheaper substitutes are available in the market.

Value Chain Analysis

Question-41

What is the concept of 'Value-chain' and why is it important for Cost Management?

Answer

Value chain is the linked set of value creating activities from the basic raw materials and components sources to the ultimate end use of the product or service delivered to the customer.

The six business functions contained in the value chain are (i) Research and Development, (ii) Design (iii) Production (iv) Marketing (v) Distribution and (vi) Customer service.

The objective of value chain is to serve as means of *increasing the customer satisfaction* and *managing costs effectively*. Coordination of the individual parts of the value chain activities creates conditions to improve customer satisfaction in terms of cost efficiency, quality and delivery. A firm which performs value chain activities more efficiently and at a lower cost than its competitors will be able to gain competitive advantage. The following methodology should be adopted.

(i) The firm should identify the industry value chain and then assign costs, revenues and assets to value activities.

(ii) Diagnose the cost drivers regulating each value activity.

(iii) Develop sustainable cost advantage either by controlling cost drivers better than competitors or by reconfiguring the chain value.

By analyzing costs, revenues and assets in each activity systematically a company can achieve low cost. Thus value chain helps managers in deciding how to apply the organization's valuable physical and human resources to each linked process so as to achieve cost effectiveness.

Question-42

Define the term 'Value-Chain'. Mention three useful strategic frameworks of the Value-Chain Analysis.

Answer

Value chain is the linked set of value-creating activities all the way from basic raw material sources for component suppliers through to the ultimate end-use product or service delivered to the customer. Proter's described the value chain as the 'internal processes or activities a company performs to design, produce, market, deliver and support its product'. He further stated that 'a firm's value chain and the way it performs individual activities are a reflection of its history, its strategy, its approach of implementing its strategy, and the underlying economics of the activities themselves'. The business activities are classified in to primary activities and support activities.

Primary activities are those activities which are involved in transforming the inputs in to outputs, delivery and after sales service to output. Support activities are intended to support the primary activities like for example procurement, human resources management, etc.

Three useful strategic frameworks for value chain analysis are:

(i) Industry structure analysis;

(ii) Core competencies; and

(iii) Segmentation analysis.

Question-43

How can value analysis achieve cost reduction?

Answer

Value analysis can do cost reduction in the following manner:

(i) By identifying and removing unnecessary components in a product which had utility earlier.

(ii) By introducing component substitution at a lesser cost without affecting the quality of the product.

(iii) By simplifying the product design.

(iv) By introducing alternative methods with less cost but improved efficiency.

Question-44

Classify the following business activities into primary and support activities under value chain analysis.

(i) *Material Handling and Warehousing.*

(ii) *Purchasing of raw materials, supplies and other consumables.*

(iii) *Order processing and distribution*

(iv) *Selection, placement and promotion of employees.*

Answer

Classification of Business Activities into Primary and Support Activities

Sl. No.	Business Activities	Primary/ Support
(i)	Material Handling and Warehousing	Primary Activities
(ii)	Purchasing of raw materials, supplies and other consumables	Support Activities
(iii)	Order processing and distribution	Primary Activities
(iv)	Selection, placement and promotion of employees	Support Activities

Question-45

In Value Chain analysis, business activities are classified into primary activities and support activities. Classify the following under the more appropriate activity.

(i) *Order processing and distribution*

(ii) *Installation, repair and parts replacement*

(ill) *Purchase of raw material and other consumable stores*

(iv) *Transforming inputs into final products*

(v) *Selection, promotion, appraisal and employee relations*

(vi) *Material handling and warehousing*

(vii) *General management, planning, finance, accounting*

(viii) *Communication, pricing and channel management*

Answer

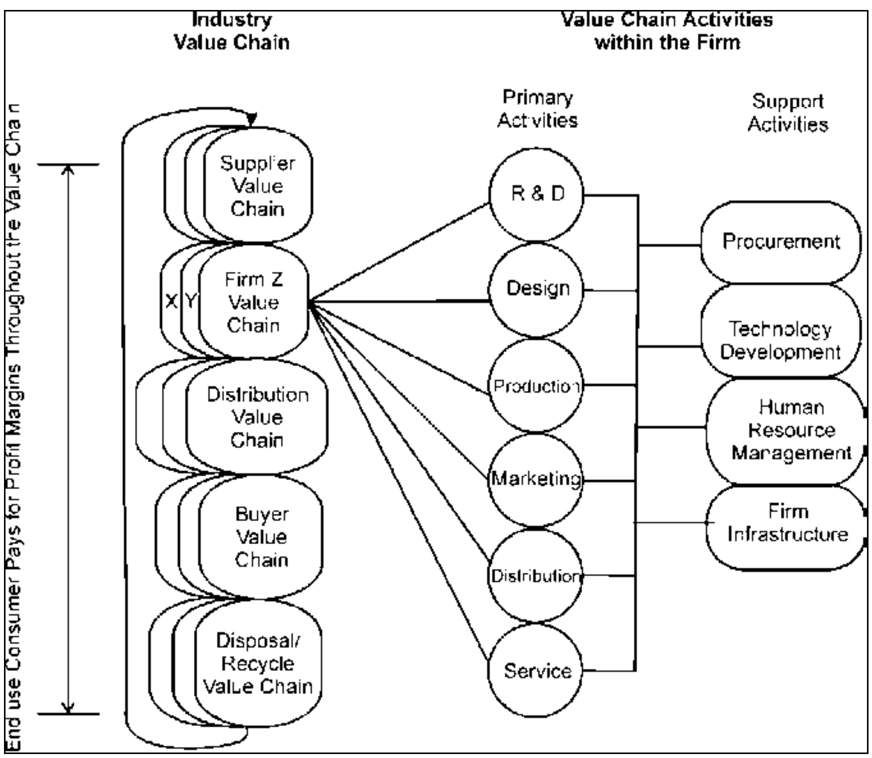
Activity		Primary Activity/Support Activity
(i)	Order processing and distribution	Primary Activity
(ii)	Installation, repair and parts replacement	Primary Activity

(iii)	Purchase of raw material and other consumable stores	Support Activity
(iv)	Transforming inputs into final products	Primary Activity
(v)	Selection, promotion, appraisal and employee relations	Support Activity
(vi)	Material handling and warehousing	Primary Activity
(vii)	General management, planning, finance, accounting	Support Activity
(viii)	Communication, pricing and channel management	Primary Activity

Question-46

Prepare a diagram showing the value chain activities within the firm with suitable classifications under primary and support activities and also the industry value chain indicating what the end use consumer pays for.

Answer



Question-47

What steps are involved in value chain analysis approach for assessing competitive advantages?

Answer

Most corporations define their mission as one of creating products and services. In contrast, the other companies are acutely aware of the strategic importance of individual activities within their value chain, They are concentrating on those activities that allow them to capture maximum value for their customers and themselves. These firms use the value chain analysis approach to better understand which segments, distribution channels, price points. Product differentiation, selling prepositions and value chain configuration will yield them the greatest competitive advantage. The way the value chain approach helps these organizations to assess competitive advantage includes the use of following steps of analysis.

(i) Internal Cost Analysis - to determine the sources of profitability and the relative cost positions of internal value creating processes;

(ii) Internal Differentiation Analysis - to understand the sources of differentiation with internal value-creating process; and

(iii) Vertical Linkage Analysis - to understand the relationships and associated costs among external suppliers and customers in order to maximize the value delivered to customers and to minimize the cost.

The value chain approach used for assessing competitive advantages is an integral part of the strategic planning process. Like strategic planning, value chain analysis is a continuous process of gathering, evaluating and communicating information for business decision-making.

Question-48

"Cost can be managed only at the point of commitment and not at the point of incidence. Therefore, it is necessary to manage cost drivers to manage cost." Explain the statement with reference to structural and executional cost drivers.

Answer

A firm commits costs at the time of designing the product and deciding the method of production. It also commits cost at the time of deciding the delivery channel (e.g. delivery through dealers or own retail stores). Costs are incurred at the time of actual production and delivery. Therefore, no significant cost reduction can be achieved at the time when the costs are incurred. Therefore, it is said that costs can be managed at the point of commitment. Cost drivers are factors that drive consumption of resources. Therefore, management of cost drivers is essential to manage costs. Structural cost drivers are those which can be managed by effecting structural changes. Examples of structural cost drivers are scale of operation, scope of operation (i.e. degree of vertical integration), complexity, technology and experience or learning. Thus, structural cost drivers arise from the business model adopted by the company. Executional cost drivers can be managed by executive decisions, examples of executional cost drivers are capacity utilization, plant layout efficiency, product configuration and linkages with suppliers and customers. It is obvious that cost drivers can be managed only at the point of structural and operating decisions, which commit resources to various activities.

Question-49

What are the limitations of Value Chain Analysis.

Answer

Limitations of Value Chain Analysis

(i) **Non-availability of data:** Internal data on costs, revenues and assets used for value chain analysis are derived from financial information of a single period. For long term strategic decision making, changes in cost structures, market prices and capital investments etc. *may not be readily available*.

(ii) **Identification of stages:** Identifying stages in an industry's value chain is limited by the ability to locate at least one firm that participates in a specific stage. Breaking a value stage into two or more stages when an outside firm does not complete in these stages is strictly judgment.

(iii) **Ascertainment of cost, revenues and assets:** Finding the costs revenues and assets for each value chain activity poses / gives rise to serious difficulties. There is no scientific approach and much depends upon trial and error and experimentation methods.

(iv) **Identification of cost drivers:** Isolating cost drivers for each value-creating activity, identifying value chain linkages across activities and computing supplier and customer profit margins present serious challenges.

(v) **Resistance from employees:** Value chain analysis is not easily understandable to all employees and hence may face resistance from employees as well as managers.

(vi) **Science vs. Art:** Value chain analysis is not exact science. It is more "art" than preparing precise accounting reports. Certain judgments and factors of analysis are purely subjective and differ from person to person.

Question-50

Differentiate between 'Traditional Management Accounting' and 'Value Chain Analysis in the strategic framework'.

Answer

Traditional Management Accounting focuses on internal information. It often places excessive emphasis on manufacturing costs. It also assumes that cost reduction must be found in the "Value-Added" process i.e. 'Selling Price less The Cost of Raw Material'.

The Value Chain Analysis approach encompasses external and internal data, uses appropriate cost drivers for all major value-creating processes, exploits linkages throughout the value chain, and provides continuous monitoring of a firm's strategic competitive advantages.

Value Chain vs. Traditional Management Accounting

Traditional Management Accounting	Value Chain Analysis in the Strategic Framework
If focuses on internal information	Focuses on external information.
Application of single cost driver at the overall firm level is taken.	Application of multiple cost drivers i.e. structural and executional are taken for each value activity.
It assume that cost reduction must be found in the value added process.	Exploits linkages throughout the value chain i.e. within firm, with suppliers and customers.
Insights for strategic decisions somewhat limited in traditional management accounting.	Identity cost driver at the individual activity level and develop cost / differentiation advantage either by controlling those drivers better than competitors by reconfiguring the value chain.

Cost Control Vs Cost Reduction

Question-51

What is difference between Cost Control & Cost Reduction.

Answer

Cost Reduction	Cost Control
(i) Cost Reduction is the achievement	(i) Cost Control involves a comparison

	of real and permanent reduction in unit cost of products manufactured.		of actual with the standards or budgets, to regulate the actual costs.
(ii)	Realistic savings in cost.	(ii)	There could be temporary savings in cost.
(iii)	Product's Utility, Quality and Characteristics are retained.	(iii)	Quality Maintenance is not a guarantee.
(iv)	It is not concerned with maintenance of performance according to standards	(iv)	The process involves setting up a target, investing variances and taking remedial measures to correct them.
(v)	Continuous process of critical examination includes analysis and challenge of standards.	(v)	Control is achieved through compliance with standards. Standards by themselves are not examined.
(vi)	Fully dynamic approach.	(vi)	Less dynamic than Cost Reduction.
(vii)	Universally applicable to all areas of business. Does not depend upon standards, though target amounts may be set.	(vii)	Limited applicability to those items of cost for which standards can be set.
(viii)	Emphasis here is partly on present costs and largely on future costs.	(viii)	Emphasis on present and past behaviour of costs.
(ix)	The function of Cost Reduction is to find out substitute ways and new means like waste reduction, expense reduction and increased production	(ix)	Cont Control does competitive analysis of actual results with established standards.
(x)	Cost reduction is a corrective measure.	(x)	Cost Control is a preventive measure.

Question-52

Write a note on "Application of Cost Control in Material Cost"

Answer

Materials Cost is the price paid and the cost incurred by an organization in procuring materials for production. If material cost is effectively controlled we must have a proper system of material control and the following are the fundamental requirement of such a control:-

(i) Definite responsibility in respect of every function of material control should be specified and allocated.

(ii) Proper co-ordination between the various sections/departments responsible for different function should be achieved.

(iii) Purchasing function should be centralised as far as possible and entrusted to a competent person conversant with purchasing function.

(iv) Controlled procedure should be standardised ad uniform forms and documents should be used all over the organisation.

(v) To facilitate the control procedures materials requirements budget and materials purchased budget should be prepared.

(vi) Adequate provision for proper storage facilities and suitable arrangements for storing materials should be made.

(vii) A proper system of stock control should be introduced and maintained.

Question-53

Name any 10 tools and techniques for 'Cost Reduction'.

Answer

Tools and techniques for cost reduction are as under-

(i) Budgetary Control and Standard Cost

(ii) Value Analysis

(iii) Simplification and Variety Reduction

(iv) Economic Batch Quantity (E. B. Q.)

(v) Coding and Classification

(vi) Improvement in Design

(vii) Substitute Material Utilisation

(viii) Operational Research

(ix) Quality Control

(x) Production Planning and Control

(xi) Inventory Control

(xii) Purchase Scheduling

(xiii) Job evaluation and merit voting.

(xiv) Training and Development

(xv) Business Forecast

(xvi) Market Research

Just in Time

Question-54

Describe the Just-in-time systems.

Answer

A complete JIT system begins with production, includes deliveries to a company's production facilities, continues through the manufacturing plant and even includes the types of transactions processed by the accounting system.

(i) The company must ensure that *it receives it supplies on time*, preferably directly at the production facility that needs them. The company engineers must assist suppliers at their premises and ensure defect free supplies. Thus *raw material inventory is reduced* if correct quantities are delivered as per production schedules.

(ii) Long *set-up times are reduced into short ones* by eliminating inefficiency. Thus the *WIP is reduced* and so is the number of products before defects are identified.

(iii) A 'Kanban' card, which authorizes production of the right quantity by its feeder machine ensures 'pulling' the production process and elimination of inventory. Another method is the introduction of a working cell, which is a cluster of machines run by a single trained operator. This also *identifies defects quickly and reduces maintenance costs.* Both methods are used together.

(iv) *Work force is trained* to be empowered to halt operations understand more about the system, product flow, different machines and thus, elaborate reporting of a past variance is eliminated.

(v) *Suppliers may be paid based on production units adjusted for defects*.

Question-55

How to reduce excessive work-in-process inventory and defective parts in JIT System?

Answer

There are two ways to reduce excessive work-in-process inventory and defective parts in JIT System.

(i) The first involves a **'Kanban Card'** which is a notification card that a downstream machine sends to each machine that feeds it parts, authorizing the production of just enough components to fulfill the production requirements being authorized in turn by the next machine further downstream. This is also known as a "pull" system, since kanbans are initiated at the *end* of the production process, pulling work authorizations through the production system. With this approach, there is no way for work-in-process inventory to build up in the production system, since it can be created only with a kanban authorization.

(ii) The second way to reduce excessive work-in-process inventory and defective parts, is to, group machines into working cells. A working cell is a small cluster of machines which can be run by a single machine operator. This individual machine operator takes each output part from machine to machine within the cell; and thus there is no way for work-in-process to build up between machines. Also, this operator can immediately identify defective output which otherwise is difficult for each machine of the cell. This configuration has the additional benefit of lower maintenance costs since the smaller machines used in a machine cell are generally much simpler than the large, automated machinery they replace. Also, because the new machines are so small, it is much easier to reconfigure the production facility when it is necessary to produce different products, avoiding the large expense of carefully repositioning and aligning equipment.

Both kanbans and machine cells should be used together—they are not mutually exclusive. By doing so a company can achieve extremely low product defect rates, as well as vanishingly small investments in work-in-process inventory.

Question-56

How does the JIT approach help in improving an organisation's profitability?

Answer

JIT approach helps in the reduction of costs/increase in prices as follows:

(i) Immediate detection of defective goods being manufactured so that early correction is ensured with least scrapping.

(ii) Eliminates / reduces WIP between machines within working cell.

(iii) Overhead costs in the form of rentals for inventory, insurance, maintenance costs etc. are reduced.

(iv) Higher product quality ensured by the JIT approach leads to higher premium in the selling price.

(v) Detection of problem areas due to better production / scrap reporting / labour tracing and inventory accuracy lead to reduction in costs by improvement.

Question-57

Explain, how the implementation of JIT approach to manufacturing can be a major source of competitive advantage.

Answer

JIT provides competitive advantage in the following ways:

(i) Stocks of raw materials and finished goods are eliminated, stock holding costs are avoided.

(ii) JIT aims at elimination of non-value added activities and elimination of cost in this direction will improve competitive advantage.

(iii) It affords flexibility to customer requirements where the company can manufacture customized products and the competitive advantage is thereby improved.

(iv) It focuses the direction of performance based production of high quality product.

(v) It minimize waiting times and transportation costs.

Question-58

What do you mean by back-flushing in JIT system? What are the problems that must be corrected before it will work properly?

Answer

Backflushing requires no data entry of any kind until a finished product is completed. At that time the total amount finished is entered into the computer system, which multiples it by all the components listed in the bill of materials for each item produced. This yields a lengthy list of components that should have been used in the production process and which is subtracted from the beginning inventory balance to arrive at the amount of inventory that should now be left of hand. Back the entire production process. Given the large transaction volumes associated with JIT, this is an ideal solution to the problem.

The following problems must be corrected before it will work properly:

(i) Production reporting

(ii) Scrap reporting

(iii) Lot tracing

(iv) Inventory accuracy.

Manufacturing Resource Planning

Question-59

Mention the data required to operate the material requirement planning system.

Answer

Data requirements to operate material requirement planning system:

(i) **The Master Production Schedule:** This schedule specifies the quantity of each finished unit of products to be produced and the time at which each unit will be required.

(ii) **The Bill of Material File:** The bill of material file specifies the sub-assemblies, components and materials required for each of the finished goods.

(iii) **The Inventory File:** This file maintains details of items in hand for each sub-assembly, components and materials required for each of the finished goods.

(iii) **The Routing File:** This file specifies the sequence of operations required to manufacture sub-assemblies, components and finished goods.

(iv) **The Master Parts File:** This file contains information on the production time of sub-assemblies; components produced internally and lead times for externally acquired items.

Question-60

Explain the pre-requisites for successful operation of material requirement planning.

Answer

Pre-requisites for successful operation of material requirement planning are-

(i) **Strict adherence to the schedule:** The successful operation of MRP system requires a strict adherence to the latest production and purchasing schedules. Workers must be educated to understand the importance of schedule adherence, and controls should be in place to ensure this adherence.

(ii) **Accurate data base:** Data accuracy is vital to the system. If a plan is based on inaccurate data it may be impossible to adhere to the schedule. For example, if the bill of materials file is not updated to reflect any changes in product composition it will be impossible to adhere to the schedule.

Question-61

Write a note on “Requirements Explosion”.

Answer

The MRP system decides the demand for materials, components and sub assemblies at each stage of production.

Once the scheduled production starts, the output of each department is pushed through the MRP system to the next department.

From the data input, the MRP system knows:

(i) What it is expected to produce (through the MPS file)?

(ii) How it should produce it (through the BOM file)? and with

(iii) What it has to produce it (through the inventory records file)?

This programme starts with the finished goods demand (from the MRPs) and converts the demand requirements backward in time to schedule the desired production of the finished goods from raw materials and component parts with 'time phased' adjustments for lead time requirements. This process is called 'Requirements Explosion'.

Synchronous Manufacturing

Question-62

Brief the principles associated with synchronous manufacturing.

Answer

It is an all encompassing manufacturing management philosophy which includes a set of principles, procedures, and techniques where every action is evaluated in terms of common goals of the organization.

The seven principles are :

(i) Focus on synchronizing the production flow than on idle capacities.

(ii) Value of time at a bottleneck resource is equal to the throughput rate of products processed by the bottle neck.

(iii) Value of time at a non bottleneck resource is negligible.

(iv) Level of utilization of a non bottleneck resource is controlled by other constraints within the system.

(v) Resources must be utilized, not simply activated.

(vi) Transfer batch should not be equal to the process batch.

(vii) A process batch should be variable both along its route and overtime.

Throughput Accounting/ Theory of Constraints

Question-63

What are the focuses of Theory of Constraints ? How it differs with regard to cost behaviour?

Answer

The theory of constraint focuses its attention on constraints and bottlenecks within the organisation which hinder speedy production. The main concept is to maximize the rate of manufacturing output i.e. the throughput of the organisation. This requires examining the bottlenecks and constraints which are defined as:

(i) A bottleneck is an activity within the organisation where the demand for that resource is more than its capacity to supply.

(ii) A constraint is a situational factor which makes the achievement of objectives/throughput more difficult than it would otherwise be. Constraints may take several forms such as lack of skilled employees, lack of customer orders or the need to achieve a high level of quality product output.

Using above definition, therefore, a bottleneck is always a constraint but a constraints need not be a bottleneck.

The theory of constraints assumes few costs are variable–generally materials, purchased parts, piecework labour, and energy to run machines. It assumes that most direct labour and overheads are fixed. This is consistent with the idea that the shorter the time period, the more costs are fixed, and the idea that the theory of constraints focuses on the short run.

Question-64

Classify the following items under the three measures used in the theory of constraints:

(i) Research and Development Cost

(ii) Rent/Utilities

(iii) Raw materials used for production

(iv) Depreciation

(v) Labour Cost

(vi) Stock of raw materials

(vii) Sales

(viii) Cost of equipments and buildings.

Answer

The 3 key measures are :

Throughput Contribution	Raw Material for Production
	Sales
Operating Costs	Rent / Utilities
	Depreciation
	Labour
Investments	Research and Development Cost
	Raw Material Stock
	Building and Equipment Cost

SECTION - B

Total Quality Management

Problem-1

Hindustan Bikes Ltd. (HBL) formerly known as HELCO is an Indian multinational company. It's headquarter is located in Bengaluru, India. It has been founded in the year 1990 as a manufacturer of locomotives. The company is presently listed locally as well as in international stock market. HBL's parent company is Hindustan Group. The management of HBL recognizes the need to establish a culture at the company so that -

"Do the right things, right the first time, every time".

Management has provide you following actual information for the most recent month of the current year:

Cost Data ₹

Customer Support Centre Cost	*35 per hr.*
Equipment Testing Cost	*18 per hr.*
Warranty Repair Cost	*1,560 per bike*
Manufacturing Rework Cost	*228 per bike*

Volume and Activity Data

Bikes Requiring Manufacturing Rework	*3,200 bikes*
Bikes Requiring Warranty Repair	*2,600 bikes*
Production Line Equipment Testing Time	*1,600 hrs.*
Customer Support Centre Time	*2,000 hrs.*

Additional information

HBL carried out a quality review of its existing suppliers to enhance quality levels during the month at a cost of ₹1,25,000. Due to the quality issues in the month, the bike production line experienced unproductive 'down time' which cost ₹7,70,000.

Required

Prepare a statement showing 'Total Quality Cost'.

Solution

Statement Showing "Total Quality Cost"

Particulars of Costs	₹
Prevention Costs	
Supplier Review	1,25,000
Appraisal Costs	
Equipment Testing (₹18 × 1,600 hrs.)	28,800
Internal Failure Costs	
Down Time	7,70,000
Manufacturing Rework (₹228 × 3,200 bikes)	7,29,600
External Failure Costs	
Customer Support (₹35 × 2,000 hrs.)	70,000
Warranty Repair (₹1,560 × 2,600 bikes)	40,56,000
Total Quality Costs	**57,79,400**

Problem-2

NZ Ltd. implemented a quality improvement programme and had the following results:

Particulars	*2012*	*2013*
	(Figures in ₹ '000)	
Sales	*6,000*	*6,000*
Scrap	*600*	*300*
Rework	*500*	*400*
Production Inspection	*200*	*240*
Product Warranty	*300*	*150*
Quality Training	*75*	*150*
Materials Inspection	*80*	*60*

Required

(i) Classify the quality costs as prevention, appraisal, internal failure and external failure and express each class as a percentage of sales.

(ii) Compute the amount of increase in profits due to quality improvement.

Solution

(i) Statement Showing Classification of Quality Costs"

	2012		2013	
	₹ '000	% of Sales	₹ '000	% of Sales
Prevention:				
Quality Training	75	1.25%	150	2.50%
Appraisal:				
Product Inspection	200	3.33..%	240	4.00%
Materials Inspection	80	1.33..%	60	1.00%
Internal Failure:				
Scrap	600	10.00%	300	5.00%
Rework	500	8.33..%	400	6.66..%
External Failure:				
Product Warranty	300	5.00%	150	2.5
Total	1,755	29.25%	1,300	21.66..%

(ii) Cost reduction was effected by 7.583% (29.25 – 21.66..) of sales, which is an increase in profit by ₹4,54,980.

Problem-3

7 Star Sports Co. (7SSC) is engaged in the manufacture of cricket bats. Following table shows the budgeted figures for the coming year:

Particulars	***₹ per unit***
Selling Price	*4,800*
Less: Components (1 Set)	*1,200*
Assembling Costs	*2,000*
Delivery Cost	*800*
Contribution	*800*

Components like willow, rubber grip and handle bar in a set, are bought in and an assembling process carried out to transform them into a single bat. Market is intensely competitive where 7SSC currently holds 30% market share. Annual demand of these bats is 1,00,000 units.

On reviewing previous performance it is revealed that 3% of the bats supplied to customers were returned for free replacement because of faults. Defective components, which are initially bought in to assembling process, are held responsible for this. These returned bats cannot be repaired and have no scrap value. Supply of faulty bats to customers could be eliminated by implementing an inspection process immediately before the goods are delivered. This would improve customer perception thus resulting in an increase of 5% in current market share (making in all a total share of 35%).

Required

(i) Calculate the quality non-conformance cost for the coming year, based on the budgeted figures and sales returns rate.

(ii) Calculate the impact on profitability due to implementation of inspection process for the bats.

Solution

(i) Calculation of Quality Non- Conformance Cost

Annual Sales = 1,00,000 × 30%

= 30,000 units

Number of returned bats which are replaced *free of cost* = $30{,}000\text{units x } \frac{3}{97}$

= 928 units

Cost of 928 units that are replaced *free of charge* = 928 × ₹4,000

= ₹37,12,000 (A)

Contribution Lost (Market Share) due to *faulty bats* = ₹35,04,000 (B)

So, Total Quality Non-Conformance Cost [(A) + (B)] = ₹72,16,000

Statement Showing "Contribution Lost (Market Share) due to *faulty bats*"

Particulars	₹ '000
Sales (5,000 units × ₹4,800)	24,000
Less: Variable Cost [(₹1,200 units + ₹2,000 + ₹800) × 5,000 units)]	20,000
Less: Relevant Cost of *faulty bats* $\left[155\text{unitsx}\left(₹2{,}000 + ₹1{,}200\right)\right]$	496
Contribution	3,504

No. of Faulty Bats = 155 $\left(5{,}000\text{unitsx}\frac{3\%}{97\%}\right)$

☞

Quality Non-Conformance Costs are costs that are incurred by a firm as an outcome of quality failures that have occurred.

(ii) Impact on Profitability due to *implementation of inspection process*

Implementing *inspection process* before delivery to the customer would eliminate risk of supplying faulty bat to the customer. This would lead to improvement in customer perception, thus increasing market share to 35%.

Additional Contribution due to *increase in market share*	=	₹35,04,000	(C)
Saving in the Delivery Cost on 928 faulty bats	=	928 units × ₹800	
	=	₹ 7,42,400	(D)
Total Increase in Profit [(C) + (D)]	=	₹ 42,46,400	

Problem-4

Thomson Ltd. makes and sells a single product; the unit specifications are as follows:

Direct Materials X	:	*8 sq. metre at ₹ 40 per square metre*
Machine Time	:	*0.6 Running hours*
Machine cost per gross hour	:	*₹ 400*
Selling price	:	*₹ 1,000*

Thomson Ltd. requires to fulfil orders for 5,000 product units per period. There are no stock of product units at the beginning or end of the period under review. The stock level of material X remains unchanged throughout the period.

Thomson Ltd. is planning to implement a Quality Management Programme (QPM). The following additional information regarding costs and revenues are given as of now and after implementation of Quality Management Programme.

Before the implementation of QMP	***After the implementation of QMP***
5% of incoming material from suppliers scrapped due to poor receipt and storage organisation.	*Reduced to 3%.*
4% of material X input to the machine process is wasted due to processing problems.	*Reduced to 2.5%*
Inspection and storage of Material X costs ₹ 1 per square metre purchased.	*No change in the unit rate*
Inspection during the production cycle, calibration checks	*Reduction of 40% of the existing*

on inspection equipment vendor rating and other checks cost ₹ 2,50,000 per period	*cost.*
Production Qty. is increased to allow for the downgrading of 12.5% of the production units at the final inspection stage. Down graded units are sold as seconds at a discount of 30% of the standard selling price.	*Reduction to 7.5%*
Production Quantity is increased to allow for return from customers (these are replaced free of charge) due to specification failure and account for 5% of units actually delivered to customer.	*Reduction to 2.5%*
Product liability and other claims by customers is estimated at 3% of sales revenue from standard product sale.	*Reduction to 1%.*
Machine idle time is 20% of Gross machine hrs used (i.e. running hour = 80% of gross/hrs.).	*Reduction to 12.5%.*
Sundry costs of Administration, Selling and Distribution total – ₹ 6,00,000 per period.	*Reduction by 10% of the existing.*
Prevention programme costs ₹ 2,00,000	*Increase to ₹ 6,00,000.*

The Total Quality Management Programme will have a reduction in Machine Run Time required per product unit to 0.5 hr.

Required

(a) Prepare summaries showing the calculation of (i) Total production units (pre inspection), (ii) Purchase of Materials X (square metres), (iii) Gross Machine Hours.

(b) In each case, the figures are required for the situation both before and after the implementation of the Quality Management Programme so that orders for 5,000 product units can be fulfilled.

Prepare Profit and Loss Account for Thomson Ltd. for the period showing the profit earned both before and after the implementation of the Total Quality Programme.

Solution

Working Note

Particulars	Existing		After TQM Programme	
Total Production Units (Preinspection)				
Total Sales Requirements		5,000		5,000
Specification Losses	5%	250	2.5%	125
		5,250		5,125

Downgrading at Inspection	$\frac{12.5}{87.5} \times 5,250$	750	$\frac{7.5}{92.5} \times 5,125$	416
Total Units Before Inspection		6,000		5,541
Purchase of Material 'X'(Sq Mtr)				
Material Required to meet Pre Inspection Production Requirement (SqMtr)	6,000 × 8	48,000	5,541 × 8	44,328
Processing Loss	$\frac{4}{96} \times 48,000$	2,000	$\frac{2.5}{97.5} \times 44,328$	1,137
Input to the Process		50,000		45,465
Scrapped Material	$\frac{5}{95} \times 50,000$	2,632	$\frac{3}{97} \times 45,465$	1,406
Total Purchases		52,632		46,871
Gross Machine Hours				
Initial Requirements	6,000 × 0.6	3,600	5,541 × 0.5	2,771
Idle Time	$\frac{20}{80} \times 3,600$	900	$\frac{12.5}{87.5} \times 2,771$	396
Gross Time		4,500		3,167

Profit and Loss Statement

Particulars	Existing (₹)		After TQM Programme (₹)	
Sales Revenue	5,000 Units × ₹ 1,000	50,00,000	5,000 Units × ₹ 1,000	50,00,000
Sales Downgraded	750 Units × ₹ 700	5,25,000	416 Units × ₹ 700	2,91,200
		55,25,000		52,91,200
Costs:				
Material	52,632 Sq Mtr × ₹ 40	21,05,280	46,871Sq Mtr × ₹ 40	18,74,840
Inspection and Storage Costs	52,632 Sq Mtr × ₹ 1	52,632	46,871Sq Mtr × ₹ 1	46,871
Machine Cost	4,500 Hrs × ₹ 400	18,00,000	3,167 Hrs× ₹ 400	12,66,800
Inspection and Other Cost		2,50,000	₹ 2,50,000 × 60%	1,50,000
Product Liability	3% × ₹ 50,00,000	1,50,000	1% × ₹ 50,00,000	50,000
Sundry Cost of Selling, Distribution and Administration		6,00,000	₹ 6,00,000 × 90%	5,40,000
Preventive Programme Cost		2,00,000		6,00,000
		51,57,912		45,28,511
Net Profit		3,67,088		7,62,689

Activity Based Costing

Problem-5

Linex Limited manufactures three products P, Q and R which are similar in nature and are usually produced in production runs of 100 units. Product P and R require both machine hours and assembly hours, whereas product Q requires only machine hours. The overheads incurred by the company during the first quarter are as under:

	₹
Machine Department expenses……………………......................	*18,48,000*
Assembly Department expenses………………………………….	*6,72,000*
Setup costs………………………………………………………….	*90,000*
Stores receiving cost……………………………………………….	*1,20,000*
Order processing and dispatch……………………………………	*1,80,000*
Inspect and Quality control cost…………………………………	*36,000*

The date related to the three products during the period are as under:

	P	*Q*	*R*
Units produced and sold	*15,000*	*12,000*	*18,000*
Machine hours worked	*30,000 hrs.*	*48,000 hrs.*	*54,000 hrs.*
Assembly hours worked (direct labour hours)	*15,000 hrs.*	*-*	*27,000 hrs.*
Customers orders executed (in numbers)	*1,250*	*1,000*	*1,500*
Number of requisitions raised on the stores	*40*	*30*	*50*

Required

Prepare a statement showing details of overhead costs allocated to each product type using activity based costing.

Solution

Calculation of "Activity Rate"

Cost Pool	Cost (₹) [A]	Cost Driver [B]	Cost Driver Rate (₹) [C] = [A]÷[B]
Machine Department Expenses	18,48,000	Machine Hours (1,32,000 hrs.)	14.00
Assembly Department Expenses	6,72,000	Assembly Hours (42,000 hrs.)	16.00

Setup Cost	90,000	No. of Production Runs (450*)	200.00
Stores Receiving Cost	1,20,000	No. of Requisitions Raised on the Stores (120)	1,000.00
Order Processing and Dispatch	1,80,000	No. of Customers Orders Executed (3,750)	48.00
Inspection and Quality Control Cost	36,000	No. of Production Runs (450*)	80.00
Total (₹)	29,46,000		

**Number of Production Run is 450 (150 + 120 + 180)*

Statement Showing "Overheads Allocation"

Particulars of Cost	Cost Driver	P	Q	R	Total
Machine Department Expenses	Machine Hours	4,20,000 (30,000 × ₹14)	6,72,000 (48,000 × ₹14)	7,56,000 (54,000 × ₹14)	18,48,000
Assembly Department Expenses	Assembly Hours	2,40,000 (15,000 × ₹16)	---	4,32,000 (27,000 × ₹16)	6,72,000
Setup Cost	No. of Production Runs	30,000 (150 × ₹200)	24,000 (120 × ₹200)	36,000 (180 × ₹200)	90,000
Stores Receiving Cost	No. of Requisitions Raised on the Stores	40,000 (40 × ₹1,000)	30,000 (30 × ₹1,000)	50,000 (50 × ₹1,000)	1,20,000
Order Processing and Dispatch	No. of Customers Orders Executed	60,000 (1,250 × ₹48)	48,000 (1,000 × ₹48)	72,000 (1,500 × ₹48)	1,80,000
Inspection and Quality Control Cost	No. of Production Runs	12,000 (150 × ₹80)	9,600 (120 × ₹80)	14,400 (180 × ₹80)	36,000
Overhead (₹)		8,02,000	7,83,600	13,60,400	29,46,000

Problem-6

G-2020 Ltd. is a manufacturer of a range of goods. The cost structure of its different products is as follows:

Particulars	*Product A*	*Product B*	*Product C*	
Direct Materials	*50*	*40*	*40*	*₹/u*
Direct Labour @ ₹ 10/ hour	*30*	*40*	*50*	*₹/u*
Production Overheads	*30*	*40*	*50*	*₹/u*
Total Cost	*110*	*120*	*140*	*₹/u*
Quantity Produced	*10,000*	*20,000*	*30,000*	*Units*

G-2020 Ltd. was absorbing overheads on the basis of direct labour hours. A newly appointed management accountant has suggested that the company should introduce ABC system and has identified cost drivers and cost pools as follows:

Activity Cost Pool	*Cost Driver*	*Associated Cost*
Stores Receiving	*Purchase Requisitions*	*2,96,000*
Inspection	*Number of Production Runs*	*8,94,000*
Dispatch	*Orders Executed*	*2,10,000*
Machine Setup	*Number of Setups*	*12,00,000*

The following information is also supplied:

Details	*Product A*	*Product B*	*Product C*
No. of Setups	*360*	*390*	*450*
No. of Orders Executed	*180*	*270*	*300*
No. of Production Runs	*750*	*1,050*	*1,200*
No. of Purchase Requisitions	*300*	*450*	*500*

Required

Calculate activity based production cost of all the three products.

Solution

The total production overheads are ₹26,00,000:

Product A: 10,000 × ₹ 30 = ₹ 3,00,000

Product B: 20,000 × ₹ 40 = ₹ 8,00,000

Product C: 30,000 × ₹ 50 = ₹ 15,00,000

On the basis of ABC analysis this amount will be apportioned as follows:

Statement Showing "Activity Based Production Cost"

Activity Cost Pool	Cost Driver	Ratio	Total Amount (₹)	A (₹)	B (₹)	C (₹)
Stores Receiving	Purchase Requisition	6:9:10	2,96,000	71,040	1,06,560	1,18,400
Inspection	Production Runs	5:7:8	8,94,000	2,23,500	3,12,900	3,57,600
Dispatch	Orders Executed	6:9:10	2,10,000	50,400	75,600	84,000
Machine Setups	Setups	12:13:15	12,00,000	3,60,000	3,90,000	4,50,000
Total Activity Cost				7,04,940	8,85,060	10,10,000
Quantity Sold				10,000	20,000	30,000
Unit Cost (Overheads)				70.49	44.25	33.67
Add: Conversion Cost				80	80	90
Total				150.49	124.25	123.67

Problem-7

Chicago Manufacturing Co. (CMC) manufactures several product of varying levels of designs and models. It uses a single overhead recovery rate based on direct labour hours. The overheads incurred by the CMC in the half of the year are as under:

	₹
Machine operation expenses……………………………….	*10,12,500*
Machine maintenance expenses…………………………….	*1,87,500*
Salaries of technical staff…………………………………….	*6,37,500*
Wages and salaries of stores staff………………………….	*2,62,500*

During this period, CMC introduced activity based costing system and the following significant activities were identified:

— *receiving materials and components*

— *set up of machines for production runs*

— *quality inspection*

It is determined that:

— *The machine operation and machine maintenance expenses should be apportioned between stores and production activity in 20:80 ratio.*

— *The technical staff salaries should be apportioned between machine maintenance , set up and quality inspection in 30:40:30 ratio.*

The consumption of activities during the period under review are as under:

— *Direct labour hours worked 40,000*

— *Direct wage rate ₹ 6 per hour*

— *Production set-ups 2,040*

— *Material and component consignments from received from suppliers 1,960*

— *Number of quality inspections carried out 1,280*

The data relating to two product manufactured by the CMC during the period are as under:

	Product P	**Product Q**
Direct material costs (₹)	*6,000*	*4,000*
Direct labour hours	*960*	*100*
Direct material consignments received	*48*	*52*
Production runs	*36*	*24*
Number of quality inspections done	*30*	*10*
Quantity produced (units)	*15,000*	*5,000*

A potential customer has approached CMC for the supply of 24,000 units of a component K to be delivered in lots of 3,000 units per quarter. The job will involve an initial design cost of ₹ 60,000 and the manufacture will involve the following per quarter:

Direct material costs	*₹12,000*
Direct labour hours	*300*
Production runs	*6*
Inspections	*24*
Number of consignments of Direct materials to be received	*20*

CMC desires a mark up of 25% on cost.

Required

(i) Calculate the cost of product P and Q based on the existing system of single overhead recovery rate.

(ii) Determine the cost of product P and Q using activity based costing system.

(iii) Compute the sales value per quarter of component K using activity based costing system.

Solution

(i)

Statement Showing "Computation of Cost of Product P and Q"
(Based on the Existing System of 'Single Overhead Recovery Rate')

	Product P	Product Q
Units	15,000	5,000
Direct Materials Cost (₹)	6,000	4,000
Direct Labour Cost (₹)	5,760 (960 hours x ₹6)	600 (100 hours x ₹6)
Overheads (₹) (Refer to W.N. 1)	50,400 (960 hours x ₹ 52.50)	5,250 (100 hours x ₹52.50)
Total Cost of Products (₹)	62,160	9,850
Cost *per unit* (₹)	4.144 (₹ 62,160 / 15,000 units)	1.97 (₹ 9,850 / 5,000 units)

(ii)

Statement Showing Computation of Cost of Products P and Q
(Using 'Activity Based Costing System')

	Product P	Product Q
Units	15,000	5,000
Direct Materials Cost (₹)	6,000	4,000
Direct Labour Cost (₹)	5,760	600
Receiving Cost (Refer to W.N. 4)	13,243 (48 x ₹275.89)	14,346 (52 x ₹275.89)
Setup Cost (Refer to W.N. 4)	24,141 (36 x ₹670.59)	16,094 (24 x 670.59)

Inspection Cost (Refer to W.N. 4)	4,482 (30 x ₹149.41)	1,494 (10 x ₹149.41)
Total Cost of Products (₹)	53,626	36,534
Cost *per unit* (₹)	3.58 (₹53,626 /15,000 units)	7.31 (₹36,534 /5,000 units)

(iii)

Computation of Sales Value per Quarter 'Component K'
(Using 'Activity Based Costing System')

3,000 units of 'Component K' to be delivered *per quarter*	₹
Initial Design Cost *per quarter* (₹60,000 / 8 quarters)	7,500
Direct Material Cost	12,000
Direct Labour Cost (300 hours x ₹6)	1,800
Receiving Cost (20 No. of Consignment x ₹275.89)	5,518
Setup Cost (6 Production Runs x ₹670.59)	4,024
Inspection Cost (24 Inspections x ₹149.41)	3,586
Total Cost	34,428
Add: Mark up (25%of cost)	8,607
Sales Value	43,035
Selling Price *per unit* 'K' (₹43,035 / 3,000 units)	14.35

Working Notes

1. Overhead Rate per Labour Hour

$$= \frac{\text{Total Overhead Incurred by the Company in First Half Year}}{\text{Total Direct Labour Hours Worked}}$$

$$= \frac{₹21,00,000}{40,000 \text{ hours}}$$

= ₹52.50 *per labour hour*

2. Statement Showing Apportionment of 'Technical Staff Salaries' Over 'Machine Maintenance', 'Setup' and 'Quality Inspection' in the Ratio 30:40:30

	Total Salaries (₹)	Machine Maintenance (₹)	Setup (₹)	Quality Inspection (₹)
Technical Staff Salaries	6,37,500	1,91,250	2,55,000	1,91,250

3. Statement Showing Apportionment of 'Machine Operation' and 'Machine Maintenance' Between 'Stores' and 'Production Activity (Setup)'

	Total Expenses (₹)	Stores / Receiving (₹)	Setup (₹)
Machine Operation (20:80)	10,12,500	2,02,500	8,10,000
Machine Maintenance (20:80) [₹1,91,250 + ₹1,87,500] (Refer to W.N. 2)	3,78,750	75,750	3,03,000
Wages and Salaries of Stores Staff	2,62,500	2,62,500	----
Component of Setup Cost (Refer to W.N. 2)	2,55,000	----	2,55,000
Total	19,08,750	5,40,750	13,68,000

4. Rate per 'Activity Cost Driver'

	Stores / Receiving (₹)	Setup (₹)	Quality Inspection (₹)
Total Overheads (₹) ...(A)	5,40,750	13,68,000	1,91,250
Units of Activities Carried out ...(B)	1,960	2,040	1,280
Rate per Activity Cost Driver (₹) ...{(A) / (B)}	275.89	670.59	149.41

Problem-8

During the last 20 years, JPY Ltd's manufacturing operation has become increasingly automated with Computer-controlled robots replacing operators. JPY currently manufactures over 100 products of varying levels of design complexity. A single plant wise overhead absorption rate, based on direct labour hours, is used to absorb overhead costs.

In the quarter ended March, JPY's manufacturing overhead costs were:

	(₹"000)
Equipment Operation Expenses.......................................	*125*
Equipment Maintenance Expense....................................	*25*
Wages Paid to Technicians..	*85*

Wages Paid to Store Men... 35

Wages Paid to Despatch Staff.. 40

During the quarter, the company reviewed the Cost Accounting System and concluded that absorbing overhead costs to individual products on a labour hour absorption basis is meaningless. Overhead costs should be attributed to products using an Activity Based Costing (ABC) system and the following was identified as the most significant activities:

(i) Receiving component consignments from suppliers

(ii) Setting up equipment for production runs

(iii) Quality inspections

(iv) Despatching goods as per customer's orders.

During the quarter:

(i) a total of 2,000 direct labour hours were worked (paid at ₹ 12 per hr.)

(ii) 980 components consignments were received from suppliers

(iii) 1020 production runs were set up

(iv) 640 quality inspections were carried out

(v) 420 orders were dispatched to customers.

Equipment operation and maintenance expenses are apportioned as:

- *Component stores 15% , manufacturing 70% and goods dispatch 15% Technician's wages are apportioned as:*
- *Equipment maintenance 30% , set up equipment for production runs 40% and quality inspections 30%*

JPY's production during the quarter included components R, S and T. The following information is available:

	Component R	***Component S***	***Component T***
Direct Material	*₹ 1,200*	*₹ 2,900*	*₹ 1,800*
Direct Labour Hrs worked	*25*	*480*	*50*
Component Consignments Recd.	*42*	*24*	*28*
Production Runs	*16*	*18*	*12*
Quality Inspections	*10*	*8*	*18*
Orders (goods) Despatched	*22*	*85*	*46*
Quantity Produced	*560*	*12,800*	*2,400*

Required

(i) *Calculate the unit cost of R, S and T components, using JPY's existing cost accounting system.*

(ii) *Explain how an ABC system would be developed using the information given. Calculate the unit cost of components R, S and T using ABC system.*

Solution

(i) Single Factory Direct Labour Hour Overhead Rate = $\frac{₹\ 3,10,000}{2,000}$

= ₹ 155 per Direct Labour Hour

Computation of Unit Cost (Existing System)

	R (₹)	S (₹)	T (₹)
Direct Labour Cost @ ₹ 12 per Hour	300	5,760	600
Direct Material	1,200	2,900	1,800
Overheads (Direct Labour Hours × ₹ 155 per Hour)	3,875	74,400	7,750
Total Cost	5,375	83,060	10,150
Quantity Produced (No.s)	560	12,800	2,400
Cost *per unit*	9.60	6.49	4.23

(ii) ABC system involves the following stages,

— Identifying the major activities that take place in an organisation.

— Creating a cost pool /cost centre for each activity.

— Determining the cost driver for each activity.

— Assigning the cost of activities to cost objects (e.g. products, components, customers etc).

The most significant activities have been identified e.g. receiving components consignments from suppliers, setting up equipment for production runs, quality inspections, and despatching orders to customers. The following shows the assignment of the costs to these activities.

(₹, 000)

Particulars	Receiving Supplies	Setups	Quality Inspection	Despatch	Total
Equipment Operation Expenses	18.75	87.50	----	18.75	125.00
Maintenance	3.75	17.50	----	3.75	25.00
Technicians Wages [Initially allocated to Maintenance(30% of ₹ 85,000) and then reallocated on same basis on Maintenance]	3.83	17.85	----	3.82	25.50
Balance of Technicians Wages (Allocated to Setups and Quality Inspections)	----	34.00	25.50	----	59.50
Stores Wages - Receiving	35.00	----	----	----	35.00
Despatch Wages - Despatch	----	----	----	40.00	40.00
Total	61.33	156.85	25.50	66.32	310.00

Equipment operation expenses and Maintenance allocated on the basis 15%,70% and 15% as specified in the problem.

The next stage is to identify the cost drivers for each activity and establish cost driver rates by dividing the activity costs by a measure of cost driver usage for the period. The calculations are as follows:-

Receiving Supplies $\left[\frac{₹61,330}{980\text{Consignments}}\right]$ = ₹ 62.58 per Consignment

Performing Setups $\left[\frac{₹1,56,850}{1,020\text{ProductionRuns}}\right]$ = ₹ 153.77 per Setup

Despatching Goods $\left[\frac{₹66,320}{420\text{Orders}}\right]$ = ₹ 157.90 per Despatch

Quality Inspection $\left[\frac{₹25,500}{640\text{Inspections}}\right]$ = ₹ 39.84 per Quality Inspection

Finally, costs are assigned to components based on their cost driver usage. The assignments are as follows:

Particulars of Costs	R (₹)	S (₹)	T (₹)
Direct Labour	300.00	5,760.00	600.00
Direct Materials	1,200.00	2,900.00	1,800.00
Receiving Supplies	2,628.36	1,501.92	1,752.24
Performing Setups	2,460.32	2,767.86	1,845.24
Quality Inspections	398.40	318.72	717.12
Despatching Goods	3,473.80	13,421.50	7,263.40
Total Costs	10,460.88	26,670.00	13,978.00
No of Units Produced	560	12,800	2,400
Cost *per unit*	18.68	2.08	5.82

For components, the overhead costs have been assigned as follows:

Particulars	Component R	Component S	Component T
Receiving Supplies	₹ 2,628.36 (42 Receipts at ₹ 62.58)	₹ 1,501.92 (24 Receipts at ₹ 62.58)	₹1,752.24 (28 Receipts at ₹ 62.58)
Performing Setups	₹2,460.32 (16 Production Runs at ₹ 153.77)	₹2,767.86 (18 Production Runs at ₹ 153.77)	₹1,845.24 (12 Production Runs at ₹ 153.77)
Quality Inspections	₹398.40 (10 Inspections at ₹ 39.84)	₹318.72 (8 Inspections at ₹ 39.84)	₹717.12 (18 Inspections at ₹ 39.84)
Despatching Goods	₹3,473.80 (22 Orders at ₹ 157.90)	₹13,421.50 (85 Orders at ₹ 157.90)	₹7,263.40 (46 Orders at ₹ 157.90)

Problem-9

Super Food Ltd. Manufactures 3 types of biscuits, A, B and C, in a fully mechanised factory. The company has been following conventional method of costing and wishes to shift to Activity Based Costing System and therefore wishes to have the following data presented under both the systems for the month.

Inspection Cost	*₹ p.m.*	*73,000*
Machine – Repairs & Maintenance	*₹ p.m.*	*1,42,000*
Dye Cost	*₹ p.m.*	*10,250*
Selling Overheads	*₹ p.m.*	*1,62,000*

	Product A	*Product B*	*Product C*
Prime Cost (₹ per unit)	*12*	*9*	*8*
Selling Price (₹ per unit)	*18*	*14*	*12*
Gross Production (units / production run)	*2,520*	*2,810*	*3,010*
No. of Defective (units / production run)	*20*	*10*	*10*
Inspection: No. of Hours / Production Run	*3*	*4*	*4*
Dye Cost / Production Run (₹)	*200*	*300*	*250*
No. of Machine Hours / Production Run	*20*	*12*	*30*
Sales – No. of Units / Month	*25,000*	*56,000*	*27,000*

The following additional information is given:

(i) *No accumulation of inventory is considered. All good units produced are sold.*

(ii) *All manufacturing and selling overheads are conventionally allocated on the basis of units sold.*

(iii) *Product A needs no advertisement. Due to its nutritive value, it is readily consumed by diabetic patients of a hospital. Advertisement costs included in the total selling overhead is ₹ 83,000.*

(iv) *Product B needs to be specially packed before being sold, so that it meets competition. ₹ 54,000 was the amount spent for the month in specially packing B, and this has been included in the total selling overhead cost given.*

Required

Present product wise profitability of statements under the conventional system and the ABC system and accordingly rank the products.

Solution

Statement Showing "Gross Margin"

Particulars	**A**	**B**	**C**	**Total**
Sales Units	25,000	56,000	27,000	1,08,000
Selling Price *per unit*	18	14	12	
Sales Value (₹) …(A)	4,50,000	7,84,000	3,24,000	15,58,000
Prime Cost Overhead	12	9	8	

No. of Units *per run*		2,520	2,810	3,010	
Prime Cost (₹)	…(B)	3,02,400	5,05,800	2,16,720	
Gross Margin	…(A) - (B)	1,47,600	2,78,200	1,07,280	5,33,080

Statement Showing "Production & Selling Overheads"

Particulars	A	B	C	Total
Inspection Cost $\left(\frac{73,000}{146} \times 30/80/36 \text{ respectively}\right)$	15,000	40,000	18,000	73,000
Machine Maintenance $\left(\frac{1,42,000}{710} \times 200/240/270 \text{ respectively}\right)$	40,000	48,000	54,000	1,42,000
Dye Cost	2,000	6,000	2,250	10,250
Production Overheads	57,000	94,000	74,250	2,25,250
Advertisement $\left(\frac{83,000}{56,000 + 27,000} \times 56/27 \text{ respectively}\right)$	----	56,000	27,000	83,000
Packing	----	54,000	----	54,000
Other Overheads $\left(\frac{25,000}{108} \times 25/56/27 \text{ respectively}\right)$	5,787	12,963	6,250	25,000
Selling Overheads	5,787	1,22,963	33,250	1,62,000

Workings

No.	Particulars	A	B	C	Total
(1)	Gross Production (unit /run)	2,520	2,810	3,010	
(2)	Defectives / Run	20	10	10	
(3)	Good Units / Run	2,500	2,800	3,000	
(4)	Sales (goods units)	25,000	56,000	27,000	
(5)	No. of Runs	10	20	9	
(6)	Gross Production …(1 × 5)	25,200	56,200	27,090	

(7)	Prime Cost / Unit	12	9	8	
(8)	Prime Cost (₹)	3,02,400	5,05,800	2,16,720	10,24,920
(9)	Inspection Hours / Run	3	4	4	
(10)	Inspection Hours ...(9 × 5)	30	80	36	146
(11)	M/c Hours / Run	20	12	30	
(12)	M/c Hours ...(11 × 5)	200	240	270	710
(13)	Dye Cost / Run	200	300	250	
(14)	Dye Cost ...(13 × 5)	2,000	6,000	2,250	10,250

"Statement Showing Rank - Conventional Accounting System"

Particulars	**A**	**B**	**C**	**Total**
Sales – Units / Production (good units)	25,000	56,000	27,000	1,08,000
Gross Margin (₹) ...(A)	1,47,600	2,78,200	1,07,280	5,33,080
Production Overheads (₹)	52,141	1,16,797	56,313	2,25,250
Selling Overheads (₹)	37,500	84,000	40,500	1,62,000
Sub-Total Overheads (₹) ...(B)	89,641	2,00,797	96,813	3,87,250
Net Profit (₹) ...(A) – (B)	57,959	77,403	10,467	1,45,830
Ranking	II	I	III	

Statement Showing "Rank - Activity Based System"

Particulars	**A**	**B**	**C**	**Total**
Sales – Units / Production (good units)	25,000	56,000	27,000	1,08,000
Gross Margin (₹) ...(A)	1,47,600	2,78,200	1,07,280	5,33,080
Production Overheads (₹)	57,000	94,000	74,250	2,25,250
Selling Overheads (₹)	5,787	1,22,963	33,250	1,62,000
Sub-Total Overheads (₹) ...(B)	62,787	2,16,963	1,07,500	3,87,250
Net Profit (₹) ...(A) – (B)	84,813	61,237	(220)	1,45,830
Ranking	I	II	III	

Problem-10

'Humara - Apna' bank offers three products, viz., deposits, Loans and Credit Cards. The bank has selected 4 activities for a detailed budgeting exercise, following activity based costing methods.

The bank wants to know the product wise total cost per unit for the selected activities, so that prices may be fixed accordingly.

The following information is made available to formulate the budget:

Activity	***Present Cost (₹)***	***Estimation for the budget period***
ATM Services:		
(a) Machine Maintenance	*4,00,000*	*All fixed, no change.*
(b) Rents	*2,00,000*	*Fully fixed, no change.*
(c) Currency Replenishment Cost	1,00,000	*Expected to double during budget period.*
	7,00,000	*(This activity is driven by no. of ATM transactions)*
Computer Processing	*5,00,000*	*Half this amount is fixed and no change is expected.* *The variable portion is expected to increase to three times the current level.* *(This activity is driven by the number of computer transactions)*
Issuing Statements	*18,00,000*	*Presently, 3 lac statements are made. In the budget period, 5 lac statements are expected.* *For every increase of one lac statement, one lac rupees is the budgeted increase.* *(This activity is driven by the number of statements)*
Computer Inquiries	*2,00,000*	*Estimated to increase by 80% during the budget period.* *(This activity is driven by telephone minutes)*

The activity drivers and their budgeted quantifies are given below:

Activity Drivers	*Deposits*	*Loans*	*Credit Cards*
No. of ATM Transactions	*1,50,000*	*---*	*50,000*
No. of Computer Processing Transactions	*15,00,000*	*2,00,000*	*3,00,000*
No. of Statements to be issued	*3,50,000*	*50,000*	*1,00,000*
Telephone Minutes	*3,60,000*	*1,80,000*	*1,80,000*

The bank budgets a volume of 58,600 deposit accounts, 13,000 loan accounts, and 14,000 Credit Card Accounts.

Required

(i) *Calculate the budgeted rate for each activity.*

(ii) *Prepare the budgeted cost statement activity wise.*

(iii) *Find the budgeted product cost per account for each product using (i) and (ii) above.*

Solution

Statement Showing "Budgeted Cost *per unit* of the Product"

Activity	Activity Cost (Budgeted) (₹)	Activity Driver	No. of Units of Activity Driver (Budget)	Activity Rate (₹)	Deposits	Loans	Credit Cards
ATM Services	8,00,000	No. of ATM Transaction	2,00,000	4.00	6,00,000	---	2,00,000
Computer Processing	10,00,000	No. of Computer Transaction	20,00,000	0.50	7,50,000	1,00,000	1,50,000
Issuing Statements	20,00,000	No. of Statements	5,00,000	4.00	14,00,000	2,00,000	4,00,000
Customer Inquiries	3,60,000	Telephone Minutes	7,20,000	0.50	1,80,000	90,000	90,000
Budgeted Cost	41,60,000				29,30,000	3,90,000	8,40,000
Units of Product (as estimated in the budget period)					58,600	13,000	14,000
Budgeted Cost *per unit* of the product					50	30	60

Working Note

Activity	Budgeted Cost (₹)	Remark
ATM Services:		
(a) Machine Maintenance	4,00,000	– All fixed, no change.
(b) Rents	2,00,000	– Fully fixed, no change.
(c) Currency Replenishment Cost	2,00,000	– Doubled during budget period.
Total	8,00,000	
Computer Processing	2,50,000	– ₹2,50,000 (half of ₹5,00,000) is fixed and no change is expected.
	7,50,000	– ₹2,50,000 (variable portion) is expected to increase to three times the current level.
Total	10,00,000	
Issuing Statements	18,00,000	– Existing.
	2,00,000	– 2 lac statements are expected to be increased in budgeted period. For every increase of one lac statement, one lac rupees is the budgeted increase.
Total	20,00,000	
Computer Inquiries	3,60,000	– Estimated to increase by 80% during the budget period. (₹2,00,000 x 180%)
Total	3,60,000	

Problem-11

Bank of HK operated for years under the assumption that profitability can be increased by increasing Rupee volumes. But that has not been the case. Cost analysis has revealed the following:

Activity	*Activity Cost (₹)*	*Activity Driver*	*Activity Capacity*
Providing ATM Service	*1,00,000*	*No. of Transactions*	*2,00,000*
Computer Processing	*10,00,000*	*No. of Transactions*	*25,00,000*

Issuing Statements	*8,00,000*	*No. of Statements*	*5,00,000*
Customer Inquiries	*3,60,000*	*Telephone Minutes*	*6,00,000*

The following annual information on three products was also made available:

Activity Driver	***Checking Accounts***	***Personal Loans***	***Gold Visa***
Units of Product	*30,000*	*5,000*	*10,000*
ATM Transactions	*1,80,000*	*0*	*20,000*
Computer Transactions	*20,00,000*	*2,00,000*	*3,00,000*
Number of Statements	*3,00,000*	*50,000*	*1,50,000*
Telephone Minutes	*3,50,000*	*90,000*	*1,60,000*

Required

(i) *Calculate rates for each activity.*

(ii) *Using the rates computed in requirement (i), calculate the cost of each product.*

Solution

Statement Showing "Activity Rate"

Activity	**Activity Cost [a] (₹)**	**Activity Driver**	**No. of Units of Activity Driver [b]**	**Activity Rate [a] / [b] (₹)**
Providing ATM Service	1,00,000	No. of ATM Transactions	2,00,000	0.50
Computer Processing	10,00,000	No. of Computer Transactions	25,00,000	0.40
Issuing Statements	8,00,000	No. of Statements	5,00,000	1.60
Customer Inquiries	3,60,000	Telephone Minutes	6,00,000	0.60

Statement Showing "Cost of Product"

Activity	**Checking Accounts (₹)**	**Personal Loans (₹)**	**Gold Visa (₹)**
Providing ATM Service	90,000 (1,80,000 tr.×₹ 0.50)	---	10,000 (20,000 tr. × ₹ 0.50)
Computer Processing	8,00,000 (20,00,000 tr. × ₹ 0.40)	80,000 (2,00,000 tr. × ₹ 0.40)	1,20,000 (3,00,000 tr. × ₹ 0.40)

Issuing Statements	4,80,000 (3,00,000 st. × ₹ 1.60)	80,000 (50,000 st. × ₹ 1.60)	2,40,000 (1,50,000 st. × ₹ 1.60)
Customer Inquiries	2,10,000 (3,50,000 min. × ₹ 0.60)	54,000 (90,000 min. × ₹ 0.60)	96,000 (1,60,000 min. × ₹ 0.60)
Total Cost [a]	₹ 15,80,000	₹ 2,14,000	₹ 4,66,000
Units of Product [b]	30,000	5,000	10,000
Cost of each Product [a] / [b]	52.67	42.80	46.60

Problem-12

DEO Limited sells two versions: Deluxe and Premium of its only product GoGo Juicer. The GoGo Juicer uses patented technology to extract the last drop of juice from most fruits. The 'Premium' version can handle larger fruit and has more options relative to the 'Deluxe' version. The following table provides the financial results of the most recent year of operations:

Particulars	***Deluxe 90,000 units***	***Premium 10,000 units***	***Total 1,00,000 units***
Revenue (₹)	*63,00,000*	*9,00,000*	*72,00,000*
Material cost (₹)	*10,80,000*	*2,50,000*	*13,30,000*
Direct labour cost (₹)	*14,40,000*	*1,60,000*	*16,00,000*
Contribution margin (₹)	*37,80,000*	*4,90,000*	*42,70,000*
Allocated fixed manufacturing overhead (₹)	*34,20,000*	*3,80,000*	*38,00,000*
Allocated fixed selling and administrative overheads (₹)	*2,51,563*	*35,937*	*2,87,500*
Profit margin (₹)	*1,08,437*	*74,063*	*1,82,500*
Profit margin per unit (₹)	*1.2048*	*7.4063*	

Labour cost is ₹ 16 per hour and each product requires one hour of labour. The company currently allocates all fixed manufacturing overheads, using labour hours as the allocation basis. It allocates fixed selling and administrative overheads, using revenue as the allocation base.

Although the profit margin per unit of 'Deluxe' juicer is rather low, DEO Limited believes that it is important to keep this model in the product mix. However, DEO can tailor its promotion and *sales strategies to improve the sales mix to 16:4 ratio from the current 9:1 ratio of 'Deluxe' to 'Premium' juicers, with total volume staying at 1,00,000 units.*

DEO Limited finds that ₹ 1.1 million of the ₹ 3.8 million of fixed manufacturing overheads pertains to batch related activities such as scheduling production runs. Similarly, ₹ 1,15,000 is the amount of administrative overheads out of the ₹ 2,87,500 of selling and administrative overheads.

It is found that the 'premium' juicer is produced in smaller batches (250 units per batch) than that of 'Deluxe' juicer (500 units per batch). Similarly, it takes 10 sales visits to sell 1,000 units of the 'Deluxe' juicer, while it takes 25 visits to sell 1,000 units of 'Premium' juicer.

Required

(i) Prepare a profitability statement based on the proposed sales mix, using the most appropriate basis of allocating fixed overheads. (In absence of an appropriate basis, do not allocate overheads to products)

(ii) Advise the company on whether it should go ahead with the propose change in sales mix.

Solution

(i) Profitability Statement New Mix - Most Appropriate Basis

Particulars	Deluxe		Premium		Total (₹)
	80,000 Units		20,000 Units		
	P.U. (₹)	Amount (₹)	P.U. (₹)	Amount (₹)	
Revenue	70.00	56,00,000.00	90.00	18,00,000.00	74,00,000.00
Material Cost	12.00	9,60,000.00	25.00	5,00,000.00	14,60,000.00
Direct Labour Cost [One hour per unit; (80,000 hrs., 20,000 hrs.)]	16.00	12,80,000.00	16.00	3,20,000.00	16,00,000.00
Contribution Margin	42.00	33,60,000.00	49.00	9,80,000.00	43,40,000.00
Unit Related Fixed Mfg. Overheads [Allocation on the basis of direct labour hours (80,000:20,000); (W.N.1)]		21,60,000.00		5,40,000.00	27,00,000.00

Particulars	Deluxe 80,000 Units P.U. (₹)	Deluxe 80,000 Units Amount (₹)	Premium 20,000 Units P.U. (₹)	Premium 20,000 Units Amount (₹)	Total (₹)
Batch Related Fixed Mfg. Overheads [Allocation on the basis of no. of batches (160:80); (W.N. 1 & 4)]		7,33,333.33		3,66,666.67	11,00,000.00
Fixed Selling Overheads [Allocated on the basis of sales visits (800:500); (W.N. 2 & 3)]		1,06,153.85		66,346.15	1,72,500.00
Profit Margin Ex Admin Overheads		3,60,512.82		6,987.18	3,67,500.00
Admin Overheads [W.N. 2]					1,15,000.00
Profit Margin					2,52,500.00

Working Note

W.N.1

Fixed Mfg. Overheads	38,00,000.00
Less: Related to *batch related activities*	11,00,000.00
Fixed Mfg. Overheads – *unit related*	27,00,000.00

W.N.2

Selling & Admn. Overheads	2,87,500.00
Less: Admn. Overheads	1,15,000.00
Selling Overheads	1,72,500.00

W.N.3

No. of Visits	10 Sales Visit for 1,000 Units (Deluxe)	25 Sales Visit for1,000 Units (Premium)	Total
For Proposed Mix - Sales Visit	800	500	1,300

W.N.4

No. of Batches	**1 Batch for 500 Units (Deluxe)**	**1 Batch for 250 Units (Premium)**	**Total**
For Proposed Mix - Batches	160	80	240

(ii) Change in product mix, yields profit of ₹ 70,000/- (₹ 2,52,500 - ₹ 1,82,500). Accordingly company should go with proposed change mix.

This problem can be solved by assuming that some portion of the fixed cost as fixed with respect to units of production, but variable with respect to certain activities. When the production size is altered, these activities are increased and therefore, the activity cost varies for the proposed production level. More batches of production and more sales visits will set off the incremental contribution.

Problem-13

Asian Mfg. Co. had decided to increase the size of the store. It wants the information about the probability of the individual product lines : Lemon, Grapes and Papaya. It provides the following data for the 2013 for each product line:

Particulars	***Lemon***	***Grapes***	***Papaya***
Revenues (₹)	*79,350*	*2,10,060*	*1,20,990*
Cost of goods sold (₹)	*60,000*	*1,50,000*	*90,000*
Cost of bottles returned (₹)	*1,200*	*0*	*0*
Number of purchase orders placed	*36*	*84*	*36*
Number of deliveries received	*30*	*219*	*66*
Hours of shelf stocking time	*54*	*540*	*270*
Items sold	*12,600*	*1,10,400*	*30,600*

Asian Mfg. Co. also provides the following information for the year 2013:

Activity	***Description of Activity***	***Total Costs (₹)***	***Cost Allocation Basis***
Bottle returns	*Returning of empty bottles to the store*	*1,200*	*Direct tracing to product line*

Ordering	*Placing of orders of purchases*	*15,600*	*156 purchase orders*
Delivery	*Physical delivery and the receipts of merchandise*	*25,200*	*315 deliveries*
Self stocking	*Stocking of merchandise on store shelves and ongoing restocking*	*17,280*	*864 hours of time*
Customer support	*Assistance provided to customers including bagging and checkout*	*30,720*	*1,53,600 items sold*

Required

(i) Asian Mfg. Co. currently allocates store support costs (all costs other than the cost of goods sold) to the product line on the basis of the cost of goods sold of each product line. Calculate the operating income and operating income as the percentage of revenue of each product line.

(ii) If Asian Mfg. Co. allocates store support costs (all costs other than the cost of goods sold) to the product lines on the basis of ABC system, calculate the operating income and operating income as the percentage of revenue of each product line.

(iii) Compare both the systems.

Solution

(i) Traditional Costing System

Operating Income-

Particulars	Lemon	Grapes	Papaya	Total
Revenue	79,350	2,10,060	1,20,990	4,10,400
Less: Cost of Goods Sold	60,000	1,50,000	90,000	3,00,000
Less: Store Support Cost	18,000	45,000	27,000	90,000
Operating Income	1,350	15,060	3,990	20,400
Operating Income (%)	1.70	7.17	3.30	4.97

(ii) ABC System

Overhead Allocation Rate-

Activity	Total Costs (₹)	Quantity of Cost Allocation Base	Overhead Allocation Rate (₹)
Ordering	15,600	156 Purchase Orders	100.00
Delivery	25,200	315 Delivering Orders	80.00
Shelf Stocking	17,280	864 Self Stocking Hours	20.00
Customer Support	30,720	1,53,600 Items Sold	0.20

Store Support Cost-

Particulars	Cost Driver	Lemon	Grapes	Papaya	Total
Bottle Returns	Direct	1,200	0	0	1,200
Ordering	Purchase Orders	3,600	8,400	3,600	15,600
Delivery	Deliveries	2,400	17,520	5,280	25,200
Self Stocking	Hours of time	1,080	10,800	5,400	17,280
Customer Support	Items Sold	2,520	22,080	6,120	30,720
Grand Total		10,800	58,800	20,400	90,000

Operating Income-

Particulars	Lemon	Grapes	Papaya	Total
Revenue	79,350	2,10,060	1,20,990	410,400
Less: Cost of Goods Sold	60,000	1,50,000	90,000	300,000
Less: Store Support Cost	10,800	58,800	20,400	90,000
Operating Income	8,550	1,260	10,590	20,400
Operating Income (%)	10.78	0.60	8.75	4.97

(iii) Comparison

Particulars	Lemon	Grapes	Papaya	Total
Under Traditional Costing System	1.70%	7.17%	3.30%	4.97%
Under ABC System	10.78%	0.60%	8.75%	4.97%

The grapes line drops sizeably when ABC is used. Although it constitutes 50 % of 'Cost of Goods Sold (COGS)', it uses a higher percentage of total resources in each activity area, especially the high cost of customer support area. In contrast, lemon line draws a much lower percentage of total resources used in each activity area than its percentage of total COGS. Hence under ABC, Lemon is most profitable. Fruitolay can explore ways to increase sales of lemons and also explore price increases on grapes.

Operating Income Ranking is highest for Grapes under Traditional System because other products bear its overhead cost, whereas under ABC a more accurate picture shows Grapes as the lowest ranking product.

Problem-14

Golden North Ltd. manufactures four products, namely A, B, C and D using the same plant and process. The following information relates to a production period:

	Product A	***Product B***	***Product C***	***Product D***
Output in units	*720*	*600*	*480*	*504*
Cost per unit:	*₹*	*₹*	*₹*	*₹*
Direct Material	*42*	*45*	*40*	*48*
Direct Labour	*10*	*9*	*7*	*8*
Machine hours per unit	*4 hrs.*	*3 hrs.*	*2 hrs.*	*1 hr.*

The four products are similar and are usually produced in production runs of 24 units and sold in batches of 12 units. Using machine hour rate currently absorbs the production overheads. The total overheads incurred by the company for the period is as follows:

Machine operation and maintenance cost (₹)	*63,000*
Setup costs (₹)	*20,000*
Store receiving (₹)	*15,000*
Inspection (₹)	*10,000*
Material handling and dispatch(₹)	*2,592*

During the period the following cost drivers are to be used for the overhead cost:

Activity	***Cost Driver***
Setup cost	*No. of production runs*
Store receiving	*Requisition raised*
Inspection	*No. of production runs*
Material handling and dispatch	*Orders executed*

It is also determined that:

— *Machine operation and maintenance cost should be apportioned between setup cost, store receiving and inspection activity in 4:3:2.*

— *Number of requisition raised on store is 50 for each product and the no. of order executed is 192, each order being for a batch of 12 of a product.*

Required

(i) *Calculate the total cost of each product, if all overhead costs are absorbed on machine hour rate basis.*

(ii) *Calculate the total cost of each product using activity base costing.*

(iii) *Comment briefly on differences disclosed between overhead traced by present system and those traced by activity based costing.*

Solution

(i) Overhead Absorption on Machine Hour Basis

Statement Showing "Total Cost of Products"

Particulars	**A** (₹)	**B** (₹)	**C** (₹)	**D** (₹)
Direct Material	42	45	40	48
Direct Labour	10	09	07	08
Overheads	72	54	36	18
Cost of Production *per unit*	124	108	83	74
Output in units	720	600	480	504
Total Cost	89,280	64,800	39,840	37,296

[6,144 Machine Hours (720 units × 4 hrs. + 600 units × 3 hrs. + 480 units × 2 hrs. + 504 units × 1 hrs.)]

Rate *per hour* = $\frac{₹1,10,592}{6,144 \text{ hours}}$ = ₹18 *per hour*

(ii) Activity Based Costing System

Statement Showing "Allocation of Machine Operation and Maintenance Cost"

Particulars	**Setup**	**Receiving**	**Inspection**
Machine Operation and Maintenance Cost of ₹ 63,000 to be distributed in the ratio of 4: 3: 2	28,000	21,000	14,000

Statement Showing "Activities/ Drivers/ Cost"

Activity	Cost (₹)	Drivers	Nos	Cost *per unit* of Driver (₹)
Setup	48,000	Production Runs	96	500.00
Store Receiving	36,000	Requisitions Raised	200	180.00
Inspection	24,000	Production Runs	96	250.00
Material Handling and Disp.	2,592	Orders	192	13.50

Note:

Production Run for A (720/24) = 30

B (600/24) = 25

C (480/24) = 20

D (504/24) = 21

Statement Showing "Total Cost of Products"

Particulars of Costs	A (₹)	B (₹)	C (₹)	D (₹)
Direct Material	30,240	27,000	19,200	24,192
Direct Labour	7,200	5,400	3,360	4,032
Setup	15,000 $\left[\frac{720units}{24units} x ₹500\right]$	12,500 $\left[\frac{600units}{24units} x ₹500\right]$	10,000 $\left[\frac{480units}{24units} x ₹500\right]$	10,500 $\left[\frac{504units}{24units} x ₹500\right]$
Store Receiving	9,000 $[50 Req. x ₹180]$	9,000 $[50 Req. x ₹180]$	9,000 $[50 Req. x ₹180]$	9,000 $[50 Req. x ₹180]$
Inspection	7,500 $\left[\frac{720units}{24units} x ₹250\right]$	6,250 $\left[\frac{600units}{24units} x ₹250\right]$	5,000 $\left[\frac{480units}{24units} x ₹250\right]$	5,250 $\left[\frac{504units}{24units} x ₹250\right]$
Material Handling and Dispatch	810 $\left[\frac{720units}{12units} x ₹13.5\right]$	675 $\left[\frac{600units}{12units} x ₹13.5\right]$	540 $\left[\frac{480units}{12units} x ₹13.5\right]$	567 $\left[\frac{504units}{12units} x ₹13.5\right]$
Total Cost	69,750	60,825	47,100	53,541
Cost *per unit*	96.875	101.375	98.125	106.23

(iii)

Particulars	**A (₹)**	**B (₹)**	**C (₹)**	**D (₹)**
Cost per unit (Traditional) ...(a)	124.00	108.00	83.00	74.00
Cost per unit (ABC) ...(b)	96.88	101.38	98.13	106.23
Difference ...(b) – (a)	(27.12)	(6.62)	15.13	32.23

The total overheads which are spread over the four products have been apportioned on different bases, causing the product cost to differ substantially: in respect of product A and D a change from traditional machine hour rate to an activity system may have effect on price and profits to the extent that pricing is based on cost plus approach.

Problem-15

Woolmark Ltd. manufactures three types of products namely P, Q and R. The data relating to a period are as under:

Particulars	***P***	***Q***	***R***
Machine hours per unit	*10*	*18*	*14*
Direct Labour hours per unit @ ₹ 20	*4*	*12*	*8*
Direct Material per unit (₹)	*90*	*80*	*120*
Production (units)	*3,000*	*5,000*	*20,000*

Currently the company uses traditional costing method and absorbs all production overheads on the basis of machine hours. The machine hour rate of overheads is ₹ 6 per hour.

The company proposes to use activity based costing system and the activity analysis is as under:

Particulars	***P***	***Q***	***R***
Batch size (units)	*150*	*500*	*1,000*
Number of purchase orders per batch	*3*	*10*	*8*
Number of inspections per batch	*5*	*4*	*3*

The total production overheads are analysed as under:

Machine set up costs.. 20%

Machine operation costs.. 30%

Inspection costs………………………………………………. 40%

Material procurement related costs………………………. 10%

Required

(i) *Calculate the cost per unit of each product using traditional method of absorbing all production overheads on the basis of machine hours.*

(ii) *Calculate the cost per unit of each product using activity based costing principles.*

Solution

(i) Statement Showing "Cost *per unit* - Traditional Method"

Particulars of Costs	**P** (₹)	**Q** (₹)	**R** (₹)
Direct Materials	90	80	120
Direct Labour [(4, 12, 8 hours) × ₹20]	80	240	160
Production Overheads [(10, 18, 14 hours) × ₹6]	60	108	84
Cost *per unit*	230	428	364

(ii) Statement Showing "Cost *per unit* - Activity Based Costing"

Products	**P**	**Q**	**R**
Production (units)	3,000	5,000	20,000
	(₹)	(₹)	(₹)
Direct Materials (90, 80, 120)	2,70,000	4,00,000	24,00,000
Direct Labour (80, 240, 160)	2,40,000	12,00,000	32,00,000
Machine Related Costs @ ₹1.80 *per hour* (30,000, 90,000, 2,80,000)	54,000	1,62,000	5,04,000
Setup Costs @ ₹9,600 *per setup* (20, 10, 20)	1,92,000	96,000	1,92,000
Inspection Costs @ ₹4,800 *per inspection* (100, 40, 60)	4,80,000	1,92,000	2,88,000
Purchase Related Costs @ ₹750 *per purchase* (60, 100, 160)	45,000	75,000	1,20,000
Total Costs	12,81,000	21,25,000	67,04,000
Cost *per unit* (Total Cost ÷ Units)	427.00	425.00	335.20

Workings

Number of Batches, Purchase Orders, and Inspections-

	Particulars	P	Q	R	Total
A.	Production (units)	3,000	5,000	20,000	
B.	Batch Size (units)	150	500	1,000	
C.	Number of Batches [A ÷ B]	20	10	20	50
D.	Number of Purchase Order *per batch*	3	10	8	
E.	Total Purchase Orders [C × D]	60	100	160	320
F.	Number of Inspections *per batch*	5	4	3	
G.	Total Inspections [C × F]	100	40	60	200

Total Machine Hours-

	Particulars	P	Q	R
A.	Machine Hours *per unit*	10	18	14
B.	Production (units)	3,000	5,000	20,000
C.	Total Machine Hours [A × B]	30,000	90,000	2,80,000

Total Machine Hours = 4,00,000

Total Production Overheads-

= 4,00,000 hrs. × ₹ 6

= ₹ 24,00,000

Cost Driver Rates-

Cost Pool	%	Overheads (₹)	Cost Driver (Units)	Cost Driver Rate (₹)
Setup	20%	4,80,000	50	9,600 per Setup
Inspection	40%	9,60,000	200	4,800 per Inspection
Purchases	10%	2,40,000	320	750 per Purchase
Machine Hours	30%	7,20,000	4,00,000	1.80 per Machine Hour

Problem-16

The following are Product Alpha's data for next year budget:

Activity	*Cost Driver*	*Cost Driver Volume / Year*	*Cost Pool (₹)*
Purchasing	*Purchase orders*	*1,500*	*75,000*
Setting	*Batches produced*	*2,800*	*1,12,000*
Materials handling	*Materials movements*	*8,000*	*96,000*
Inspection	*Batches produced*	*2,800*	*70,000*
Machining costs	*Machine hours*	*50,000*	*1,50,000*

Purchase orders………………………… 25

Output…………………………………… 15,000 units

Production batch size………………….. 100 units

Materials movements per batch………. 6

Machine hours per unit………………… 0.1

Required

(i) Calculate the budgeted overhead costs using activity based costing principles.

(ii) Calculate the budgeted overhead costs using absorption costing (absorb overhead using machine hours).

(iii) How can the company reduce the ABC for Product Alpha?

Solution

(i) 'Budgeted Overhead Costs' using 'Activity Based Costing'

Computation of **'Cost *per unit* of Cost Driver'**

Activity	Cost Driver	Cost Pool [(a)]	Cost Driver Volume / Yr [(b)]	Cost / Unit of Cost Driver [(a) / (b)]
Purchasing	Purchase Orders	₹ 75,000	1,500	₹ 50 per Purchase Order
Setting	Batches Produced	₹ 112,000	2,800	₹ 40 per Batch

Materials Handling	Material Movements	₹ 96,000	8,000	₹ 12 per Movement
Inspection	Batches Produced	₹ 70,000	2,800	₹ 25 per Batch
Machining	Machine Hours	₹ 150,000	50,000	₹ 3 per Machine Hour

Computation of the '**Volume of Cost Drivers**' consumed by 'Product Alpha'

Purchase Orders (given) = 25

Batches (15,000 / 100) = 150

Materials Movement (150 batches × 6) = 900

Machine Hours (15,000 units × 0.1) = 1,500

Computation of the '**Overheads Cost**' for 'Product Alpha'

Activity	**Cost Driver**	**Costing Rate / Cost Driver Unit (₹)**	**Overhead Cost (₹)**
Purchasing	Purchase Orders	50	₹1,250 (25 Order × ₹50)
Setting	Batches Produced	40	₹6,000 (150 Batches × ₹ 40)
Material Handling	Material Movements	12	₹10,800 (900 Movement × ₹12)
Inspection	Batches Produced	25	₹ 3,750 (150 Batches × ₹ 25)
Machining	Machine Hours	3	₹ 4,500 (1,500 Hours × ₹ 3)
Total			₹ 26,300

(ii) 'Budgeted Overheads Costs' using 'Absorption Costing'

Budgeted Overheads = ₹ 503,000

(₹ 75,000 + ₹ 96,000 + ₹ 112,000 + ₹ 70,000 + ₹ 150,000)

Budgeted Absorption Cost per Machine Hour = ₹10.06

(₹503,000 / 50,000 Hours)

Budgeted Machining Hours for Product Alpha = 1,500 hrs.

Budgeted Absorbed Overhead (1,500 hrs. × ₹ 10.06) = ₹15,090

(iii) Ways in which the company can reduce the ABC for 'Product Alpha'

- Reduce the number of batches by increasing the batch size which will then reduce the setting up overhead, materials handling and inspection costs.
- Reduce the number of purchase orders.
- Innovate ways of speeding up production so that the machining hours are reduced.

Target Costing

Problem-17

NEC Ltd. manufactures two parts 'P' and 'Q' for Computer Industry.

P : Annual production and sales of 1,00,000 units at a selling price of ₹ 100.05 per unit.

Q : Annual production and sales of 50,000 units at a selling price of ₹ 150 per unit.

Direct and Indirect costs incurred on these two parts are as follows:

(₹ in thousand)

Particulars of Costs	P	Q	Total
Direct Material Cost (Variable)	4,200	3,000	7,200
Labour Cost (Variable)	1,500	1,000	2,500
Direct Machining Cost (See Note)*	700	550	1,250
Indirect Costs			
Machine Setup Cost			462
Testing Cost			2,375
Engineering Cost			2,250

Note: Direct machining costs represents the cost of machine capacity dedicated to the production of each product. These costs are fixed and are not expected to vary over the long-run horizon.

Additional information is as follows:

	P	Q
Production Batch Size	1,000 units	500 units
Set-up Time per batch	30 hours	36 hours
Testing Time per unit	5 hours	9 hours
Engineering Cost incurred on each product	8.40 lakhs	14.10 lakhs

A foreign competitor has introduced product very similar to 'P'. To maintain the company's share and profit, NEC Ltd. has to reduce the price to ₹ 86.25. The company calls for a meeting and comes up with a proposal to change design of product 'P'. The expected effect of new design is as follows:

— *Direct Material cost is expected to decrease by ₹ 5 per unit.*

— *Labour cost is expected to decrease by ₹ 2 per unit.*

— *Machine time is expected to decrease by 15 minutes, previously it took 3 hours to produce 1 unit of 'P'. The machine will be dedicated to the production of new design.*

— *Set up time will be 28 hours for each set up.*

— *Time required for testing each unit will be reduced by 1 hour.*

— *Engineering cost and batch size will be unchanged.*

Required

(i) *Company management identifies that cost driver for Machine set-up costs is 'Set up hours used in batch setting' and for testing costs is 'testing time'. Engineering costs are assigned to products by special study. Calculate the full cost per unit for 'P' and 'Q' using Activity-Based Costing.*

(ii) *What is the Mark-up on full cost per unit of P?*

(iii) *What is the Target Cost per unit for new design to maintain the same markup percentage on full cost per unit as it had earlier? Assume cost per unit of cost drives for the new design remains unchanged.*

(iv) *Will the new design achieve the cost reduction target?*

(v) *List four possible management actions that the NEC Ltd. should take regarding new design.*

Solution

Working Notes

Particulars		**P**	**Q**
(a)	Production / Sales Quantity (units)	1,00,000	50,000
(b)	Batch Size (units)	1,000	500
(c)	No. of Batches …(a ÷ b)	100	100
(d)	Setup Time per Batch (hours)	30	36

(e)	Total Setup Hours (hours)	…(c × d)	3,000	3,600
(f)	Machine Setup Cost ₹ 4,62,000			
(g)	Cost Driver per Machine Setup Hour = $\frac{₹4,62,000}{6,600\text{hours}} = ₹70$			
(h)	Testing Time per Unit (hours)		5	9
(i)	Total Testing Time (hours)	…(a × h)	5,00,000	4,50,000
(j)	Testing Cost ₹23,75,000			
(k)	Cost Driver per Testing Hour = $\frac{₹23,75,000}{9,50,000\text{hours}} = ₹2.50$			

(i) Statement Showing "Cost *per unit*- Activity Based Costing"

Particulars of Costs	**Basis**	**P**	**Q**
Direct Material	Direct	42,00,000	30,00,000
Direct Labour	Direct	15,00,000	10,00,000
Direct Machine Cost	Direct	7,00,000	5,50,000
Machine Setup Cost	3,000 hrs. @ ₹70	2,10,000	----
	3,600 hrs. @ ₹70	----	2,52,000
Testing Cost	5,00,000 hrs. @ ₹2.50	12,50,000	----
	4,50,000 hrs. @ ₹2.50	----	11,25,000
Engineering Cost	Allocated	8,40,000	14,10,000
Total Cost (₹)		87,00,000	73,37,000
Cost *per unit* (₹)		87.00	146.74

(ii) Statement Showing "Mark-up *(full cost basis)*- Product P"

Particulars	**Per unit**
Selling Price	100.05
Less: Full Cost	87.00
Markup	13.05
Percentage of Markup on Full Cost $\left[\frac{13.05}{87.00} \text{x}100\right]$	15%

(iii) Statement Showing "Target Cost of Product P"

(After New Design is Implemented)

Particulars	**(₹)**
Target Price (given)	86.25
Mark-up $\left[\frac{86.25}{115.00} x15\right]$	11.25
Target Cost *per unit*	75.00

(iv) Statement Showing "Cost of P (New Design)"

Particulars of Costs	**Basis of Costs**	**Rate***	**Total Cost**
Direct Material	Decrease by ₹ 5 p.u.	37.00	37,00,000
Direct Labour	Decrease by ₹ 2 p.u.	13.00	13,00,000
Direct Machining Cost	No Change as Machine is Dedicated	7.00	7,00,000
Machine Setup Cost	100 Setup × 28 hrs. × ₹ 70	1.96	1,96,000
Testing Cost	1,00,000 units × ₹ 2.50 × 4 hrs.	10.00	10,00,000
Engineering Cost	No Change	8.40	8,40,000
Total Cost		77.36	77,36,000

* *Rate per unit*

The target cost is ₹ 75 p.u. and estimated cost (new design) is ₹ 77.36 p.u. The new design does not achieve the target cost set by NEC Ltd. Hence the target mark up shall not be achieved.

(v) Possible Management Action

— Value engineering and value analysis to reduce the direct material costs.

— Time and motion study in order to redefine the direct labour time and related costs.

— Exploring possibility of cost reduction in direct machining cost by using appropriate techniques.

— Identification of non-value added activities and eliminating them in order to reduce overheads.

— The expected selling price based on estimated cost of ₹ 77.36 per unit is (₹ 77.36 +15%) ₹ 88.96. Introduce sensitivity analysis after implementation of new design to study the sales quantity changes in the price range of ₹ 86.25 to ₹ 88.96.

Problem-18

Ice-Cream Ltd. is engaged in production of three types of ice-cream products: Coco, Strawberry and Vanilla. The company presently sells 50,000 units of Coco @ ₹ 25 per unit, Strawberry 20,000 @ ₹ 20 per unit and Vanilla 60,000 units @ ₹ 15 per unit. The demand is sensitive to selling price and it has been observed that every reduction of ₹ 1 per unit in selling price, increases the demand for each product by 10% to the previous level. The company has the production capacity of 60,500 units of Coco, 24,200 units of Strawberry and 72,600 units of Vanilla. The company marks up 25% on cost of the product.

The Company management decides to apply ABC analysis. For this purpose it identifies four activities and the rates as follows:

Activity	*Cost Rate*
Ordering……………………………………….	*₹ 800 per purchase order*
Delivery………………………………………	*₹ 700 per delivery*
Shelf stocking…………………………………	*₹ 199 per hour*
Customer support and assistance…………..	*₹ 1.10 p.u. sold*

The other relevant information for the products are as follows:

Particulars	*Coco*	*Strawberry*	*Vanilla*
Direct Material p.u. (₹)	*8*	*6*	*5*
Direct Labour p.u. (₹)	*5*	*4*	*3*
No. of Purchase Orders	*35*	*30*	*15*
No. of Deliveries	*112*	*66*	*48*
Shelf Stocking Hours	*130*	*150*	*160*

Under the traditional costing system, store support costs are charged @ 30% of prime cost. In ABC these costs are coming under customer support and assistance.

Required

(i) Calculate target cost for each product after a reduction of selling price required to achieve the sales equal to the production capacity.

(ii) Calculate the total cost and unit cost of each product at the maximum level using traditional costing.

(iii) Calculate the total cost and unit cost of each product at the maximum level using activity based costing.

(iv) Compare the cost of each product calculated in (i) and (ii) with (iii) and comment on it.

Solution

(i) Cost of Products Under 'Target Costing'

Statement Showing "Demanded Unit and Selling Price"

Coco		Strawberry		Vanilla	
Selling Price	Demand	Selling Price	Demand	Selling Price	Demand
25	50,000	20	20,000	15	60,000
24	55,000	19	22,000	14	66,000
23	60,500	18	24,200	13	72,600

Statement Showing "Cost *per unit*"

Particulars	Coco	Strawberry	Vanilla
Selling Price after reduction	23.00	18.00	13.00
Profit Mark up 25% on Cost (20 % on Selling Price)	4.60	3.60	2.60
Target Cost of Production (per unit)	18.40	14.40	10.40

(ii) Cost of Product Under 'Traditional Costing'

Statement Showing "Cost *per unit*"

Particulars	Coco (₹)	Strawberry (₹)	Vanilla (₹)
Units	60,500	24,200	72,600
Material Cost *per unit*	8.00	6.00	5.00
Labour Cost *per unit*	5.00	4.00	3.00
Prime Cost *per unit*	13.00	10.00	8.00
Store Support Costs (30% of Prime)	3.90	3.00	2.40
Cost *per unit*	16.90	13.00	10.40

(iii) Cost of Product Under 'Activity Based Costing'

Statement Showing "Cost *per unit*"

Particulars	Coco (₹)	Strawberry (₹)	Vanilla (₹)
Units	60,500	24,200	72,600
Material Cost	4,84,000	1,45,200	3,63,000
Labour Cost	3,02,500	96,800	2,17,800
Prime Cost	7,86,500	2,42,000	5,80,800
Ordering Cost @ ₹ 800 (35, 30, 15)	28,000	24,000	12,000
Delivery Cost @ ₹ 700 (112, 66, 48)	78,400	46,200	33,600
Shelf Stocking @ ₹ 199 (130,150,160)	25,870	29,850	31,840
Customer Support ₹ 1.10	66,550	26,620	79,860
Total Cost	9,85,320	3,68,670	7,38,100
Cost Per unit	16.29	15.23	10.17

(iv) Comparative Analysis of 'Cost of Production'

Particulars	Coco (₹)	Strawberry (₹)	Vanilla (₹)
(a) As per Target Costing	18.40	14.40	10.40
(b) As per Traditional Costing	16.90	13.00	10.40
(c) As per Activity Based Costing	16.29	15.23	10.17
(a) – (c)	2.11	(-) 0.83	0.23
(b) – (c)	0.61	(-) 2.23	0.23

Comment

The cost of product of strawberry is higher in ABC method in comparison to target costing and traditional methods. It indicated that actual profit under ABC is less than targeted. For remaining two products, ABC is most suitable.

Problem-19

Transnet Ltd. is engaged in the production of four products: A, B, C and D. The price charged for the four products are ₹ 180, ₹ 175, ₹ 130 and ₹ 180 respectively, Market research has *indicated that if Transnet Ltd can reduce the selling prices of its products by ₹ 5, it will be successful in getting bulk orders and gain a significant share of market of those products. The company's profit markup is 25 per cent on cost of the product. The relevant information of products are as follows:*

Products	***A***	***B***	***C***	***D***
Output in units	*600*	*500*	*400*	*600*
Cost per unit -				
Direct material (in ₹)	*40*	*50*	*30*	*60*
Direct labour (in ₹)	*28*	*21*	*14*	*21*
Machine hours (per unit)	*4*	*3*	*2*	*3*

The four products are usually produced in production runs of 20 units and sold in batches of 10 units. The production overhead is currently absorbed by using a machine hour rate, and the total of the production overheads for the period has been analysed as follows:

	(₹)
Machine department costs	*52,130*
Setup costs	*26,250*
Stores receiving	*18,000*
Inspection / Quality control	*10,500*
Material handling and dispatch	*23,100*

The cost drivers to be used for the overhead costs are as follows:

Cost	*Cost drivers*
Setup costs	*Number of production runs*
Store receiving	*Requisitions raised*
Inspection / Quality control	*Number of production runs*
Materials handling and dispatch	*Order executed*

The number of requisitions raised in the stores was 100 for each product and the number of orders executed was 210, each order being for a batch of 10 units of a product.

Required

(i) To compute the target cost for each product.

(ii) To compute total cost of each product using activity based costing.

(iii) *Compare target cost and activity based cost of each product and comment whether the price reduction is profitable or not.*

Solution

(i) Statement Showing "Target Cost of Product A, B, C, D"

Product	Present Price (₹)	Proposed Price (₹)	Target Cost (₹) (with 25% Margin)
A	180	175	140
B	175	170	136
C	130	125	100
D	180	175	140

(ii) Statement Showing "Cost/unit of Driver- ABC'

Cost	Amount	Driver	No.	Cost / unit of Driver (₹)
Setups	26,250	Production Runs	105	250.00
Stores Receiving	18,000	Requisition	400	45.00
Inspection / Quality	10,500	Production Runs	105	100.00
Handling / Dispatch	23,100	Orders	210	110.00
Machine Department	52,130	Machine Hrs.	6,500	8.02

Production Runs = 105

$$\left[\frac{600\text{units}}{20\text{units}}+\frac{500\text{units}}{20\text{units}}+\frac{400\text{units}}{20\text{units}}+\frac{600\text{units}}{20\text{units}}\right]$$

No. of Requisitions = 400

[100 for each product]

Machine Hours = 6,500 hours

[600 units x 4 hrs. + 500 units x 3 hrs. + 400 units x 2 hrs. + 600 units x 3 hrs.]

No. of Orders = 210

$$\left[\frac{600\text{units}}{10\text{units}}+\frac{500\text{units}}{10\text{units}}+\frac{400\text{units}}{10\text{units}}+\frac{600\text{units}}{10\text{units}}\right]$$

Statement Showing "Total Cost & Cost *per unit*- ABC"

Particulars of Costs	A (₹)	B (₹)	C (₹)	D (₹)
Direct Material	24,000	25,000	12,000	36,000
Direct Labour	16,800	10,500	5,600	12,600
Setup	7,500 [30Runsx₹250]	6,250 [25Runsx₹250]	5,000 [20Runsx₹250]	7,500 [30Runsx₹250]
Stores Receiving	4,500 [100Req.x₹45]	4,500 [100Req.x₹45]	4,500 [100Req.x₹45]	4,500 [100Req.x₹45]
Inspection / Quality	3,000 [30Runsx₹100]	2,500 [25Runsx₹100]	2,000 [20Runsx₹100]	3,000 [30Runsx₹100]
Handling / Dispatch	6,600 [60Ordersx₹110]	5,500 [50Ordersx₹110]	4,400 [40Ordersx₹110]	6,600 [60Ordersx₹110]
Machine Dept. Cost	19,248 [2,400hrs.x₹8.02]	12,030 [1,500hrs.x₹8.02]	6,416 [800hrs.x₹8.02]	14,436 [1,800hrs.x₹8.02]
Total Cost	81,648	66,280	39,916	84,636
Output (Units)	600	500	400	600
Cost *per unit*	136.08	132.56	99.79	141.06

(iii) Statement Showing "Target Cost Vs Actual Cost"

Cost	A (₹)	B (₹)	C (₹)	D (₹)
Actual	136.08	132.56	99.79	141.06
Target	140.00	136.00	100.00	140.00
Difference	(-) 3.92	(-) 3.44	(-) 0.21	(+) 1.06

Comment

The total actual cost of A, B and C product is less than the target cost so there is no problem in reducing the cost of these product by ₹ 5 from the present price. It will increase the profitability of the company but the cost of D is slightly more than the target cost, it is therefore, suggested that the company should either control it or redesign it.

Life Cycle Costing

Problem-20

P & G International Ltd. (PGIL) has developed a new product "K" which is about to be launched into the market and anticipates to sell 80,000 of these units at a sales price of ₹300 over the product's life cycle of four years. Data pertaining to product "K" are as follows:

Costs of Design and Development of Molds, Dies, and Other Tools	*₹8,25,000*
Manufacturing Costs	*₹125 per unit*
Selling Costs	*₹12,500 per year + ₹100 per unit*
Administration Costs	*₹50,000 per year*
Warranty Expenses	*5 Replacement Parts per 25 units at ₹10 per part ; 1 Visit per 500 units (Cost ₹ 500 per visit)*

Required

(i) Compute the product "K"'s 'Life Cycle Cost'.

(ii) Suppose PGIL can increase sales volume by 25% through 10% reduction in selling price. Should PGIL choose the lower price?

Solution

(i) Statement Showing "K's Life Cycle Cost (80,000 units)"

Particulars	Amount (₹)
Costs of Design and Development of Molds, Dies, and Other Tools	8,25,000
Manufacturing Costs (₹125 × 80,000 units)	1,00,00,000
Selling Costs (₹100 × 80,000 units + ₹12,500 × 4)	80,50,000
Administration Costs (₹50,000 × 4)	2,00,000
Warranty	
(80,000 units / 25 units × 5 parts × ₹10)	1,60,000
(80,000 units / 500 units × 1 visit × ₹500)	80,000
Total Cost	1,93,15,000

(ii) **Statement Showing "K's Life Cycle Cost (1,00,000 units)"**

Particulars	Amount (₹)
Costs of Design and Development of Molds, Dies, and Other Tools	8,25,000
Manufacturing Costs (₹125 × 1,00,000 units)	1,25,00,000
Selling Costs (₹100 × 1,00,000 units + ₹12,500 × 4)	1,00,50,000
Administration Costs (₹50,000 × 4)	2,00,000
Warranty (1,00,000 units / 25 units × 5 parts × ₹10) (1,00,000 units / 500 units × 1 visit × ₹500)	 2,00,000 1,00,000
Total Cost	2,38,75,000

Statement Showing "K's Life Time Profit"

Particulars	Amount (₹) 80,000 units	Amount (₹) 100,000 units
Sales	2,40,00,000 (80,000 × ₹300)	2,70,00,000 (1,00,000 × ₹270)
Less: Total Cost	1,93,15,000	2,38,75,000
Profit	46,85,000	31,25,000

Decision

Reducing the price by 10% will decrease profit by 33% (₹15,60,000). Therefore, PGIL should not cut the price.

Problem-21

Y-Connections, China based firm, has just developed ultra-thintablet S-5 with few features like the ability to open two apps at the same time. This tablet cost ₹ 5,00,000 to develop; it has undergone extensive research and is ready for production. Currently, the firm is deciding on plant capacity, which could cost either ₹ 35,00,000 or ₹ 52,00,000. The additional outlay would allow the plant to increase capacity from 500 units to 750 units. The relevant data for the life cycle of the tablet at different capacity level are as under:

Expected Sales	*500 units*	*750 units*
Sale Price	*₹79,600 per unit*	*₹69,600 per unit*
Variable Selling Costs	*10% of Selling Price*	*10% of Selling Price*
Salvage Value - Plant	*₹ 6,25,000*	*₹ 9,00,000*
Profit Volume Ratio	*40%*	

Required

Advise Y-Connections, regarding the 'Optimal Plant Capacity' to install. The tablet's life cycle is two years.

Note: Ignore the time value of money.

Solution

Workings

Statement Showing "Variable Manufacturing Cost *per unit*"

Particulars of Costs	₹ / unit
Sales	79,600
Less: Contribution (40%)	31,840
Variable Cost	47,760
Less: Variable Selling Costs (₹79,600 × 0.1)	7,960
Variable Manufacturing Cost	39,800

Statement Showing "Expected Profit"

Particulars of Costs	('000) ₹ / unit	
	500 units	750 units
Sales	39,800 (₹79,600 × 500)	52,200 (₹69,600 × 750)
Less: Variable Mfg. Cost	19,900 (₹39,800 × 500)	29,850 (₹39,800 × 750)
Less: Variable Selling Cost	3,980 (₹39,800 × 0.1)	5,220 (₹52,200 × 0.1)
Add: Salvage Value	625	900
Less: Cost of Plant	3,500	5,200
Net Profit	13,045	12,830

Development cost is sunk and is not relevant.

Advice

Based on the above 'Expected Profit' statement which is purely based on *financial considerations* firm may go for high price – low volume i.e. 500 units level. However, *non-financial considerations* are also given due importance as they account for actions that may not contribute directly to profits in the short run but may contribute significantly to profits in long run. Here, it is important to note that life cycle of product is two years and there is no significant difference between the profits at both levels. In this scenario firm may opt the plant having high capacity not only to increase its market share but also to establish a long term brand image.

Problem-22

Great Eastern Appliances Ltd. (GEAL) manufactures consumer durable products in a very highly competitive market. GEAL is considering launching a new product 'Kitchen Care' into the market and gathered the following data:

Expected Market Price	*₹5,000 per unit*
Direct Material Cost	*₹1,850 per unit*
Direct Labour Cost	*₹80 per hour*
Variable Overhead Cost	*₹1,000 per unit*
Packing Machine Cost (specially to be purchased for this product)	*₹5,00,000*

GEAL expects the selling price for the new product will continue throughout the product's life and a total of 1,000 units can be sold over the entire lifetime of the product.

Direct labour costs are expected to reduce as the volume of output increases due to the effects of 80% learning curve (index is -0.3219). The expected time to be taken for the first unit is 30 hours and the learning effect is expected to end after 250 units have been produced. Units produced after first 250 units will take the same time as the 250th unit.

Required

(i) Calculate the expected total labour hours over the life time of the product 'Kitchen Care'.

(ii) Profitability of product 'Kitchen Care' that GEAL will earn over the life time of the product.

(iii) Average target labour cost per unit over the life time of the product if GEAL requires average profit of ₹ 800 per unit, to achieve its long term objectives.

Note: $250^{-0.3219} = 0.1691$, $249^{-0.3219} = 0.1693$

Solution

(i) Calculation of 'Total Labour Hours' over the Life Time of the Product 'Kitchen Care'

The average time per unit for 250 units is

$$Y_x = ax^b$$
$$Y_{250} = 30 \times 250^{-0.3219}$$
$$Y_{250} = 30 \times 0.1691$$
$$Y_{250} = 5.073 \text{ hours}$$

Total time for 250 units = 5.073 hours × 250 units

= 1,268.25 hours

The average time per unit for 249 units is

Y_{249} = $30 \times 249^{-0.3219}$

Y_{249} = 30 × 0.1693

Y_{249} = 5.079 hours

Total time for 249 units = 5.079 hours × 249 units

= 1,264.67 hours

Time for 250th unit = 1,268.25 hours – 1,264.67 hours

= 3.58 hours

Total Time for 1,000 units = (750 units × 3.58 hours) + 1,268.25 hours

= 3,953.25 hours

(ii) Profitability of the Product 'Kitchen Care'

Particulars	Amount (₹)	Amount (₹)
Sales (1,000 units)		50,00,000
Less: Direct Material	18,50,000	
Direct Labour (3,953.25 hours × ₹ 80)	3,16,260	
Variable Overheads (1,000 units× ₹1,000)	10,00,000	31,66,260
Contribution		18,33,740
Less: Packing Machine Cost		5,00,000
Profit		13,33,740

(iii) Average 'Target Labour Cost' *per unit*

Particulars	Amount (₹)
Expected Sales Value	50,00,000
Less: Desired Profit (1,000 units × ₹ 800)	8,00,000
Target Cost	42,00,000
Less: Direct Material (1,000 units × ₹ 1,850)	18,50,000
Variable Cost (1,000 units × ₹ 1,000)	10,00,000
Packing Machine Cost	5,00,000
Target Labour Cost	8,50,000
Average Target Labour Cost *per unit* (₹ 8,50,000 ÷ 1,000 units)	850

Problem-23

P & G International Ltd. (PGIL) has developed a new product 'α^3 'which is about to be launched into the market. Company has spent ₹ 30,00,000 on R&D of product 'α^3 '. It has also bought a machine to produce the product 'α^3 ' costing ₹ 11,25,000 with a capacity of producing 1,100 units per week. Machine has no residual value.

The company has decided to charge price that will change with the cumulative numbers of units sold:

Cumulative Sales (units)	Selling Price ₹ per unit
0 to 2,200	750
2,201 to 7,700	600
7,701 to 15,950	525
15,951 to 59,950	450
59,951 and above	300

Based on these selling prices, it is expected that sales demand will be as shown below:

Weeks	Sales Demand per week (units)
1-10	220
11-20	550
21-30	825
31-70	1,100
71-80	880
81-90	660
91-100	440
101-110	220
Thereafter	NIL

Unit variable costs are expected to be as follows:

	₹ per unit
First 2,200 units	375
Next 13,750 units	300
Next 22,000 units	225
Next 22,000 units	188
Thereafter	225

PGIL uses just-in-time production system. Following is the total contribution statement of the product 'α³ ' for its Introduction and Growth phase:

	Introduction	*Growth*	
Weeks	*1 - 10*	*11 - 30*	
Number of units Produced and Sold	*2,200*	*5,500*	*8,250*
Selling Price per unit (₹)	*750*	*600*	*525*
Variable Cost per unit (₹)	*375*	*300*	*300*
Contribution per unit (₹)	*375*	*300*	*225*
Total Contribution (₹)	*8,25,000*	*16,50,000*	*18,56,250*

Required

(i) Prepare the total contribution statement for each of the remaining two phases of the product's life cycle.

(ii) Discuss Pricing Strategy of the product 'α³ '.

(iii) Find possible reasons for the changes in cost during the life cycle of the product 'α³ '.

Note: Ignore the time value of money.

Solution

(i) Total Contribution Statement

Statement Showing "Total Contribution- for remaining two phases"

Particulars	Maturity		Decline
Weeks	31 - 50	51 - 70	71 - 110
Number of units Produced and Sold	22,000	22,000	22,000
Selling Price per unit (₹)	450	450	300
Less: Unit Variable Cost (₹)	225	188	225
Unit Contribution (₹)	225	262	75
Total Contribution (₹)	49,50,000	57,64,000	16,50,000

(ii) Pricing Strategy for Product α³

PGIL is following the skimming price strategy that's why it has planned to launch the product α³ initially with high price tag.

A skimming strategy may be recommended when a firm has incurred large sums of money on research and development for a new product.

In the problem, PGIL has incurred a huge amount on research and development. Also, it is very difficult to start with a low price and then raise the price. Raising a low price may annoy potential customers.

Price of the product α^3 is decreasing gradually stage by stage. This is happening because PGIL wants to tap the mass market by lowering the price.

(iii) Possible Reasons for the changes in cost during the life cycle of the product 'α^3'

Product life cycle costing involves tracing of costs and revenues of each product over several calendar periods throughout their entire life cycle. Possible reasons for the changes in cost during the life cycle of the product are as follows:

PGIL is expecting reduction in unit cost of the product α^3 over the life of product as a consequence of economies of scale and learning / experience curves.

Learning effect may be the possible reason for reduction in per unit cost if the process is labour intensive. When a new product or process is started, performance of worker is not at its best and learning phenomenon takes place. As the experience is gained, the performance of worker improves, time taken per unit reduces and thus his productivity goes up. The amount of improvement or experience gained is reflected in a decrease in cost.

Till the stage of maturity, PGIL is in the expansion mode. The PGIL may be able to take advantages of quantity discount offered by suppliers or may negotiate the price with suppliers.

Product α^3 has the least variable cost ₹188 in last phase of maturity stage; this is because a product which is in the mature stage may require less marketing support than a product which is in the growth stage so, there is a saving of marketing cost per unit.

Again the cost per unit of the product α^3 jumps to ₹225 in decline stage. As soon as the product reaches its decline stage, the need or demand for the product disappear and quantity discount may not be available. Even PGIL may have to incur heavy marketing expenses for stock clearance.

Workings

Statement of Cumulative Sales along with Sales Price and Variable Cost

Weeks	Demand *per week*	Total Sales	Cumulative Sales	Selling Price per unit (₹)	Variable Cost per unit (₹)
1 - 10	220	2,200	2,200	750	375
11 - 20	550	5,500	7,700	600	300
21 - 30	825	8,250	15,950	525	300

31 - 50	1,100	22,000	37,950	450	225
51 - 70	1,100	22,000	59,950	450	188
71 - 80	880	8,800	68,750	300	225
81 - 90	660	6,600	75,350	300	225
91 - 100	440	4,400	79,750	300	225
101 - 110	220	2,200	81,950	300	225

Just In Time

Problem-24

United Video International Company (UVIC) sells package of blank video tapes to its customer. It purchases video tapes from Indian Tape Company (ITC) @ ₹ 140 a package. ITC pays all freight to UVIC. No incoming inspection is necessary because ITC has a superb reputation for delivery of quality merchandise. Annual demand of UVIC is 13,000 packages. UVIC requires 15% annual return on investment. The purchase order lead time is two weeks. The purchase order is passed through Internet and it costs ₹ 2 per order. The relevant insurance, material handling etc ₹ 3.10 per package per year. UVIC has to decide whether or not to shift to JIT purchasing. ITC agrees to deliver 100 packages of video tapes 130 times per year (5 times every two weeks) instead of existing delivery system of 1,000 packages 13 times a year with additional amount of ₹ 0.02 per package. UVIC incurs no stock out under its current purchasing policy. It is estimated UVIC incurs stock out cost on 50 video tape packages under a JIT purchasing policy. In the event of a stock out, UVIC has to rush order tape packages which costs ₹ 4 per package. Comment whether UVIC should implement JIT purchasing system.

Hindustan Tape Company (HTC) also supplies video tapes. It agrees to supply @ ₹ 136 per package under JIT delivery system. If video tape purchased from HTC, relevant carrying cost would be ₹ 3 per package against ₹ 3.10 in case of purchasing from ITC. However HTC. doesn't enjoy so sterling a reputation for quality. UVIC anticipates following negative aspects of purchasing tapes from HTC.

— *To incur additional inspection cost of 5 paisa per package.*

Average stock out of 360 tapes packages per year would occur, largely resulting from late deliveries. HTC cannot rush order at short notice. UVIC anticipates lost contribution margin per package of ₹ 8 from stock out.

— *Customer would likely return 2% of all packages due to poor quality of the tape and to handle this return an additional cost of ₹ 25 per package.*

Required

Comment whether UVIC places order to HTC.

Solution

(i) Comparative 'Statement of Cost' *for*

Purchasing from ITC under 'Current Policy' & 'JIT'

Particulars	**Current Policy** (₹)	**JIT** (₹)
Purchasing Cost	18,20,000 (13,000 Packages × ₹140)	18,20,260 (13,000 Packages × ₹140.02)
Ordering Cost	26.00 (₹2 × 13 Orders)	260.00 (₹2 ×130 Orders)
Opportunity / Carrying Cost	10,500.00 (1/2 × 1,000 Packages × ₹140 × 15%)	1,050 (1/2 × 100 Packages × ₹ 140.02 × 15%)
Other Carrying Cost (Insurance, Material Handling etc)	1,550.00 (1/2 × 1,000 Packages × ₹3.10)	155.00 (1/2 × 100 Packages × ₹3.10)
Stock Out Cost	---	200 (50 Packages × ₹4.00)
Total Relevant Cost	18,32,076	18,21,925

Comments

As may be seen from above, the relevant cost under the JIT purchasing policy is lower than the cost incurred under the existing system. Hence, a JIT purchasing policy should be adopted by the company.

(ii) 'Statement of Cost' for Purchasing from HTC under 'JIT'

Particulars	**JIT** (₹)
Purchasing Cost	17,68,000 (13,000 Packages × ₹136)
Ordering Cost	260.00 (₹2 ×130 Orders)

Opportunity / Carrying Cost	1,020 (1/2 × 100 Packages × ₹ 136 × 15%)
Other Carrying Cost (Insurance, Material Handling etc)	150.00 (1/2 × 100 Packages × ₹3.00)
Inspection Cost	650 (13,000 Packages × ₹0.05)
Stock Out Cost	2,880 (360Packages × ₹8.00)
Customer Return Cost	6,500 (13,000 Packages × 2% × ₹25.00)
Total Relevant Cost	17,79,460

Comments

The comparative costs are as follows:

Under Current Policy	₹ 18,32,076
Under Purchase under JIT from ITC	₹ 18,21,925
Under Purchase under JIT from HTC	₹ 17,79,460

Packages should be bought from HTC under JIT as it is the *cheapest*.

Problem-25

KP Ltd. (KPL) manufactures and sells one product called "KEIA". Managing Director is not happy with its current purchasing and production system. There has been considerable discussion at the corporate level as to use of 'Just in Time' system for "KEIA". As per the opinion of managing director of KPL Ltd. –

"Just-in-time system is a pull system, which responds to demand, in contrast to a push system, in which stocks act as buffers between the different elements of the system such as purchasing, production and sales. By using Just in Time system, it is possible to reduce carrying cost as well as other overheads".

KPL is dependent on contractual labour which has efficiency of 95%, for its production. The labour has to be paid for minimum of 4,000 hours per month to which they produce 3,800 standard hours.

For availing services of labour above 4,000 hours in a month, KPL has to pay overtime rate which is 45% premium to the normal hourly rate of ₹110 per hour. For avoiding this overtime payment, KPL in its current production and purchase plan utilizes full available normal working hours so that the higher inventory levels in the month of lower demand would be able to meet *sales of month with higher demand level. KPL has determined that the cost of holding inventory is ₹70 per month for each standard hour of output that is held in inventory.*

KPL has forecast the demand for its products for the first six months of year 2014 as follows:

Month	***Demand (Std. Hrs.)***
Jan'14	*3,150*
Feb'14	*3,760*
Mar'14	*4,060*
Apr'14	*3,350*
May'14	*3,650*
Jun'14	*4,830*

Following other information is given:

(i) All other production costs are either fixed or are not driven by labour hours worked.

(ii) Production and sales occur evenly during each month and at present there is no stock at the end of Dec'13.

(iii) The labour are to be paid for their minimum contracted hours in each month irrespective of any purchase and production system.

Required

As a chief accountant you are requested to comment on managing director's view.

Solution

Workings

Statement Showing 'Inventory Holding Cost' under Current System

Particulars	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Opening Inventory* (A)	---	650	690	430	880	1,030
Add: Production*	3,800	3,800	3,800	3,800	3,800	3,800
Less: Demand*	3,150	3,760	4,060	3,350	3,650	4,830
Closing Inventory* (B)	650	690	430	880	1,030	-
Average Inventory $\left(\frac{A+B}{2}\right)$	325	670	560	655	955	515
Inventory Holding Cost @ ₹70	22,750	46,900	39,200	45,850	66,850	36,050

(*) *in terms of standard labour hours*

Inventory Holding Cost *for the six months* = ₹2,57,600
(₹22,750 + ₹46,900 + ₹39,200 + ₹45,850 + ₹66,850 + ₹36,050)

Calculation of Relevant Overtime Cost under JIT System

Particulars	Jan	Feb	Mar	Apr	May	Jun
Demand*	3,150	3,760	4,060	3,350	3,650	4,830
Production*	3,150	3,760	4,060	3,350	3,650	4,830
Normal Availablility*	3,800	3,800	3,800	3,800	3,800	3,800
Shortage (=Overtime*) (C)	---	---	260	----	----	1,030
Actual Overtime Hours $\left(\frac{C}{0.95}\right)$	---	---	273.68	----	----	1,084.21
Overtime Payment @ ₹159.50 [110+45%]	---	---	43,652	----	----	1,72,931

(*) *in terms of standard labour hours*

Total Overtime payment = ₹2,16,583
(₹43,652 + ₹1,72,931)

Therefore, saving in JIT system = ₹2,57,600 – ₹2,16,583 = ₹41,017

Comments

Though KPL is saving ₹41,017 by changing its production system to Just-in-time but it has to consider other factors as well before taking any final call which are as follows:-

(i) KPL has to ensure that it receives materials from its suppliers on the exact date and at the exact time when they are needed. Credentials and reliability of supplier must be thoroughly checked.

(ii) To remove any quality issues, the engineering staff must visit supplier's sites and examine their processes, not only to see if they can reliably ship high-quality parts but also to provide them with engineering assistance to bring them up to a higher standard of product.

(iii) KPL should also aim to improve quality at its process and design levels with the purpose of achieving "Zero Defects" in the production process.

(iv) KPL should also keep in mind the efficiency of its work force. KPL must ensure that labour's learning curve has reached at steady rate so that they are capable of performing a variety of operations at effective and efficient manner. The workforce must be completely retrained and focused on a wide range of activities.

Theory of Constraints

Problem-26

BTS Ltd. produces three products A, B and C. The following information is available for a period:

	A	B	C
Contribution (per unit)	*₹ 30*	*₹ 25*	*₹ 15*
[Sales – Direct materials]			

Machine hours required per unit of production:

	Hours			Throughout Accounting Ratio
	A	*B*	*C*	
Machine 1	*10*	*2*	*4*	*133.33%*
Machine 2	*15*	*3*	*6*	*200.00%*
Machine 3	*5*	*1*	*2*	*66.67%*

Estimated sales demand for A, B and C are 500 units each and machine capacity is limited to 6,000 hours for each machine.

Required

Analyse the above information and apply theory of constraints process to remove the constraints. How many units of each product will be made?

Solution

Throughout Accounting Ratio is *highest* for 'Machine 2'. Accordingly 'Machine 2' is the bottleneck. Total 6,000 'Machine 2' hours are available.

Contribution *per unit* of Bottleneck Machine hour

Particulars	**A**	**B**	**C**
Contribution *per unit* (₹) ...(A)	30	25	15
'Machine 2' Hours ...(B)	15	3	6
Contribution *per* 'Machine 2' *hours* ...(C) = (A) / (B)	2	8.33	2.50
Ranking ...(D)	3	1	2
Maximum Demand ...(E)	500	500	500
'Machine 2' Hours Required ...(F) = (B) x (E)	7,500	1,500	3,000
'Machine 2' Hours Available ...(G)	1,500* (Balance)	1,500	3,000
Units ...(H) = (G) / (B)	100	500	500

(*) [6,000 hrs – 1,500 hrs – 3,000hrs]

Problem-27

Phi Ltd. produces 4 products P, Q, R and S by using three different machines X, Y and Z. Each machine capacity is limited to 6,000 hours per month. The details given below are for July, 2013:

Particulars	***P***	***Q***	***R***	***S***
Selling Price p.u. (₹)	*10,000*	*8,000*	*6,000*	*4,000*
Variable Cost p.u. (₹)	*7,000*	*5,600*	*4,000*	*2,800*
Machine Hours Required p.u.				
Machine X	*20*	*12*	*4*	*2*
Machine Y	*20*	*18*	*6*	*3*
Machine Z	*20*	*6*	*2*	*1*
Expected Demand (units)	*200*	*200*	*200*	*200*

Required

(i) Find out the bottleneck activity.

(ii) Allocate the machine hours on the basis of the bottleneck.

(iii) Ascertain the profit expected in the month if the monthly fixed cost amounts to ₹ 9,50,000.

(iv) Calculate the unused spare hours of each machine.

Solution

(i)

Mach.	**Time Required for Products (Hours)**				**Total Time**	**Time Avail.**	**Machine Utilization**
	P	**Q**	**R**	**S**			
X	4,000 (200 units × 20 hours)	2,400 (200 units × 12 hours)	800 (200 units × 4 hours)	400 (200 units × 2 hours)	7,600	6,000	126.67%
Y	4,000 (200 units × 20 hours)	3,600 (200 units × 18 hours)	1,200 (200 units × 6 hours)	600 (200 units × 3 hours)	9,400	6,000	156.67%
Z	4,000 (200 units × 20 hours)	1,200 (200 units × 6 hours)	400 (200 units × 2 hours)	200 (200 units × 1 hours)	5,800	6,000	96.67%

Since Machine Y has the *highest machine utilization* it represents the bottleneck activity. Hence Product Ranking & Resource Allocation should be based on Contribution/Machine Hour of Machine Y.

(ii)

Allocation of Resources						
Particulars	**P**	**Q**	**R**	**S**	**Machine Utilization**	**Spare Capacity**
Selling Price *per unit* (₹)	10,000	8,000	6,000	4,000		
Variable Cost *per unit* (₹)	7,000	5,600	4,000	2,800		
Contribution *per unit* (₹)	3,000	2,400	2,000	1,200		
Time Required in Machine 'Y' (hrs.)	20	18	6	3		
Contribution per Machine Hour (₹)	150	133.33	333.33	400		
Rank	III	IV	II	I		
Allocation of Machine 'Y' time (hrs.)	4,000 (200 units × 20 hrs.)	200 (Balance)	1,200 (200 units × 6 hrs.)	600 (200 units × 3 hrs.)	6,000	
Production (units)	200	11.11 (200 hrs. / 18 hrs.)	200	200		
Allocation of Machine 'X' time (hrs.)	4,000 (200 units × 20 hrs.)	133.32 (11.11 units × 12 hrs.)	800 (200 units × 4 hrs.)	400 (200 units × 2 hrs.)	5,333.32	666.68
Allocation of Machine 'Z' time (hrs.)	4,000 (200 units × 20 hrs.)	66.66 (11.11 units × 6 hrs.)	400 (200 units × 2 hrs.)	200 (200 units × 1 hr.)	4,666.66	1,333.34

(iii) Calculation of Expected Profit

Particulars	Amount (₹)
P (200 units × ₹ 3,000)	6,00,000
Q (11.11 units × ₹ 2,400)	26,664
R (200 units × ₹ 2,000)	4,00,000
S (200 units × ₹ 1,200)	2,40,000
Total Contribution	12,66,664
Less: Fixed Cost	9,50,000
Expected Profit	3,16,664

(iv) Unused Spare Hours

Machine 'X'

Particulars	Amount (₹)
Machine Hours Available	6,000.00 hrs.
Less: Machine Hours Utilized	5,333.32 hrs.
Spare Hours	666.68 hrs.

Machine 'Z'

Particulars	Amount (₹)
Machine Hours Available	6,000.00 hrs.
Less: Machine Hours Utilized	4,666.66 hrs.
Spare Hours	1,333.34 hrs.

☞

While calculating Production (units) of Product 'Q' *on the basis of allocated hours,* round figure (complete units) can also be considered and rest of the solution will be changed accordingly.

Problem-28

H. Ltd. manufactures three products. The material cost, selling price and bottleneck resource details per unit are as follows:

Particulars	***Product X***	***Product Y***	***Product Z***
Selling Price (₹)	*66*	*75*	*90*
Material and Other Variable Cost (₹)	*24*	*30*	*40*
Bottleneck Resource Time (Minutes)	*15*	*15*	*20*

Budgeted factory costs for the period are ₹ 2,21,600. The bottlneck resources time available is 75,120 minutes per period.

Required

(i) Company adopted throughput accounting and products are ranked according to 'product return per minute'. Select the highest rank product.

(ii) Calculate throughput accounting ratio and comment on it.

Solution

(i) Calculation of Rank According to 'Product Return *per minute*'

Particulars	**X**	**Y**	**Z**
Selling Price	66	75	90
Variable Cost	24	30	40
Throughput Contribution	42	45	50
Minutes *per unit*	15	15	20
Contribution *per minute*	2.8	3	2.5
Ranking	II	I	III

(ii) Ranking Based on 'TA Ratio'

Contribution *per minute*	2.80	3.00	2.50
Factory Cost *per minute* (2,21,600 / 75,120)	2.95	2.95	2.95
TA Ratio (Cont. *per minute* / Cost *per minute*)	0.95	1.02	0.85
Ranking Based on TA Ratio	II	I	III

Comment

Product Y yields more contribution compared to average factory contribution per minute, whereas X and Z yield less.

SECTION - C

Total Quality Management

Problem-1

Quality products can be determined by using a few of the dimensions of quality. Identify the following under the appropriate dimension:

(i) Consistency of performance over time.

(ii) Primary product characteristics.

(iii) Exterior finish of a product

(iv) Useful life of a product.

Solution

Quality of Products with Appropriate Dimension

Sl. No	Quality of Products (Examples)	Dimension
(i)	Consistency of performance over time	Reliability
(ii)	Primary product characteristics	Performance
(iii)	Exterior finish of a product	Aesthetics
(iv)	Useful like of a product	Durability

Problem-2

Classify the following items under appropriate categories of equality costs viz. Prevention Costs, appraisal Cost, Internal Failure Costs and External Failure costs:

(i) Rework

(ii) Scrap

(iii) Warranty Repairs

(iv) Revenue loss

(v) Repair to manufacturing equipment

(vi) Discount on defective sale

(vii) Establishment of quality circles

(viii) Packaging inspection

Solution

(i)	Rework	----- Internal Failure
(ii)	Scrap	----- Internal Failure
(iii)	Warranty Repairs	----- External Failure
(iv)	Revenue Loss	----- External Failure
(v)	Repairs to Manufacturing Equipment	----- Internal Failure
(vi)	Discount on Defective Sales	----- External Failure
(vii)	Establishment of Quality Circles	----- Prevention Cost
(viii)	Packaging Inspection	----- Appraisal Cost

Problem-3

A Ltd. is going to introduce Total Quality Management (TQM) in its company. State whether and why the following are valid or not for the successful implementation of TQM.

(i) Some departments serve both the external and internal customers. These departments have been advised to focus on satisfying the needs of the external customers.

(ii) Hold a training program at the beginning of a production cycle to ensure the implementation of TQM.

(iii) Implement Management by Objectives for faster achievement of TQM.

(iv) Appoint the Head of each department as the person responsible to develop improvement strategies and performance measures.

(v) Eliminate wastage of time by avoiding documentation and procedures.

Solution

Point	Valid/ Invalid	Reason
(i)	Invalid	TQM advocates focus to be given on both external and internal customers. Hence, focus satisfying the needs of the external customers only will not be valid for the successful implementation of TQM.
(ii)	Valid	Training at the beginning would improve productivity by bringing standardization in work habits and eliminating variations in production.
(iii)	Invalid	For implementation of TQM, Management by Objectives should be eliminated as targets of production will encourage delivery of poor quality goods and thus will defeat the collective nature of TQM.

(iv)	Invalid	Appointing the head of each department as the responsible person is not valid for the successful implementation of TQM as Total Employee Involvement (TIE) principle is an important part of TQM.
(v)	Invalid	Documentation, procedures and awareness of current best practice are essential in TQM implementation. If documentation and procedures are in place then only improvement can be monitored & measured and consequently deficiency can be corrected.

Activity Based Costing

Problem-4

State with a brief reason whether you would recommend an activity based system of costing in each of the following independent situations:

(i) *Company K produces one product. The overhead costs mainly consist of depreciation.*

(ii) *Company L produces 5 different products using different production facilities.*

(iii) *A consultancy firm consisting of lawyers, accountants and computer engineers provides management consultancy services to clients.*

(iv) *Company S produces two different labour intensive products. The contribution per unit in both products is very high. The BEP is very low. All the work is carried on efficiently to meet the target costs.*

Solution

Sl. No	Description	Recommend ABC (Yes / No)	Reasons
(i)	K produces one product. Overhead is mainly depreciation.	No	▪ One product situation. For allocation of overhead, ABC is not required. ▪ ABC for cost reduction not beneficial since most of the overhead is depreciation.
(ii)	L produces 5 different products with different facilities.	Yes	▪ Multi product situation. ABC is required for allocation of overhead. ▪ ABC is necessary for pricing. ▪ Cost drivers are likely to be different. ▪ Cost reduction may be possible. ▪ Production facilities are different.

(iii)	Professional services – lawyers / / accountants / computer engineers.	Yes	▪ Variety of services. Hence ABC is required for cost allocation. ▪ Services are very different. ▪ ABC is necessary for pricing. ▪ Cost reduction possible.
(iv)	S produces 2 different labour intensive products. High unit contribution and efficient operations.	No	▪ Different products, but labour intensive. Hence, overhead allocation based on readily traceable direct labour cost will be accurate. Hence, ABC not required for cost allocation. ▪ Low BEP level implies low level of fixed cost as a % of sale price or as a % of total cost. ▪ Many fixed cost activity drivers are likely to align with the direct labour costs. Hence not required for cost allocation. ▪ Efficient operation. Hence ABC not required even for cost reduction or ABC management.

Problem-5

State whether each of the following independent activities is value-added or non-value-added:

(i) *Polishing of furniture used by a systems engineer in a software firm.*

(ii) *Maintenance by a software company of receivables management software for a banking company.*

(iii) *Painting of pencils manufactured by a pencil factory.*

(iv) *Cleaning of customers' computer key boards by a computer repair centre.*

(v) *Providing, brake adjustments in cars received for service by a* car service station.

Solution

Sl. No	**Item**	**Value Added / Non Value Added**
(i)	Polishing furniture used by a Systems Engineer in a software firm.	Non-Value Added

(ii)	Maintenance by a software company of receivables management software for a banking company.	Value-Added
(iii)	Painting of pencils manufactured by a pencil factory.	Value-Added
(iv)	Customers' computer key board cleaning by a computer repair centre.	Value-Added
(v)	Providing brake adjustments in cars for repairs by a care service station.	Value-Added

Target Costing> Kaizen Costing

Problem-6

M. India Ltd. (MIL) is an automobile manufacturer in India and a subsidiary of Japanese automobile and motorcycle manufacturer Leon. It manufactures and sells a complete range of cars from the entry level to the hatchback to sedans and has a present market share of 22% of the Indian passenger car markets. MIL uses a system of standard costing to set its budgets. Budgets are set semi-annually by the Finance department after the approval of the Board of Directors at MIL. The Finance department prepares variance reports each month for review in the Board of Directors meeting, where actual performance is compared with the budgeted figures. Mr. Suzuki, group CEO of the Leon is of the opinion that Kaizen costing method should be implemented as a system of planning and control in the MIL.

Required

Recommend key changes vital to MIL's planning and control system to support the adoption of 'Kaizen Costing Concepts'.

Solution

Kaizen Costing emphasizes on *small but continuous improvement*. Targets once set at the beginning of the year or activities are *updated continuously* to reflect the improvement that has already been achieved and that are yet to be achieved.

The suggestive changes which are required to be adopted Kaizen Costing concepts in MIL are as follows:

Standard Cost Control System to Cost Reduction System: Traditionally Standard Costing system assumes stability in the current manufacturing process and standards are set keeping the normal manufacturing process into account thus the whole effort is on to meet performance cost standard. On the other hand Kaizen Costing believes in continuous improvements in manufacturing processes and hence, the goal is to achieve cost reduction target. The first change required is the standard setting methodology i.e. from earlier Cost Control System to Cost Reduction System.

Reduction in the periodicity of setting Standards and Variance Analysis: Under the existing planning and control system followed by the MIL, standards are set semi-annually and based on these standards monthly variance reports are generated for analysis. But under Kaizen Costing system cost reduction targets are set for small periods say for a week or a month. So the period covered under a standard should be reduced from semi-annually to monthly and the current practice of generating variance reports may be continued or may be reduced to a week.

Participation of Executives or Workers in standard setting: Under the Kaizen Costing system participation of workers or executives who are actually involved in the manufacturing process are highly appreciated while setting standards. So the current system of setting budgets and standards by the Finance department with the mere consent of Board of Directors required to be changed.

Problem-7

ABC Ltd. is planning to introduce Kaizen Costing approach in its manufacturing plant. State whether and why the following are Valid or Not in respect of Kaizen Costing.

(i) *VP (Finance) is of the view that company has to make a huge initial investment to bring a large scale modification in production process.*

(ii) *Head (Personnel) has made a point that introduction of Kaizen Costing does not eliminate the training requirement of employees.*

(iii) *General Manager (Manufacturing) firmly believes that only shop floor employees and workers' involvement is prerequisite of Kaizen Costing approach.*

(iv) *Manager (Operations) has concerns about creation of confusion among employees and workers regarding their roles and degradation in quality of production.*

Solution

(i) **Invalid:** Kaizen Costing is the system of cost reduction procedures which involves making small and continuous improvements to the production processes rather than innovations or large-scale investment.

(ii) **Valid:** The training of employees is very much a long-term and ongoing process in the Kaizen costing approach. Training enhances the abilities of employees.

(iii) **Invalid:** Kaizen costing approach involves everyone from top management level to the shop floor employees. Every employee's active participation is a must requirement.

(iv) **Invalid:** Though the aim of Kaizen Costing is to reduce the cost but at the same time it also aims to maintain the quality. Kaizen costing also aims to bring the clarity in roles and responsibilities for all employees.

Life Cycle Costing

Problem-8

Fiona is a news reporter and feature writer for an economic daily. Her assignment is to develop a feature article on 'Product Life-Cycle Costing', including interviews with the Chief Financial Officers (CFO) and Operating Managers. Fiona has been given a liberal budget for travel so as to research into company's history, operations, and market analysis for the firm she selects for the article.

Required

Fiona has asked you to recommend industries and firms that would be good candidates for the article. What would you advice? Explain your recommendations.

Solution

The product life cycle span the time from the initial R & D on a product to when customer service and support is no longer offered for that product.

Life Cycle Costing technique is particularly important when:

(i) High percentage of total life-cycle costs are incurred before production begins and revenue are earned over several years and

(ii) High fraction of the life cycle costs are locked in at the R & D and design stages.

Fiona should identify those industries and then companies belonging to those industries where above mentioned feature are prevalent. For example, Automobile and Pharmaceutical Industries companies like Tata Motors Ltd., Ranbaxy Laboratories Ltd., and Dabur India Ltd. will be good candidates for study on product life cycle costing.

Cost Control Vs Cost Reduction

Problem-9

Classify the following items under the more appropriate category:

Category (CC) – Cost Control Or Category (CR) – Cost Reduction:

(i) Costs exceeding budgets or standards are investigated.

(ii) Preventive function

(iii) Corrective function

(iv) Measures to standardize for increasing productivity

(v) Provision of proper storage facilities for materials.

(vi) Continuous comparison of actual with the standards set.

(vii) Challenges the standards set

(viii) Value analysis

Solution

Classification of Items under Cost Reduction (CR)/ Cost Control (CC)

Sl. No.	Item	Category CC/ CR
(i)	Costs exceeding budgets or standards are investigated	CC
(ii)	Preventive function	CC
(iii)	Corrective function	CR
(iv)	Measures to standardize for increasing productivity	CR
(v)	Provision of proper storage facilities for materials	CC
(vi)	Continuous comparison of actual with the standards set	CC
(vii)	Challenges the standards set	CR
(viii)	Value analysis	CR

Value Chain Analysis

Problem-10

ABC Ltd. is engaged in business of manufacturing branded readymade garments. It has a single manufacturing facility at Ludhiana. Raw material is supplied by various suppliers.

Majority of its revenue comes from export to Euro Zone and US. To strengthen its position further in the Global Market, it is planning to enhance quality and provide assurance through long term warranty.

For the coming years company has set objective to reduce the quality costs in each of the primary activities in its value chain.

Required

State the primary activities as per Porter's Value Chain Analysis in the value chain of ABC Ltd with brief description.

Solution

Primary activities are the activities that are directly involved in transforming inputs into outputs and delivery and after-sales support to output. Following are the primary activities in the value chain of ABC Ltd.:-

(i) **Inbound Logistics**: These activities are related to the material handling and warehousing. It also covers transporting raw material from the supplier to the place of processing inside the factory.

(ii) **Operations:** These activities are directly responsible for the transformation of raw material into final product for the delivery to the consumers.

(iii) **Outbound Logistics:** These activities are involved in movement of finished goods to the point of sales. Order processing and distribution are major part of these activities.

(iv) **Marketing and Sales:** These activities are performed for demand creation and customer solicitation. Communication, pricing and channel management are major part of these activities.

(v) **Service:** These activities are performed after selling the goods to the consumers. Installation, repair and parts replacement are some examples of these activities.

Problem-11

Examine the Validity of following statements along with the reasons:

(i) *The concepts, tools and techniques of value chain analysis apply only to all those organizations which produce and sell a product.*

(ii) *Procurement activities are included in the Primary activities as classified by Porter under value chain analysis concept.*

(iii) *As per Porter's five forces model, bargaining power of buyers does influence the profitability of an industry or market.*

(iv) *Value chain analysis in the strategic framework consists of single cost driver concept.*

Solution

(i) **Invalid**

The concepts, tools and techniques of value chain analysis apply to organizations which produce and sell a product and also to organizations which provide a service.

(ii) **Invalid**

Procurement activities are included in the support activities rather than primary activities.

(iii) Valid

Bargaining power of buyers is one of the factor or force that influences the profitability of a market or industry. More the bargaining power buyers have, more the pressure on the industry to not increase the price of product or service. They may even have to reduce the price sometimes.

(iv) Invalid

Value chain analysis in the strategic framework consists of multiple cost drivers concept. In value chain analysis, a set of unique cost drivers is identified for each value activity instead of single cost driver application at the overall firm level. Multiple cost drivers may be classified into Structural drivers and Executional drivers.

Just In Time

Problem-12

Indian Petrons Ltd. (IPL) is a leading manufacturing company. Under increasing pressure to reduce costs, to contain inventory and to improve service, IPL's Costing Department has recently undertaken a decision to implement a JIT System.

The management of IPL is convinced of the benefits of their changes. But Supplies Manager Mr. Brian fears with the Costing Department's decision. He said:

"We've been driven by suppliers for years ... they would insist that we could only purchase in thousands, that we would have to wait weeks, or that they would only deliver on Mondays!"

Is Mr. Brian's view point correct and why?

Solution

JIT Inventory System

"For successful operation of JIT inventory system, the suppliers chosen must be willing to make frequent deliveries in small lots. Rather than deliver a week's or a month's material at one time, suppliers must be willing to make deliveries several times a day and in the exact quantities specified by the buyer."

It is described in the problem that suppliers are not willing to

- make frequent deliveries and
- make supplies in the exact quantities as required

Accordingly Mr. Brian's doubt is correct on successful implementation of JIT System.

2 Decision Making using Cost Concepts and CVP Analysis

Basic Concepts

Absorption Costing*	Assigns direct costs and all or part of overhead to cost units using one or more overhead absorption rates.
Absorbed Overhead*	Overhead attached to products or services by means of an absorption rate, or rates.
Allocate*	To assign a whole item of cost, or of revenue, to a single cost unit, centre, account or time period.
Apportion*	To spread indirect revenues or costs over two or more cost units, centres, accounts or time periods. This may also be referred to as *indirect allocation*.
Application of Incremental / Differential Cost Techniques in Managerial Decisions	The areas in which the above techniques of cost analysis can be used for making managerial decisions are: (i) Whether to process a product further or not. (ii) Dropping or adding a product line. (iii) Making the best use of the investment made. (iv) Acceptance of an additional order from a special customer at lower than existing price. (v) Opening of new sales territory and branch. (vi) Make or Buy decisions. (vii) Submitting tenders (viii) Lease or buy decisions (ix) Equipment replacement decision.
Avoidable Cost*	Specific cost of an activity or sector of a business that would be avoided if the activity or sector did not exist.
Bottleneck*	Facility that has lower capacity than prior or subsequent facilities and restricts output based on current capacity.
Breakeven Point*	Level of activity at which there is neither profit nor loss.
Cost*	As a noun – The amount of cash or cash equivalent paid or

	the fair value of other consideration given to acquire an asset at the time of its acquisition or construction.
Cost-Benefit Analysis*	Comparison between the costs of the resources used plus any other costs imposed by an activity.
Cost Centre*	Production or service location, function, activity or item of equipment for which costs are accumulated.
Common Cost*	Cost relating to more than one product or service.
Committed Cost*	Cost arising from prior decisions, which cannot, in the short run, be changed. Committed cost incurrence often stems from strategic decisions concerning capacity with resulting expenditure on plant and facilities. Initial control of committed costs at the decision point is through investment appraisal techniques.
Conversion Cost*	Cost of converting material into finished product, typically including direct labour, direct expense and production overhead.
Cost Classification*	Arrangement of elements of cost into logical groups with respect to their nature (fixed, variable, value adding), function (production, selling) or use in the business of the entity.
Cost Elements*	Constituent parts of costs according to the factors upon which expenditure is incurred, namely material, labour and expenses.
Cost Management*	Application of management accounting concepts, methods of data collection, analysis and presentation in order to provide the information needed to plan, monitor and control costs.
Cost Object*	For example a product, service, centre, activity, customer or distribution channel in relation to which costs are ascertained.
Cost Pool*	Grouping of costs relating to a particular activity in an activity-based costing system.
Cost-Volume-Profit Analysis	Cost-Volume-Profit Analysis (as the name suggests) is the analysis of three variable viz., cost, volume and profit. Such an analysis explores the relationship existing amongst costs, revenue, activity levels and the resulting profit. It aims at measuring variations of cost with volume. In the profit planning of a business, cost-volume-profit (C-V-P) relationship is the most significant factor.
Differential / Incremental Cost*	Difference in total cost between alternatives. This is calculated to assist decision making.
Direct Cost*	Expenditure that can be attributed to a specific cost unit, for example material that forms part of the product.

Distribution costs	Cost of warehousing saleable products and delivering them to customers. These costs are reported in the income of statement.
Discretionary Cost*	Cost whose amount within a time period is determined by a decision taken by the appropriate budget holder. Marketing, research and training are generally regarded as discretionary costs. Also known as managed or policy costs.
Efficiency*	Achievement of either maximum useful output from the resources devoted to an activity or the required output from the minimum resource input.
Expand or Contract Decision	Whenever a decision is to be taken as to whether the capacity is to be expanded or not, consideration should be given to the following points: (i) Additional fixed expenses to be incurred. (ii) Possible decrease in selling price due to increase in production. (iii) Whether the demand is sufficient to absorb the increased production.
Export v/s Local Sale Decision	When the firm is catering to the needs of the local market and surplus capacity is still available, it may think of utilising the same to meet export orders at price lower than that prevailing in the local market. This decision is made only when the local sale is earning a profit, i.e., where its fixed expenses have already been recovered by the local sales. In such cases, if the export price is more than the marginal cost, it is preferable to enter the export market. Any reduction in the price prevailing in the local market to fulfil surplus capacity may have adverse effect on the normal local sales. Dumping in the export market at a lower price will not, however, have any such adverse effect on local sales.
Features of CVP Analysis	Features of CVP Analysis are as follows: (i) It is a technique for studying the relationship between cost volume and profit. (ii) Profit of an undertaking depends upon a large number of factors. But the most important of these factors are the cost of manufacture, volume of sales and selling price of products. (iii) In words of Herman C. Heiser, 'the most significant single factor in profit planning of the average business is the relationship between volume of business, cost and profits'. (iv) The CVP relationship is an important tool used for profit planning of a business.

Fixed Cost*	Cost incurred for an accounting period, that, within certain output or turnover limits, tends to be unaffected by fluctuations in the levels of activity (output or turnover).
Joint Cost*	Cost of a process which results in more than one main product.
Long-term Variable Cost*	All costs are variable in the long run. Full unit costs may be surrogates for long-term variable costs if calculated in a manner which utilises long-term cost drivers, for example activity-based costing.
Make or Buy Decision	Very often management is faced with the problem as to whether a part should be manufactured or it should be purchased from outside market. Under such circumstances two factors are to be considered: (i) Whether surplus capacity is available, and (ii) The marginal cost.
Marginal Cost*	Part of the cost of one unit of product or service that would be avoided if the unit were not produced, or that would increase if one extra unit were produced.
Marginal Costing	According to CIMA, Marginal costing is the system in which variable costs are charged to cost units and fixed costs of the period are written off in full against the aggregate contribution. Marginal costing is not a distinct method of costing like job costing, process costing, operating costing, etc. but a special technique used for managerial decision making. Marginal costing is used to provide a basis for the interpretation of cost data to measure the profitability of different products, processes and cost centre in the course of decision making. It can, therefore, be used in conjunction with the different methods of costing such as job costing, process costing, etc., or even with other technique such as standard costing or budgetary control.
Marginal Revenue*	Additional revenue generated from the sale of one additional unit of output.
Normal Loss*	Expected loss, allowed for in the budget, and normally calculated as a percentage of the good output from a process during a period of time. Normal losses are generally either valued at zero or at their disposal values.
Notional Cost*	Cost used in product evaluation, decision making and performance measurement to reflect the use of resources that

	have no actual (observable) cost. For example, notional interest for internally generated funds or notional rent for use of space.
Opportunity Cost*	The value of the benefit sacrificed when one course of action is chosen in preference to an alternative. The opportunity cost is represented by the foregone potential benefit from the best rejected course of action.
Outsourcing*	Use of external suppliers as a source of finished products, components or services. This is also known as contract manufacturing or subcontracting.
Overhead/Indirect Cost*	Expenditure on labour, materials or services that cannot be economically identified with a specific saleable cost unit.
Period Cost*	Cost relating to a time period rather than to the output of products or services.
Post-Purchase Cost*	Cost incurred after a capital expenditure decision has been implemented and facilities acquired. May include training, maintenance and the cost of upgrades.
Pricing Decisions-Special Circumstances	If goods were sold in the normal circumstances under normal business conditions, the price would cover the total cost plus a margin of profit. Selling prices are not always determined by the cost of production. They may be determined by market conditions but in the long run they tend to become equal to the cost of production of marginal firm. Therefore, a business cannot continue to sell below the total cost for a long period. Occasionally, a firm may have to sell below the total cost. The problem of pricing can be summarised under three heads: (i) Pricing in periods of recession, (ii) Differential selling prices and (iii) Acceptance of an offer and submission of a tender.
Prime Cost*	Total cost of direct material, direct labour and direct expenses.
Product Cost*	Cost of a finished product built up from its cost elements.
Production Cost*	Prime cost plus absorbed production overhead.
Product Mix Decision	Many times the management has to take a decision whether to produce one product or another instead. Generally decision is made on the basis of contribution of each product. Other things being the same the product which yields the highest contribution is best one to produce. But, if there is

	shortage or limited supply of certain other resources which may act as a key factor like for example, the machine hours, then the contribution is linked with such a key factor for taking a decision.
Price-Mix Decision	When a firm can produce two or more products from the same production facilities and the demand of each product is affected by the change in their prices, the management may have to choose price mix which will give the maximum profit, particularly when the production capacity is limited. In such a situation, the firm should compute all the possible combinations and select a price-mix which yields the maximum profitability.
Re-apportion*	The re-spread of costs apportioned to service departments to production departments.
Relevant Costs / Revenues*	Costs and revenues appropriate to a specific management decision. These are represented by future cash flows whose magnitude will vary depending upon the outcome of the management decision made. If stock is used, the relevant cost, used in the determination of the profitability of the transaction, would be the cost of replacing the stock, not its original purchase price, which is a sunk cost. Abandonment analysis, based on relevant cost and revenues, is the process of determining whether or not it is more profitable to discontinue a product or service than to continue it.
Replacement Cost*	Cost of replacing an asset. This is important in relevant costing because if, for example, material that is in constant use is needed for a product or service, the relevant cost of that material will be its replacement cost. Replacement cost has also been proposed as an alternate to historic cost accounting and it can, therefore, be an important concept with relevance to accounting for inflation or measuring performance where the value of assets is important.
Semi-Variable Cost*	Cost containing both fixed and variable components and thus partly affected by a change in the level of activity.
Shut Down or Continue Decision	Very often it becomes necessary for a firm to temporarily close down the factory due to trade recession with a view to reopening it in the future. In such cases, the decision should be based on the marginal cost analysis. If the products are making a contribution towards fixed expenses or in other words if selling price is above the marginal cost, it is preferable to continue because the losses are minimised. By

	suspending the manufacture, certain fixed expenses can be avoided and certain extra fixed expenses may be incurred depending upon the nature of the industry, say, for example, extra cost incurred in protecting the machinery. So the decision is based on as to whether the contribution is more than the difference between the fixed expenses incurred in normal operation and the fixed expenses incurred when the plant is shut down.
Standard Cost*	Planned unit cost of a product, component or service. The standard cost may be determined on a number of bases. The main uses of standard costs are in performance measurement, control, stock valuation and in the establishment of selling prices.
Sunk Cost*	Cost that has been irreversibly incurred or committed and cannot therefore be considered relevant to a decision. Sunk costs may also be termed irrecoverable costs.
Under / Over Absorbed Overhead*	The difference between overhead incurred and overhead absorbed, using an estimated rate, in a given period. If overhead absorbed is less than that incurred there is under-absorption, if overhead absorbed is more than that incurred there is over-absorption. Over- and under-absorptions are treated as period cost adjustments.
Unit Cost*	Unit of product or service in relation to which costs are ascertained.
Variable Cost*	Cost that varies with a measure of activity.

(*) Source- CIMA's Official Terminology

SECTION - A

CVP Analysis / Cost Concepts/ Decision Making

Question-1

Explain, how Cost Volume Profit (CVP) - based sensitivity analysis can help managers cope with uncertainty.

Answer

Sensitivity analysis focuses on how a result will be changed if the original estimates or the underlying assumptions change.

Cost Volume Profit (CVP) – based sensitivity analysis can help managers to provide answers to the following questions to cope with uncertainty.

- What will be the profit if the sales mix changes from that originally predicted?
- What will be the profit if fixed costs increase by 10% and variable costs decline by 5%?

The use of spreadsheet packages has enabled managers to develop CVP computerised models which can answer the above questions. Managers can now consider alternative plans by keying the information into a computer, which can quickly show changes both graphically and numerically. Thus managers can study various combinations of changes in selling prices, fixed costs, variable costs and product mix, and can react quickly without waiting for formal reports from the accountant. In this manner the use of CVP based sensitivity analysis can help managers to cope up with uncertainty.

Question-2

Explain briefly the concepts of Opportunity costs and Relevant costs.

Answer

(i) **Opportunity Cost-** Opportunity cost is a measure of the benefit of opportunity forgone when various alternatives are considered. In other words, it is the cost of sacrifice made by alternative action chosen. For example, opportunity cost of funds invested in business is the interest that could have been earned by investing the funds in bank deposit.

(ii) **Relevant Cost-** Expected future costs which differ for alternative course. It is not essential that all variable costs are relevant and all fixed costs are irrelevant. Fixed, or variable costs that differ for various alternatives are relevant costs. Relevant costs draw our attention to those elements of cost which are relevant for the decision.

Example-

Direct Labour under alternative I – ₹10/ hour; Direct Labour under alternative II – ₹20/hour; Then, Direct Labour is Relevant Cost.

Question-3

Comment on the use of opportunity cost for the purpose of:

(i) decision-making and

(ii) cost control

Answer

(i) Decision Making- Opportunity costs apply to the use of scarce resources, where resources are not scarce; there is no sacrifice from the use of these resources. Where a course of action requires the use of scarce resources, it is necessary to incorporate the lost profit which will be foregone from using scarce resources. If resources have no alternative use only the additional cash flow resulting from the course of action should be included in decision making as relevant cost.

(ii) Cost Control- The conventional variance analysis will report an adverse usage variance and adverse sales volume variance. However, the failure to achieve the budgeted optimum level of output may be due to inefficient usage of scarce resources. The foregone contribution should therefore be charged to the manager responsible for controlling the usage of scarce resources and not to the sales manager because the failure to achieve the budgeted sales is due to the failure to use scarce resources efficiently. Thus if resources are scarce, the usage variance should reflect the acquisition cost plus budgeted contribution per unit of the scarce resources. If the lost sales are made good in subsequent periods, the real opportunity cost will consists of lost interest arising from delay in receiving the net cash-flows and not the foregone contribution.

Question-4

Distinguish between "Marginal cost" and 'Differential Cost".

Answer

Marginal Cost represents the increase or decrease in total cost which occurs with a small change in output say, a unit of output. In Cost Accounting variable costs represent marginal cost.

Differential Cost is the change (increase or decrease) in the total cost (variable as well as fixed) due to change in the level of activity, technology or production process or method of production.

In other words, it can be defined as the cost of one unit of product or service which would be avoided if that unit was not produced or provided.

The main point which distinguishes marginal cost and differential as that change in fixed cost when volume of production increases or decreases by a unit of production. In the case of differential cost variable as well as fixed cost. i.e. both costs change due to change in the level of activity, whereas under marginal costing only variable cost changes due to change in the level of activity.

Question-5

Explain the concept of discretionary costs. Give three examples.

Answer

Discretionary Costs can be explained with the help of following two important features-

- They arise from periodic (usually yearly) decisions regarding the maximum outlay to be incurred.
- They are not tied to a clear cause and effect relationship between inputs and outputs.

Examples of Discretionary Costs

Advertising, public relations, executive training, teaching, research, health care and management consulting services. The noteworthy feature of discretionary costs is that managers are seldom confident that the "correct" amounts are being spent.

Question-6

Discuss how control may be exercised over discretionary costs.

Answer

To control **Discretionary Costs** control points/parameters may be established. But these points need to be devised individually. For research and development function to control discretionary costs, data may be established for submitting major reports to management. For advertising and sales promotion, such costs may be controlled by pre-setting targets. In the case of employees benefits, discretionary costs may be controlled by calling a meeting of employees union and making them aware that the company would meet only the fixed costs and the variable costs should be met by them.

Question-7

What is meant by incremental Revenue?

Answer

Incremental Revenue is the additional revenue that arise from the production or sale of a group of additional units. It is one of the two basic concepts the other being incremental cost which go together with differential cost analysis. Incremental cost in fact is the added cost due to change either in the level of activity of in the nature of activity.

Question-8

What are the applications of incremental cost techniques in making managerial decisions?

Answer

Incremental Cost Technique- It is a technique used in the preparation of ad-hoc information in which only cost and income differences between alternative courses of action are taken into consideration.

The essential pre-requisite for making managerial decisions by using incremental cost technique, is to compare the incremental costs with incremental revenues. So long as the incremental revenue is greater than incremental costs, the decision should be in favour of the proposal.

Applications of Incremental Cost Techniques in making Managerial Decisions- The important areas in which incremental cost analysis could be used for managerial decision making are as under-

- Introduction of a new product.
- Discontinuing a product, suspending or closing down a segment of the business.

- Whether to process a product further or not.
- Acceptance of an additional order from a special customer at lower than existing price.
- Opening of new sales territory and branch.
- Optimizing investment plan out of multiple alternatives.
- Make or buy decisions.
- Submitting tenders.
- Lease or buy decisions.
- Equipment replacement decisions.

Question-9

"Sunk cost is irrelevant in decision-making, but irrelevant costs are not sunk costs". Explain with example.

Answer

Sunk Costs are costs that have been created by a decision made in the past and that cannot be changed by any decision that will be made in the future. For example, the written down value of assets previously purchased are sunk costs. Sunk costs are not relevant for decision making because they are past costs.

But not all irrelevant costs are sunk costs. For example, a comparison of two alternative production methods may result in identical direct material costs for both the alternatives. In this case, the direct material cost will remain the same whichever alternative is chosen. In this situation, though direct material cost is the future cost to be incurred in accordance with the production, it is irrelevant, but, it is not a sunk cost.

Question-10

Explain the concept of relevancy of cost by citing three examples each of relevant costs and non-relevant costs.

Answer

Relevant costs are those costs which are pertinent to a decision. In other words, these are the costs which are influenced by a decision. Those costs which are not affected by the decision are not relevant costs.

Examples of Relevant Costs

- All variable costs are relevant costs.

- Fixed Costs which vary with the decision are relevant costs.
- Incremental costs are relevant costs.

Examples of Non-Relevant Costs

- All fixed costs are generally non-relevant.
- Variable costs which do not vary with the decision are not relevant costs.
- Book value of the asset is not relevant.

Question-11

Mention any four important factors to be considered in Marginal Costing Decisions.

Answer

Important factors to be considered in **"Marginal Costing Decisions"** are as follows:

- Whether the product or production makes a contribution,
- In the selection of alternatives, additional fixed costs if any should be considered.
- The continuity of demand after expression and its impact on selling price are to be considered.
- Non-cost factors such as the need to keep labour force intact and governmental attitude are also to be taken into account.

Question-12

"Cost is not the only criterion for deciding in favour of shut down" – Briefly explain.

Answer

Cost is not only criterion for deciding in the favour of *shut down*. **Non-Cost Factors** worthy of consideration in this regard are as follows:

- Interest of workers, if the workers are discharged, it may become difficult to get skilled workers later, on reopening of the factory. Also shut-down may create problems.
- In the face of competition it may difficult to re-establish the market for the product.
- Plant may become obsolete or depreciate at a faster rate or get rusted. Thus, heavy capital expenditure may have to be incurred on re-opening.

Question-13

State the relative economics of the "makes vs. buy" decision in management control.

Answer

Generally for taking a **Make vs. Buy Decision** comparison is made between the supplier's price and the marginal cost of making plus the opportunity cost. Make vs. buy decision is a strategic decision, and, therefore, both short-term as well as well as long-term thinking about various cost and other aspects needs to be done.

A company generally buy a component instead of making it under following situations:

- If it costs less to buy rather than to manufacture it internally;
- If the return on the necessary investment to be made to manufacture is not attractive enough;
- If the company does not have the requisite skilled manpower to make;
- If the concern feels that manufacturing internally will mean additional labour problem;
- If adequate managerial manpower is not available to take charge of the extra work of manufacturing;
- If the component shows much seasonal demand resulting in a considerable risk of maintaining inventories;
- If transport and other infrastructure facilities are adequately available;
- If the process of making is confidential or patented;
- If there is risk of technological obsolescence for the component such that it does not encourage capital investment in the component.

Question-14

State the non-cost factors to be considered in make/buy decisions.

Answer

Non-Cost Factors in Make / Buy Decisions

- Possible use of released production capacity and facility as a result of buying instead of making.
- Sources of supply should be reliable and they are capable of meeting un-interruptedly the requirement of the concern.
- Assurance about the quality of goods supplied by outside supplier.
- Reasonable certainty, from the side of supplier about, meeting the delivery dates.
- The decision of buying the product / component from outside suppliers should be discouraged, if the technical know- how used is highly secretive.

- The decision of buying from outside sources should not result in the laying off of workers and create industrial relation problems. In fact, on buying from outside the resources freed should be better utilised elsewhere in the concern.
- The decision of manufacturing product / component should not adversely affect the concern's relationship with suppliers.
- Ensure that more than one supplier of product/component is available to reduce the risk of outside buying.
- In case the necessary technical expertise is not available internally then it is better to buy the requirements from outside.

Question-15

Enumerate the factors involved in decisions relating to expansion of capacity.

Answer

The factors involved in decisions relating to *expansion of capacity* are enumerated as below:

- Additional fixed overheads involved should be considered.
- Possible decrease in selling price due to increased production capacity.
- Whether the demand is sufficient to absorb the increased production.

Question-16

Discuss the role of costs in product-mix decisions.

Answer

Role of Costs in Product Mix Decisions- All types of cost involved in cost accounting system are useful in decision making. The cost which plays a major role in product mix decision is the relevant cost. Costs to be relevant should meet the following criteria:

- The costs should be expected as future costs.
- The costs differ among the alternatives course of action.

While making decision about product mix using the facilities and other available resources, the end results should always aim at profit maximisation. Variable costs are relevant costs in product mix decisions and consequently contribution plays a major role in maximisation of profit. In addition to the relevancy of costs, the other factors and costs that should be taken into account at the time of deciding the products mix are:

- The available production capacity
- The limiting factor (s)
- Contribution per unit of the limiting factor

- Market demand for the products.
- Opportunity costs

Question- 17

What are the major areas of decision-making in which differential costing is used?

Answer

Differential Costing can be used for all short, medium and long term decisions. When two levels of activities are being considered, or while choosing between competing alternatives differential cost analysis is essential. The differential cost is useful for decision making in the following areas:

- Capital Expenditure Decisions.
- Make or Buy Decision
- Production Planning
- Sales Mix Decision
- Production or Product Decision
- Change in Level or Nature of an Activity.

Question-18

"The use of Absorption costing method in decision-making process leads to anomalies." Discuss.

Answer

In absorption costing, fixed overheads are assigned to products by establishing overhead absorption rates based on budgeted or normal output. By using absorption costing principles, it is possible for profit to decline when sales volume increases. If the stock levels fluctuate significantly, profits may be distorted because stock changes will significantly affect the amount of fixed overheads allocated to a period. If profits are measured on monthly or quarterly or on periodical basis, seasonal variations in sales may cause significant fluctuations in profits. Internal profit statements on monthly or quarterly basis are used for measuring the managerial performance. In the circumstances, managers may deliberately alter inventory levels to influence profit, if absorption costing is used. When sales are less and the closing inventory increases, a part of the fixed overheads contained in the value of the closing stock is reduced from the fixed costs allocated to production for the period. Thus, if sales are reduced, inventories will increase and absorption cost will post higher profits. Similarly, if sales are increased as compared to production, inventories will be reduced and absorption costing will return lower profits.

SECTION - B

CVP Analysis

Problem-1

M.K. Ltd. manufactures and sells a single product X whose selling price is ₹ 40 per unit and the variable cost is ₹ 16 per unit.

(i) If the Fixed Costs for this year are ₹ 4,80,000 and the annual sales are at 60% margin of safety, calculate the rate of net return on sales, assuming an income tax level of 40%

(ii) For the next year, it is proposed to add another product line Y whose selling price would be ₹ 50 per unit and the variable cost ₹ 10 per unit. The total fixed costs are estimated at ₹ 6,66,600. The sales mix of X : Y would be 7 : 3. At what level of sales next year, would M.K. Ltd. break even? Give separately for both X and Y the break even sales in rupee and quantities.

Solution

(i) Contribution *per unit* = Selling price – Variable cost

= ₹40 – ₹16

= ₹24

Break-even Point = $\frac{₹4,80,000}{₹24}$

= 20,000 units

Percentage Margin of Safety = $\frac{\text{Actual Sales} - \text{Break-even Sales}}{\text{Actual Sales}}$

Or, 60% = $\frac{\text{Actual Sales} - 20,000\,units}{\text{Actual Sales}}$

∴ Actual Sales = 50,000 units

	(₹)
Sales Value (50,000 units × ₹40)	20,00,000
Less: Variable Cost (50,000 units × ₹16)	8,00,000
Contribution	12,00,000
Less: Fixed Cost	4,80,000
Profit	7,20,000

Less: Income Tax @ 40%	2,88,000
Net Return	4,32,000

Rate of Net Return on Sales = 21.6% $\left(\frac{₹4,32,000}{₹20,00,000}\times 100\right)$

(ii) Products

	X (₹)	Y (₹)
Selling Price *per unit*	40	50
Variable Cost *per unit*	16	10
Contribution *per unit*	24	40
Individual Product's Contribution Margin	60% $\left(\frac{₹24}{₹40}\text{x}100\right)$	80% $\left(\frac{₹40}{₹50}\text{x}100\right)$

Contribution Margin (X & Y)

$60\% \times \frac{7}{10} + 80\ \% \times \frac{3}{10}$ = 66%

Break-even Sales = ₹10,10,000 $\left(\frac{₹6,66,600}{66\%}\right)$

Break-even Sales Mix

X - 70% of 10,10,000 = ₹7,07,000 i.e.17,675 units.

Y - 30% of 10,10,000 = ₹3,03,000 i.e. 6,060 units.

Alternative

If it is assumed that sales mix is based on quantity, the following will be the computations:

	(₹)
Sales Price :	
X : $\left(₹40 \text{ x } \frac{7}{10}\right)$	28.00
Y : $\left(₹50 \text{ x } \frac{3}{10}\right)$	15.00
Variable Cost:	
X : $\left(₹16 \text{x } \frac{7}{10}\right)$	11.20

Y : $\left(₹10 \times \frac{3}{10}\right)$	3.00
Contribution	28.80

Break-even Sale = 23,146 units $\left(\frac{₹6,66,600}{₹28.80}\right)$

Break-even Sales Mix:

X (23,146 units × 70%) = 16,202 units

Or = ₹6,48,080

Y (23,146 units × 30%) = 6,944 units

Or = ₹3,47,200

Problem-2

X Ltd. supplies spare parts to an air craft company Y Ltd. The production capacity of X Ltd. facilitates production of any one spare part for a particular period of time. The following are the cost and other information for the production of the two different spare parts A and B:

Per unit	*Part A*	*Part B*
Alloy usage……………………………………	*1.6 kgs.*	*1.6 kgs.*
Machine Time: Machine A……………………..	*0.6 hrs.*	*0.25 hrs.*
Machine Time: Machine B……………………..	*0.5 hrs.*	*0.55 hrs.*
Target Price (₹)………………………………..	*145*	*115*
Total hours available:…………………..........	*Machine A 4,000 hours*	
	Machine B 4,500 hours	

Alloy available is 13,000 kgs. @ ₹ 12.50 per kg.

Variable overheads per machine hours:……. *Machine A: ₹ 80*

Machine B: ₹ 100

Required

(i) Identify the spare part which will optimize contribution at the offered price.

(ii) If Y Ltd. reduces target price by 10% and offers ₹ 60 per hour of unutilized machine hour, what will be the total contribution from the spare part identified above?

Solution

(i)

	Part A	Part B
Machine "A" (4,000 hrs)	6,666	16,000
Machine "B" (4,500 hrs)	9,000	8,181
Alloy Available (13,000 kg.)	8,125	8,125
Maximum Number of Parts *to be manufactured*	6,666	8,125

	(₹)	(₹)
Material (₹12.5 × 1.6 kg.)	20.00	20.00
Variable Overhead: Machine "A"	48.00	20.00
Variable Overhead: Machine "B"	50.00	55.00
Total Variable Cost *per unit*	118.00	95.00
Price Offered	145.00	115.00
Contribution *per unit*	27.00	20.00
Total Contribution *for units produced* ...(I)	1,79,982	1,62,500

Spare Part A will optimize the contribution.

(ii)

	Part A
Parts to be manufactured numbers	6,666
Machine A : to be used	4,000
Machine B : to be used	3,333
Underutilized Machine Hours (4,500 hrs. – 3,333 hrs.)	1,167
Compensation for unutilized machine hours (1,167hrs. × ₹60) ...(II)	70,020
Reduction in Price by 10%, Causing fall in Contribution of ₹14.50 *per unit* (6,666 units × ₹14.5) ...(III)	96,657
Total Contribution ...(I + II – III)	1,53,345

Problem-3

The profit for the year of R.J. Ltd. works out to 12.5% of the capital employed and the relevant figures are as under:

Sales.. ₹ 5,00,000

Direct Materials.. ₹ 2,50,000
Direct Labour... ₹ 1,00,000
Variable Overheads.. ₹ 40,000
Capital Employed.. ₹ 4,00,000

The new Sales Manager who has joined the company recently estimates for next year a profit of about 23% on capital employed, provided the volume of sales is increased by 10% and simultaneously there is an increase in Selling Price of 4% and an overall cost reduction in all the elements of cost by 2%.

Required

Find out by computing in detail the cost and profit for next year, whether the proposal of Sales Manager can be adopted.

Solution

Statement Showing "Cost and Profit for the Next Year"

Particulars	Existing Volume, etc.	Volume, Costs, etc. after 10% Increase	Estimated Sale, Cost, Profit, etc.*
	(₹)	(₹)	(₹)
Sale	5,00,000	5,50,000	5,72,000
Less: Direct Materials	2,50,000	2,75,000	2,69,500
Direct Labour	1,00,000	1,10,000	1,07,800
Variable Overheads	40,000	44,000	43,120
Contribution	1,10,000	1,21,000	1,51,580
Less: Fixed Cost#	60,000	60,000	58,800
Profit	50,000	61,000	92,780

(*) for the next year after increase in selling price @ 4% and overall cost reduction by 2%.

(#)

Fixed Cost = Existing Sales – Existing Marginal Cost – 12.5% on ₹4,00,000
= ₹5,00,000 – ₹3,90,000 – ₹50,000
= ₹60,000

Percentage Profit on Capital Employed equals to 23.19% $\left(\frac{₹92,780}{₹4,00,000} \text{x } 100\right)$

Since the Profit of ₹92,780 is more than 23% of capital employed, the proposal of the Sales Manager can be adopted.

Problem-4

A company manufactures two types of herbal product, A and B. Its budget shows profit figures after apportioning the fixed joint cost of ₹15 lacs in the proportion of the numbers of units sold. The budget for 2012, indicates:

	A	*B*
Profit (₹)	*1,50,000*	*30,000*
Selling Price / unit (₹)	*200*	*120*
P/V Ratio (%)	*40*	*50*

Required

Advise on the best option among the following, if the company expects that the number of units to be sold would be equal.

(i) *Due to exchange in a manufacturing process, the joint fixed cost would be reduced by 15% and the variables would be increased by 7½ %.*

(ii) *Price of A could be increased by 20% as it is expected that the price elasticity of demand would be unity over the range of price.*

(iii) *Simultaneous introduction of both the option, viz, (i) and (ii) above.*

Solution

Option (i)

Increase in profit when due to change in a manufacturing process there is reduction in joint fixed cost and increase in variable costs.

	(₹)
Revised Contribution from 12,000 units of A due to 7.5% increase in Variable Cost {12,000 units × (₹200 – ₹129)}	8,52,000
Revised Contribution from 12,000 units of B due to 7.5% increase in Variable Cost {12,000 units × (₹120 – ₹64.50)}	6,66,000
Total Revised Contribution	15,18,000
Less: Fixed Cost (₹15,00,000 – 15% × ₹15,00,000)	12,75,000
Revised Profit	2,43,000
Less: Existing Profit	1,80,000
Increase in Profit	63,000

Option (ii)

Increase in profit when the price of product A increased by 20% and the price elasticity of its demand would be unity over the range of price.

	(₹)
Budgeted Revenue from Product A (12,000 units × ₹200)	24,00,000
Revised Demand (in units) (₹24,00,000 / ₹240)	10,000
Revised Contribution (in ₹) [10,000 units × (₹240 – ₹120)]	12,00,000
Less: Existing Contribution (12,000 units × ₹80)	9,60,000
Increase in Profit (Contribution)	2,40,000

***Note:** Since Price Elasticity of Demand is 1, therefore the Revenue in respect of Products will remain same.

Option (iii)

Increase in profit on the simultaneous introduction of above two options.

	(₹)
Revised Contribution from Product A [10,000 units × (₹240 – ₹129)]	11,10,000
Revised Contribution from Product B [12,000 units × (₹120 – ₹64.50)]	6,66,000
Total Revised Contribution	17,76,000
Less: Revised Fixed Cost	12,75,000
Revised Profit	5,01,000
Less: Existing Profit	1,80,000
Increase in Profit	3,21,000

Advise

A comparison of increase in profit figures under above three options clearly indicates that the option (iii) is the best as it increases the profit of the concern by ₹3,21,000.

Note

The budgeted profit / (loss) for 2012 in respect of products A and B should be ₹2,10,000 and (₹30,000) respectively instead of ₹1,50,000 and ₹30,000.

Workings

1. Contribution per unit of each product:

	Product	
	A (₹)	**B (₹)**
Contribution *per unit* (Sales × P/V Ratio)	80 (₹200 × 40%)	60 (₹120 × 50%)

2. Number of units to be sold:

Total Contribution – Fixed Cost = Profit

Let x be the number of units of each product sold, therefore:

(80x + 60x) – ₹15,00,000 = ₹1,50,000 + ₹30,000

Or x = 12,000 units

Problem-5

You have been approached by a friend who is seeking your advice as to whether he should give up his job as an engineer, with a current salary of ₹14,800 per month and go into business on his own assembling and selling a component which he has invented. He can procure the parts required to manufacture the component from a supplier.

It is very difficult to forecast the sales potential of the component, but after some research, your friend has estimated the sales as follows:

(i) Between 600 to 900 components per month at a selling price of ₹250 per component.

(ii) Between 901 to 1,250 components per month at a selling price of ₹220 per component for the entire lot.

The costs of the parts required would be ₹140 for each completed component. However if more than 1,000 components are produced in each month, a discount of 5% would be received from the supplier of parts on all purchases.

Assembly costs would be ₹60,000 per month up to 750 components. Beyond this level of activity assembly costs would increases to ₹70,000 per month.

Your friend has already spent ₹30,000 on development, which he would write – off over the first five years of the venture.

Required

(i) Calculate for each of the possible sales levels at which your friend could expect to benefit by going into the venture on his own.

(ii) Calculate the 'Break – Even Point' of the venture for each of the selling price.

(iii) Advice your friend as to the viability of the venture.

Solution

The salary of ₹14,800 per month is a benefit foregone by going into business. It should therefore be considered as a minimum profit which must be earned p.m. from the new venture in order to be not worse – off than before.

Sum of ₹30,000 spent on the development work of the new venture cannot be recovered irrespective of the decision and thus it should be ignored.

At a Selling Price of	₹250
Contribution *per unit* (₹250 – ₹140)	₹110

Minimum Sales (units) to recover *assembly costs* of ₹60,000 p.m. and earn a *profit* of ₹14,800 p.m. (Break – even Sales Level)

$$\frac{₹60{,}000 + ₹14{,}800}{₹110} = 680 \text{ units}$$

Note that at 600 units and up to 679 units i.e. units below the break-even level the loss would be ₹110/- per unit. From 680 units up to 750 units i.e. on additional 70 units the total profit would be ₹7,700 (70 units × ₹110).

Minimum Sales (units) to recover *assembly cost* of ₹70,000 p.m. and earn a *profit* of ₹14,800 p.m. (Break – even Sales Level)

$$\frac{₹70{,}000 + ₹14{,}800}{₹110} = 770.909 \text{ units}$$

If the sales units are more than 770.909 units and up to 900 units, profit would be made. The total amount of profit comes to ₹14,200 [(900 units – 770.909 units) × ₹110]

It is not worthwhile to proceed if the demand of components is less than 680 units or between 750 to 770.909 units.

At a Selling Price of ₹220

Minimum Sales (units) to recover *assembly cost* of ₹70,000 p.m. and earn a *profit* of ₹14,800 p.m. (Break even – Sales Level)

$$\frac{₹70{,}000 + ₹14{,}800}{₹220 - ₹140} = 1{,}060 \text{ units}$$

Minimum Sales (units) to recover *assembly cost* of ₹70,000 p.m. and earn a profit of ₹14,800 p.m.; after availing a discount of 5% on the purchases of all parts.

$$\frac{₹70{,}000 + ₹14{,}800}{₹220 - \left(₹140 - \frac{5}{100} \times ₹140\right)} = 974.712 \text{ units}$$

Or 975 units

Conclusion

It is not worthwhile to sell between 900 and 1,000 units when no discount is available. Also, it is worthwhile selling at ₹220 if sales units are in excess of 1,000 units and a discount of 5% is available on the purchase of all components–parts.

Profit on the Sale (1,250 units) ₹23,950 (1,250 units × ₹87 – ₹84,800)

Advice on the viability of the venture

At a selling price of ₹250 he will not be at a loss if the demand of the component exceeds 680 units to 750 units and 770.909 units to 900 units.

At a selling price of ₹220, it is not worthwhile to sell if the demand is less than 1,000 components without availing a discount of 5%.

Problem-6

Mr. Rajesh is quite displeased and frustrated as despite his and his staff's best efforts, although the sales are increasing, the profits are declining over the last three years. He supplies you with the following information:

(₹ in '000's)

	2011 – 12	***2012 –13***	***2013 –14***
Sales (At ₹ 20 per unit)	*1,000*	*1,100*	*1,200*
Cost of Production:			
Variable	*260*	*240*	*160*
Fixed (Applied)	*390*	*360*	*240*
Opening Inventory (Added)	*50*	*200*	*250*
Closing Inventory (Deducted)	*200*	*250*	*50*
	500	*550*	*600*
Adjustment for Overheads Applied	*(30)*	*---*	*120*
Actual Cost of Goods Sold	*470*	*550*	*720*
Gross Profit	*530*	*550*	*480*
Less: Selling Expense (Semi – Variable)	*490*	*530*	*570*
Net Profit / (Loss)	*40*	*20*	*(90)*

Actual productions for the last three years were 65,000, 60,000 and 40,000 units respectively. 5,000 units were in stock at the beginning of 2011 – 12. Fixed manufacturing overheads are applied to production based on planned activity of 60,000 units every year. Actual overheads were ₹ 10,80,000 for past three – year period and were evenly incurred.

Required

Analyse the Profitability of each year.

Solution

Working Notes

		2011 – 12	2012 –13	2013 –14
1.	Units Sold	50,000	55,000	60,000
	$\left(\frac{\text{Sales}}{₹20}\right)$	$\left(\frac{₹10,00,000}{₹20}\right)$	$\left(\frac{₹11,00,000}{₹20}\right)$	$\left(\frac{₹12,00,000}{₹20}\right)$
2.	Variable Expenses *per unit*	₹4	₹4	₹4
	$\left(\frac{\text{Variable Cost}}{\text{Output}}\right)$	$\left(\frac{₹2,60,000}{65,000}\right)$	$\left(\frac{₹2,40,000}{60,000}\right)$	$\left(\frac{₹1,60,000}{40,000}\right)$

3. Variable Selling Expenses *per unit* (High – Low method)

$$= \frac{₹5,30,000 - ₹4,90,000}{55,000 \text{ units} - 50,000 \text{ units}}$$

= ₹8 *per unit*

4. Fixed Manufacturing Expenses = ₹10,80,000 / 3 years

= ₹3,60,000 p.a.

Fixed Selling Expenses = ₹4,90,000 – (50,000 units × ₹ 8)

= ₹90,000 p.a.

Total Fixed Costs = ₹3,60,000 + ₹90,000

= ₹4,50,000 p.a.

5. Contribution *per unit* = ₹20 – ₹4 – ₹8

= ₹8

Statement Showing "Profit for Three Years"

(Under Variable Costing)

(₹ in '000)

	2011–12	2012–13	2013–14
Units Sold (in units) (W.N.-1)	50,000	55,000	60,000
Sales	1,000	1,100	1,200
Less: Variable Costs:			
Manufacturing, ₹ 4 per unit (W.N.-2)	200	220	240
Selling Expenses, ₹ 8 per unit	400	440	480

Contribution		400	440	480
Less: Fixed Costs	(W.N.-4)	450	450	450
Net Profit / (Loss)		(50)	(10)	30

$$\text{Break – even Sales} = \frac{₹\,4,50,000}{₹\,8}$$

$$= 56,250 \text{ units}$$

The above statement shows that in 2011 – 2012 and 2012 –13 sales were below the break–even point. Due to which loss occurred during this period. It is only in 2013 – 14 that sales exceeded break–even point resulting in profit. The increasing sales trend really supports Mr. Rajesh's efforts. He need not feel frustrated but should continue the present sales trend.

Production during 2011–12 was of 65,000 units. This fell down to 60,000 units in 2012 – 13 and to 40,000 units in 2013 –14. The opening and closing inventories were valued by him at ₹ 10 per unit (including fixed cost of production) for arriving at the results shown under the given statement. This valuation of Mr. Rajesh was based on absorption costing method due to which book profits emerged during 2011–12 and 2012–13.

Mr. Rajesh should adjust his production in such a manner so that the net sales exceed the break – even point of 56,250 units per annum to increase his profits.

Problem-7

Gourmet Food Products is a new entrant in the market for chocolates. It has introduced a new product—Sweetee. This is a small rectangular chocolate bar. The bars are wrapped in aluminium foil and packed in attractive cartons containing 50 bars. A carton, is therefore, considered the basic sales unit. Although management had made detailed estimates of costs and volumes prior to undertaking this venture, new projections based on actual cost experience are now required.

Income Statements for the last two quarters are each thought to be representative of the costs and productive efficiency we can expected in the next few quarter. There were virtually no inventories on hand at the end of each quarter. The income statements reveal the following:–

	First Quarter (₹)	***Second Quarter (₹)***
Sales :		
50,000 × ₹ 24	*12,00,000*	*—*
70,000 × ₹ 24	*—*	*16,80,000*
Less: Cost of Goods Sold	*7,00,000*	*8,80,000*

Gross Margin	*5,00,000*	*8,00,000*
Less: Selling and Administration	*6,50,000*	*6,90,000*
Net Income / (Loss) before Taxes	*(1,50,000)*	*1,10,000*
Less: Tax	*(60,000)*	*44,000*
Net Income / (Loss)	*(90,000)*	*66,000*

The firm's overall marginal and average income tax rate is 40%. This 40% figure has been used to estimate the tax liability arising from the chocolate operations.

Required

(i) Management would like to know the breakeven point in terms of quarterly carton sales for the chocolates.

(ii) Management estimates that there is an investment of ₹ 30,00,000 in this product line. What quarterly carton sales and total revenue are required in each quarter to earn an after tax return of 20% per annum on investment?

(iii) The firm's marketing people predict that if the selling price is reduced by ₹ 1.50 per carton (₹ 0.03 off per chocolate bar) and a ₹ 1,50,000 advertising campaign among school children is mounted, sales will increase by 20% over the second quarter sales. Should the plan be implemented?

Solution

(i) Estimation of the Fixed and Variable Costs.

Variable Manufacturing Cost per carton:

$$= \frac{\text{Change in Costs}}{\text{Change in Activity}}$$

$$= \frac{₹8,80,000 - ₹7,00,000}{70,000 - 50,000}$$

$$= \frac{₹1,80,000}{20,000}$$

= ₹9 *per carton*

Fixed Manufacturing Costs:

Costs of Goods Sold = Fixed Manufacturing Cost + Variable Manufacturing Cost

₹7,00,000	=	Fixed Manufacturing Cost + (50,000 Cartons × ₹9)
Fixed Manufacturing Cost	=	₹7,00,000 – ₹4,50,000
	=	₹2,50,000

Variable Selling and Administration Cost per unit:

$$= \frac{₹6,90,000 - ₹6,50,000}{70,000 - 50,000}$$

$$= \frac{₹40,000}{20,000}$$

= ₹ 2 *per unit*

Fixed Selling & Administration Costs:

Total Selling & Admn. Costs	=	Fixed Selling & Admn. Cost + Variable Selling & Admn. Costs
₹6,50,000	=	Fixed Selling & Admn. Costs + (50,000 Cartons × ₹2)
Fixed Selling & Admn. Cost	=	₹6,50,000 – ₹1,00,000
	=	₹5,50,000

So the Total Variable Costs *per unit* are ₹11 *per unit* (₹9 + ₹2).

Total Fixed Costs are ₹8,00,000 *per quarter* (₹2,50,000 + ₹5,50,000).

Given Sale Price of ₹24 *per carton* and Variable Costs of ₹11 *per carton*, the Contribution *per carton* is ₹13 (₹24 – ₹11).

Breakeven Point (in terms of carton units)

$$= \frac{\text{Fixed cost (per quarter)}}{\text{Contribution per Carton}}$$

$$= \frac{₹8,00,000}{₹13}$$

= 61,539 Cartons

(ii) To earn an After Tax Return of 20% on ₹30,00,000, the Desired Annual After Tax Net Income is ₹6,00,000 (₹30,00,000 × 20%). The Quarterly After Tax Net Income will be ₹1,50,000. Given the Tax Rate of 40%, the Pre-tax Return will be ₹2,50,000 (₹1,50,000 × 100/60).

$$\text{Quarterly Sales (units)} = \frac{\text{Fixed Cost + Desired Return}}{\text{Contribution per unit}}$$

$$= \frac{₹(8,00,000+2,50,000)}{₹13}$$

$$= \frac{₹10,50,000}{₹13}$$

= 80,769 Cartons

Quarterly Sales Revenue = ₹19,38,456 (80,769 Cartons × ₹24)

(iii) The proposal involves reducing Selling Price from ₹24 *per carton* to ₹22.50 *per carton*. Hence the Contribution *per carton* will be ₹11.50 (₹22.50 – ₹11.00).

The increase in Advertising Costs will push Fixed Costs up by ₹1,50,000 to ₹9,50,000.

A 20% increase over second quarter's Sales would increase Sales form 70,000 cartons to 84,000 cartons.

The Expected Earnings Before Taxes will be ₹ 16,000 [(84,000 Cartons × ₹11.50) – ₹9,50,000].

After deducting Tax at 40%, the Net Income will be ₹9,600 (₹16,000 – ₹6,400).

Earning has reduced from ₹66,000 to ₹9,600, accordingly this plan should not be implemented.

Problem-8

Electro Life Ltd. is a leading Home Appliances manufacturer. The company uses just-in- time manufacturing process, thereby having no inventory. Manufacturing is done in batch size of 100 units which cannot be altered without significant cost implications. Although the products are manufactured in batches of 100 units, they are sold as single units at the market price. Due to fierce competition in the market, the company is forced to follow market price of each product. The following table provides the financial results of its four unique products:

	Alpha	***Beta***	***Gamma***	***Theta***	
Sales (units)	*2,00,000*	*2,60,000*	*1,60,000*	*3,00,000*	***Total***
	(₹)	*(₹)*	*(₹)*	*(₹)*	*(₹)*
Revenue	*26,00,000*	*45,20,000*	*42,40,000*	*32,00,000*	*145,60,000*
Less: Material Cost	*6,00,000*	*18,20,000*	*18,80,000*	*10,00,000*	*53,00,000*
Less: Labour Cost	*8,00,000*	*20,80,000*	*12,80,000*	*12,00,000*	*53,60,000*
Less: Overheads	*8,00,000*	*7,80,000*	*3,20,000*	*12,00,000*	*31,00,000*
Profit / (Loss)	*4,00,000*	*(1,60,000)*	*7,60,000*	*(2,00,000)*	*8,00,000*

Since, company is concerned about loss in manufacturing and selling of two products so, it has approached you to clear picture on its products and costs. You have conducted a detailed investigation whose findings are below:

The overhead absorption rate of ₹ 2 per machine hour has been used to allocate overheads into the above product costs. Further analysis of the overhead cost shows that some of it is caused by the number of machine hours used, some is caused by the number of batches produced and some are product specific fixed overheads that would be avoided if the product were discontinued. Other general fixed overhead costs would be avoided only by the closure of the factory. Numeric details are summarized below:

	₹	₹
Machine hour related		*6,20,000*
Batch related		*4,60,000*
Product specific fixed overhead:		
Alpha	*10,00,000*	
Beta	*1,00,000*	
Gamma	*2,00,000*	
Theta	*1,00,000*	*14,00,000*
General fixed overheads		*6,20,000*
		31,00,000

The other information is as follows:-

	Alpha	*Beta*	*Gamma*	*Theta*	*Total*
Machine Hours	*4,00,000*	*3,90,000*	*1,60,000*	*6,00,000*	*15,50,000*
Labour Hours	*1,00,000*	*2,60,000*	*1,60,000*	*1,50,000*	*6,70,000*

Required

(i) Prepare a profitability statement that is more useful for decision making than the profit statement prepared by Electro Life Ltd.

(ii) Calculate the break-even volume in batches and also in approximate units for Product 'Alpha'.

Solution

(i) Statement Showing "Profitability of Electro Life Ltd"

	Products (Amount in ₹)				
	Alpha	**Beta**	**Gamma**	**Theta**	**Total**
Sales	26,00,000	45,20,000	42,40,000	32,00,000	1,45,60,000

Direct Materials	6,00,000	18,20,000	18,80,000	10,00,000	53,00,000
Direct Wages	8,00,000	20,80,000	12,80,000	12,00,000	53,60,000
Overheads (W.N.2):					
Machine Related	1,60,000	1,56,000	64,000	2,40,000	6,20,000
Batch Related	1,00,000	1,30,000	80,000	1,50,000	4,60,000
Contribution	9,40,000	3,34,000	9,36,000	6,10,000	28,20,000
Product Specific Fixed Overheads	10,00,000	1,00,000	2,00,000	1,00,000	14,00,000
Gross Profit	(60,000)	2,34,000	7,36,000	5,10,000	14,20,000
General Fixed Overheads					6,20,000
Profit					8,00,000

(ii) Break-even Point

Total Sale Value of Product 'Alpha' = ₹ 26,00,000

Total Contribution of Product 'Alpha' = ₹ 9,40,000

Specific Fixed Overheads (Product Alpha) = ₹ 10,00,000

Break-even Sales (₹) $= \frac{\text{Specific Fixed Cost}}{\text{Total Contribution}} \text{x Total Sales Value}$

$= \frac{₹\ 10,00,000}{₹\ 9,40,000} \text{x} ₹26,00,000$

$= ₹27,65,957.45$

Break-even Sales (units) $= \frac{₹\ 27,65,957.45}{₹\ 13.00}$

= 2,12,766 units

However, production must be done in batches of 100 units. Therefore, **2,128 batches** are required for break even. Due to the production in batches, 34 units (2,128 batches × 100 units – 2,12,766 units) would be produced extra. These 34 units would add extra cost ₹282.20 (34 units × ₹8.3*). Accordingly, break-even units as calculated above will increase by 22 units $\left(\frac{₹\ 282.20}{₹\ 13.00}\right)$.

(*) $\left(\frac{₹\ 6,00,000 + ₹\ 8,00,000 + ₹\ 1,60,000 + ₹\ 1,00,000}{2,00,000 \text{ units}}\right)$

Break-even units of product 'Alpha' is 2,12,788 units (2,12,766 units + 22 units).

Workings

W.N.-1

Calculation Showing Overhead Rates

Overhead's Related Factors	Overhead Cost (₹) [a]	Total No. of Units of Factors [b]	Overhead Rate (₹) [a] / [b]
Machining Hours	6,20,000	15,50,000 hrs.	0.40
Batch Production	4,60,000	9,200 batches	50.00

W.N.-2

Statement Showing - Overhead Costs Related to Product

Particulars	Alpha	Beta	Gamma	Theta
Machining hrs. related overheads	₹ 1,60,000 (4,00,000 hrs × ₹0.40)	₹ 1,56,000 (3,90,000 hrs × ₹0.40)	₹ 64,000 (1,60,000 hrs × ₹0.40)	₹ 2,40,000 (6,00,000 hrs × ₹0.40)
Batch related overheads	₹1,00,000 (2,000 batches × ₹50)	₹1,30,000 (2,600 batches × ₹50)	₹80,000 (1,600 batches × ₹50)	₹1,50,000 (3,000 batches × ₹50)

Opportunity Cost

Problem-9

A company can make any one of the 3 products X, Y or Z in a year. It can exercise its option only at the beginning of each year.

Relevant information about the products for the next year is given below.

	X	*Y*	*Z*
Selling Price (₹ / unit)	*10*	*12*	*12*
Variable Costs (₹ / unit)	*6*	*9*	*7*
Market Demand (unit)	*3,000*	*2,000*	*1,000*
Production Capacity (unit)	*2,000*	*3,000*	*900*
Fixed Costs (₹)	*30,000*		

Required

Compute the opportunity costs for each of the products.

Solution

		X	Y	Z
I.	Contribution *per unit* (₹)	4	3	5
II.	Units (Lower of Production / Market Demand)	2,000	2,000	900
III.	Possible Contribution (₹) [I × II]	8,000	6,000	4,500
IV.	Opportunity Cost* (₹)	6,000	8,000	8,000

(*)

Opportunity cost is the maximum possible contribution forgone by not producing alternative product i.e. if Product X is produced then opportunity cost will be maximum of (₹ 6,000 from Y, ₹ 4,500 from Z).

Incremental Revenue / Differential Cost

Problem-10

Maruthi Agencies has received an order from a valuable client for supplying 3,00,000 pieces of a component at ₹ 550 per unit at a uniform rate of 25,000 units a month.

Variable manufacturing costs amount to ₹ 404.70 per unit, of which direct materials is ₹ 355 per unit. Fixed production overheads amount to ₹ 30 lacs per annum, including depreciation. There is a penalty/reward clause of ₹ 30 per unit for supplying less/more than 25,000 units per month. To adhere to the schedule of supply, the company procured a machine worth ₹ 14.20 lacs which will wear out by the end of the year and will fetch ₹ 3.55 lacs at the year end. After this supply of machine, the supplier offers another advanced machine which will cost ₹ 10.65 lacs, will wear out by the year end and not have any resale value. If the advanced machine is purchased immediately, the purchaser will exchange the earlier machine supplied at the price of the new machine. Fixed costs of maintaining the advanced machine will increase by ₹ 14,200/- per month for the whole year. While the old machine had the capacity to complete the production in 1 year, the new machine can complete the entire job in 10 months. The new machine will have material wastage of 0.5% . Assume uniform production throughout the year for both the machines.

Required

Using incremental cost/revenue approach, decide whether the company should opt for the advanced version.

Solution

	Old (₹)	New (₹)	Incremental
Depreciation (₹14.20 lakhs – ₹3.55 lakhs)	10,65,000	10,65,000	---
Fixed Cost Increase (12 months × ₹14,200)	---	1,70,400	(-) 1,70,400
Resale Value	3,55,000	---	(-) 3,55,000
Material (₹ 355 × 0.5% × 3,00,000 pieces)	---	5,32,500	(-) 5,32,500
Increase in Costs in New Machine Purchased			(-) 10,57,900
Penalty ₹30 *per unit*	---	---	---
Reward ₹30 *per unit* (5,000 units *per month* × 10 months × ₹30)	---	15,00,000	15,00,000
Gain			4,42,100

Decision

Buy the advanced version.

Working Note

Old Machine's Production is 25,000 units *per month.* Hence, no penalty and no reward.

New Machine's Production is 30,000 units $\left(\frac{3,00,000\text{units}}{10\text{months}}\right)$ *per month.*

Hence, there is reward for 5,000 units (30,000 units – 25,000 units) *per month*.

Cost Indifference Point

Problem-11

The following are cost data for three alternative ways of processing the clerical work for cases brought before the LC Court System:

	A *Manual (₹)*	*B* *Semi-Automatic (₹)*	*C* *Fully-Automatic (₹)*
Monthly fixed costs:			
Occupancy	*15,000*	*15,000*	*15,000*
Maintenance contract	---	*5,000*	*10,000*
Equipment lease	---	*25,000*	*1,00,000*

Unit variable costs (per report):			
Supplies	*40*	*80*	*20*
Labour	*₹200* *(5 hrs × ₹40)*	*₹60* *(1 hr × ₹60)*	*₹20* *(0.25 hr × ₹80)*

Required

(i) *Calculate cost indifference points. Interpret your results.*

(ii) *If the present case load is 600 cases and it is expected to go up to 850 cases in near future, which method is most appropriate on cost considerations?*

Solution

(i) Cost Indifference Point

	A and B (₹)	**A and C (₹)**	**B and C (₹)**
Differential Fixed Cost ...(I)	₹30,000 (₹45,000 – ₹15,000)	₹1,10,000 (₹1,25,000 – ₹15,000)	₹80,000 (₹1,25,000 – ₹45,000)
Differential Variable Costs ...(II)	₹100 (₹240 –₹140)	₹200 (₹240 – ₹40)	₹100 (₹140 – ₹40)
Cost Indifference Point ...(I/II) (Differential Fixed Cost / Differential Variable Costs *per case*)	300 Cases	550 Cases	800 Cases

Interpretation of Results

At activity level below the indifference points, the alternative with lower fixed costs and higher variable costs should be used. At activity level above the indifference point alternative with higher fixed costs and lower variable costs should be used.

No. of Cases	**Alternative to be Chosen**
Cases ≤ 300	Alternative ‘A’
300 ≥ Cases ≤ 800	Alternative ‘B’
Cases ≥ 800	Alternative ‘C’

(ii) Present case load is 600. Therefore, alternative B is suitable. As the number of cases is expected to go upto 850 cases, alternative C is most appropriate.

Problem-12

X Ltd. wants to replace one of its old machines. Three alternative machines namely M_1, M_2 and M_3 are under its consideration. The costs associated with these machines are as under:

	M_1	M_2	M_3
	₹	₹	₹
Direct material cost p.u……………….....	*50*	*100*	*150*
Direct labour cost p.u……………………	*40*	*70*	*200*
Variable overhead p.u……………………	*10*	*30*	*50*
Fixed cost p.a…………………………….	*2,50,000*	*1,50,000*	*70,000*

Required

(i) Compute the cost indifference points for these alternatives.

(ii) Based on these points suggest a most economical alternative machine to replace the old one when the expected level of annual production is 1,200 units.

Solution

Computation of Cost Indifference Points *for three alternatives*

Cost Indifference Point of *two machines* = $\frac{\text{Difference in Fixed Cost}}{\text{Difference in Variable Cost per unit}}$

Machine M_1 & M_2 $= \frac{₹\,2,50,000 - ₹\,1,50,000}{(₹100 + ₹\,70 + ₹\,30) - (₹\,50 + ₹\,40 + ₹10)}$

$= \frac{₹1,00,000}{₹\,100}$

= 1,000 units

Machine M_2 & M_3 $= \frac{₹\,1,50,000 - ₹\,70,000}{(₹\,150 + ₹\,200 + ₹\,50) - (₹\,100 + ₹\,70 + ₹\,30)}$

$= \frac{₹\,80,000}{₹\,200}$

= 400 units

Machine M_1 & M_3 $= \frac{₹\,2,50,000 - ₹\,70,000}{(₹\,150 + ₹\,200 + ₹\,50) - (₹\,50 + ₹\,40 + ₹\,10)}$

$= \frac{₹\,1,80,000}{₹\,300}$

= 600 units

From the above computations, it is clear that at activity level below the indifference point the alternative (machine) with lower fixed cost and higher variable costs should be used. In case the activity level exceeds the indifference point, a machine with lower variable cost per unit (or higher contribution per unit) and higher fixed cost, is more profitable to operate.

At the activity level equal to the indifference point both machines are on equal footing. Hence from the above we conclude as follows:

Activity Level	**Machine Preference**
Less than 400 units	$\mathbf{M_3}$
Exactly 400 units	**Either $\mathbf{M_2}$ or $\mathbf{M_3}$**
Above 400 units but *less than* 1,000 units	$\mathbf{M_2}$
Exactly 1,000 units	**Either $\mathbf{M_1}$ or $\mathbf{M_2}$**
Above 1,000 units	$\mathbf{M_1}$

When expected level of activity is 1,200 units i.e. more than 1,000 units, Machine M_1 should be used.

Problem-13

XY Ltd. makes two products X and Y, whose respective fixed costs are F_1 and F_2. You are given that the unit contribution of Y is one. fifth less than the unit contribution of X, that the total of F_1 and F_2 is ₹ 1,50,000, that the BEP of X is 1,800 units (for BEP of X F_2 is not considered) and that 3,000 units is the indifference point between X and Y.(i.e. X and Y make equal profits at 3,000 unit volume, considering their respective fixed costs). There is no inventory buildup as whatever is produced is sold.

Required

Find out the values F_1 and F_2 and units contributions of X and Y.

Solution

Let C_x be the Contribution per unit of Product X.

Therefore Contribution per unit of Product Y $=C_y=4/5C_x = 0.8C_x$

Given $F_1 + F_2 = 1{,}50{,}000$,

$F_1 = 1{,}800C_x$ (Break even Volume × Contribution per unit)

Therefore $F_2 = 1{,}50{,}000 – 1{,}800C_x$.

$3{,}000C_x – F_1 = 3{,}000 \times 0.8C_x – F_2$ or $3{,}000C_x – F_1 = 2{,}400\,C_x - F_2$ (Indifference Point)

i.e., $3{,}000C_x – 1{,}800C_x = 2{,}400C_x – 1{,}50{,}000 + 1{,}800C_x$

i.e., 3,000C_x = 1,50,000, Therefore C_x = ₹ 50/- (1,50,000 / 3,000)

Therefore Contribution per unit of X = ₹ 50

Fixed Cost of X = F_1 = ₹ 90,000 (1,800 × 50)

Therefore Contribution per unit of Y is ₹ 50 × 0.8 = ₹ 40 and

Fixed Cost of Y = F_2 = ₹ 60,000 (1,50,000 – 90,000)

The Value of F_1 = ₹ 90,000, F_2 = ₹ 60,000 and X = ₹ 50 and ₹ 40

Relevant Costing

Problem-14

XL Polymers, located in Sahibabad Industrial Area, manufactures high quality industrial products. AT Industries has asked XL Polymers for a special job that must be completed within one week.

Raw material R_1 (highly toxic) will be needed to complete the AT Industries' special job. XL Polymers purchased the R_1 two weeks ago for ₹7,500 for a job 'A' that recently was completed. The R_1 currently in stock is the excess from that job and XL Polymers had been planning to dispose of it. XL Polymers estimates that it would cost them ₹1,250 to dispose of the R_1. Current replacement cost of R_1 is ₹6,000.

Special job will require 250 hours of labour G_1 and 100 hours of labour G_2. XL Polymers pays their G_1 and G_2 employees ₹630 and ₹336 respectively for 42 hours of work per week. XL Polymers anticipates having excess capacity of 150 [G_1] and 200 [G_2] labour hours in the coming week. XL Polymers can also hire additional G_1 and G_2 labour on an hourly basis; these part-time employees are paid an hourly wage based on the wages paid to current employees.

Suppose that material and labour comprise XL Polymers's only costs for completing the special job.

Required

Calculate the 'Minimum Price' that XL Polymers should bid on this job?

Solution

Opportunity Cost of Labour - The G_2 labour has zero opportunity cost as there is no other use for the time already paid for and is available. However, XL Polymers needs to pay an additional amount for G_1 labour. This amount can be save if the special job were not there.

G_1 labour:	
Hours Required	250

Hours Available	150
Extra Hours Needed	100
Cost *per hour* (₹630/42hrs)	₹15
Opportunity Cost	₹1,500

Thus, the 'Opportunity Cost of Labour' for completing the special job is ₹1,500.

Opportunity Cost of Material – XL Polymers has no alternative use for the R_1, they must dispose of it at a cost of ₹1,250. Thus, XL Polymers actually *saves* ₹1,250 by using the materials for the AT Industries' special job. Consequently, the 'Opportunity Cost of Material' is - ₹1,250 (i.e., the opportunity cost of this resource is negative).

The *minimum price* is the price at which XL Polymers just recovers its 'Opportunity Cost'. XL Polymers's 'Total Opportunity Cost' is ₹250 (₹1,500 − ₹1,250). Accordingly, minimum Price for the Special Job is ₹250.

Problem-15

A company has to decide whether to accept a special order or not for a certain product M in respect of which the following information is given:

Material A required	*5,000 kg*	*Available in stock. It was purchased 5 years ago at ₹ 35 per kg. If not used for M, it can be sold as scrap @ ₹ 15 per kg.*
Material B required	*8,000 kg*	*This has to be purchased at ₹ 25 per kg from the market.*
Other hardware items	*₹ 10,000*	*To be incurred*
Dept X - Labour oriented	*5 men for 1 month @ ₹ 7,000 per month per man*	*Labour to be freshly hired. No spare capacity available.*
Dept Y - Machine oriented	*3,000 machine hours @ ₹ 5 per machine hour*	*Existing spare capacity may be used.*
Patten and Specification	*₹ 15,000*	*To be incurred for M, but after the order, it can be sold for ₹ 2,000*

Required

Considering relevant costs, find out the minimum value above which the company may accept the order.

Solution

Determination of Minimum Value of Special Order

Cost Element	Relevant / Irrelevant	Calculation	Amt. (₹)
Material – A	Realisable value is relevant.	5,000 Kg. × ₹15	75,000
Material – B	Relevant as it has to be purchased.	8,000 Kg. × ₹25	2,00,000
Other hardware items	Relevant as it is to be incurred.	----	10,000
Dept X – Labour oriented	Relevant as fresh labours are to be hired.	5 men × 1 month × ₹7,000	35,000
Dept Y – Machine oriented	Irrelevant, as spare capacity is available.	----	----
Pattern and Specification	Relevant, Net cost after considering its resale value.	₹ 15,000 − ₹ 2,000	13,000
Minimum Value of Special Order			**3,33,000**

Problem-16

S Limited is engaged in manufacturing activities. It has received a request from one of its important customers to supply a product which will require conversion of material 'M', which is a non-moving item.

The following details are available:

Book value of material M.......... ₹ 60

Realisable value of material M.......... ₹ 80

Replacement cost of material M.......... ₹ 100

It is estimated that conversion of one unit of 'M' into one unit of the finished product will require one labour hour. At present, labour is paid at the rate of ₹ 20 per hour. Other costs are as follows:

Out-of-pocket expenses.......... ₹ 30 per unit

Allocated overheads.......... ₹ 10 per unit

The labour will be re-deployed from other activities. It is estimated that the temporary redeployment will not result in loss of contribution. The employees to be re-deployed are permanent employees of the company.

Required

Estimate the minimum price to be charged from the customer so that the company is not worse off by executing the order.

Solution

Relevant Cost of Producing One Unit of the Finished Product

	(₹)
Cost of Material 'M' (Realisable Value)	80
Cost of Labour (Being Sunk Cost)	0
Out-of-Pocket Expenses	30
	110

Allocated Overhead is not relevant for the decision. The customer should be charged ₹110 *per unit*.

Problem-17

A research project, to date, has cost a company ₹ 1,25,000 and is under review. It is anticipated that, should the project be allowed to proceed, it will be completed in about one year and can be sold for ₹ 2,00,000. The following additional information is available:

(i) *Materials have just been received for ₹ 30,000. These are extremely toxic, and if not used in the project, have to be disposed of by special means at ₹ 7,500.*

(ii) *Labour: ₹ 37,500. The men are highly skilled. If they are released from the Research Project, they may be transferred to the Works Department of the company and consequently the sales could increase by ₹ 75,000. The accountant estimates that the prime cost of those sales would be ₹ 50,000 and the overhead absorbed (all fixed) would amount to ₹ 12,500.*

(iii) *Share of General Building Expenses: ₹ 17,500. The Managing Director is not sure what is included in this amount, but the accounts staff charge similar amounts each year to each department.*

Required

Advise whether the project should be allowed to proceed and explain the reasons for the treatment of each of the amounts above in your analysis.

✍ **Solution**

Research Project

Particulars	**Relevancy**	**Reason**	**Amount(₹)**
Project Cost *till date*	Not Relevant	Sunk Cost	-
Sale Price of the Project	Relevant	Incremental Revenue/ Opportunity Gain	2,00,000
Cost of Materials Received	Not Relevant	Sunk Cost	-
Cost of Disposal of Materials	Relevant	Avoidable/ Opportunity Cost	7,500
Cost of Labour	Not Relevant	Common Costs	-
Contribution Lost *on the alternative use*	Relevant	Opportunity Cost [Sales – (Prime Cost - Labour)]	(62,500)
Absorbed Fixed Overheads	Not Relevant	Sunk Cost	-
Share of General Building Expenses	Not Relevant	Sunk Costs	-
Total Incremental Inflow *if the project is proceed with*			1,45,000

Decision

Better to continue the project.

Problem-18

Golden Bird Airlines Ltd. operates its services under the brand 'Golden Bird'. The 'Golden Bird' route network spans prominent business metropolis as well as key leisure destinations across the Indian subcontinent. 'Golden Bird', a low-fare carrier launched with the objective of commoditizing air travel, offers airline seats at marginal premium to train fares across India.

Profits of the 'Golden Bird' have been decreasing for several years. In an effort to improve the company's performance, consideration is being given to dropping several flights that appear to be unprofitable.

Income statement for one such flight from 'New Delhi' to 'Leh' (GB - 022) is given below (per flight):

	₹	₹
Ticket Revenue *(175 seats x 60% Occupancy x ₹ 7,000 ticket price)*		*7,35,000*

Less: Variable Expenses (₹ 1,400 per person)		*1,47,000*
Contribution Margin		*5,88,000*
Less:Flight Expenses:		
Salaries, Flight Crew	*1,70,000*	
Salaries, Flight Assistants	*31,500*	
Baggage Loading and Flight Preparation	*63,000*	
Overnight Costs for Flight Crew and Assistants at destination	*12,600*	
Fuel for Aircraft	*2,38,000*	
Depreciation on Aircraft	*49,000**	
Liability Insurance	*1,47,000*	
Flight Promotion	*28,000*	
Hanger Parking Fee for Aircraft at destination	*7,000*	*7,46,100*
Net Gain / (Loss)		*(1,58,100)*

** Based on obsolescence*

The following additional information is available about flight GB-022.

1. *Members of the flight crew are paid fixed annual salaries, whereas the flight assistants are paid by the flight.*
2. *The baggage loading and flight preparation expense is an allocation of ground crew's salaries and depreciation of ground equipment.*
3. *One third of the liability insurance is a special charge assessed against flight GB-022 because in the opinion of insurance company, the destination of the flight is in a "high-risk" area.*
4. *The hanger parking fee is a standard fee charged for aircraft at all airports.*
5. *If flight GB-022 is dropped, 'Golden Bird' Airlines has no authorization at present to replace it with another flight.*

Required

Using the data available, prepare an analysis showing what impact dropping flight GB-022 would have on the airline's profit.

Solution

Statement Showing Impact on Airline's Profit if Flight GB-022 is Discontinued

		₹
Contribution Margin lost if the flight is discontinued		(5,88,000)
Less: Flight Costs which can be avoided if the flight is discontinued:		
	₹	
Flight Promotion	28,000	
Fuel for Aircraft	2,38,000	
Liability Insurance (1/3 x ₹ 1,47,000)	49,000	
Salaries, Flight Assistants	31,500	
Overnight Costs for Flight Crew and Assistants	12,600	3,59,100
		(2,28,900)

If Golden Bird Airlines Ltd. goes for discontinuation of flight GB-022, its profit will go down by ₹ 2, 28,900.

Following costs are not relevant to the decision:

- Salaries, flight crew - Fixed annual salaries which will not change
- Baggage loading and flight preparation- This is an allocated cost, which will continue even if the flight is discontinued.
- Depreciation of aircraft -Sunk Cost
- Liability insurance (two third) - Sunk Cost
- Hanger parking fee- This cost will be incurred regardless of whether the flight is made.

Problem-19

A company had nearly completed a job relating to construction of a specialised equipment, when it discovered that the customer had gone out of business. At this stage, the position of the job was as under:

	(₹)
Original cost estimate	*1,75,200*
Costs incurred so far	*1,48,500*
Costs to be incurred	*29,700*
Progress payment received from original customer	*1,00,000*

After searches, a new customer for the equipment has been found. He is interested to take the equipment, if certain modifications are carried out. The new customer wanted the equipment in its original condition, but without its control device and with certain other modifications. The costs of these additions and modifications are estimated as under:

Direct Materials (at cost)	*₹ 1,050*
Direct Wages Dept.: A	*15 men days*
Dept.: B	*25 men days*
Variable Overheads	*25% of Direct Wages in each Dept.*
Delivery Costs	*₹ 1,350*

Fixed overheads will be absorbed at 50% of direct wages in each department.

The following additional information is available:

(1) The direct materials required for the modification are in stock and if not used for modification of this order, they will be used in another job in place of materials that will now cost ₹ 2,250.

(2) Department A is working normally and hence any engagement of labour will have to be paid at the direct wage rate of ₹ 120 per man day.

(3) Department B is extremely busy. Its direct wages rate is ₹ 100 per man day and it is currently yielding a contribution of ₹ 3.20 per rupee of direct wages.

(4) Supervisory overtime payable for the modification is ₹ 1,050.

(5) The cost of the control device that the new customer does not require is ₹ 13,500. If it is taken out, it can be used in another job in place of a different mechanism. The latter mechanism has otherwise to be bought for ₹ 10,500. The dismantling and removal of the control mechanism will take one man day in department A.

(6) If the conversion is not carried out, some of the materials in the original equipment can be used in another contract in place of materials that would have cost ₹ 12,000. It would have taken 2 men days of work in department A to make them suitable for this purpose. The remaining materials will realize ₹ 11,400 as scrap. The drawings, which are included as part for the job can he sold for ₹ 1,500.

Required

Calculate the minimum price, which the company can afford to quote for the new customer as staled above.

Solution

Statement of Minimum Price Which the Company Can Afford to Quote for the New Customer (Based on Relevant Cost)

	(₹)	(₹)
Cost to be incurred *to bring the equipment in its original condition*		29,700
Direct Material (Replacement Value)		2,250
Direct Wages		
Dept. A: (15 men days × ₹120)	1,800	
Dept. B: (25 men days × ₹100)	2,500	
Opportunity Cost of Contribution Lost by Dept. B (₹2,500 × ₹3.20)	8,000	12,300
Variable Overheads [25% × (₹1,800 + ₹2,500)]		1,075
Delivery Costs		1,350
Supervisory Overtime *payable for modification*		1,050
Saving Due to Alternative Use of Control Device		
Bought Out Price	10,500	
Less: Dismantling & Removal Cost (1 man day × ₹120)	120	
Less: Variable Cost (25% × ₹120)	30	(10,350)
Net Loss on Material Cost Savings (W.N.)		11,700
Opportunity Cost of Remaining Materials *which can be sold as scrap*		11,400
Opportunity Cost of Sale of Drawings		1,500
Total Minimum Price which may be quoted		61,975

Working Note

	(₹)
Loss on Material Cost Saving of Equipment	12,000
Less: Conversion Cost (2 man days × ₹120)	240
Less: Variable Overheads (25% × ₹240)	60
Net Loss on Material Cost Saving of Equipment	11,700

Problem-20

B Ltd. is a company that has, in stock, materials of type XY that cost ₹ 75,000, but that are now obsolete and have a scrap value of only ₹ 21,000. Other than selling the material for scrap, there are only two alternative uses for them.

Alternative-1

Converting the obsolete materials into a specialized product, which would require the following additional work and materials:

Material A	*600 units*
Material B	*1,000 units*
Direct Labour	
5,000 hours unskilled	
5,000 hours semi skilled	
5,000 hours highly skilled	
Extra selling and delivery expenses	*₹ 27,000*
Extra advertising	*₹ 18,000*

The conversion would produce 900 units of saleable product and these could be sold for ₹ 300 per unit.

Material A is already in stock and is widely used within the firm. Although present stocks together with orders already planned, will be sufficient to facilitate normal activity and extra material used by adopting this alternative will necessitate such materials being replaced immediately. Material B is also in stock, stock, but is unlikely that any additional supplies can be obtained for some considerable time, because of an industrial dispute. At the present time material B is normally used in the production of product Z, which sells at ₹ 390 per unit and incurs total variable cost (excluding Material B) of ₹ 210 per unit. Each unit of product Z uses four units of Material B. The details of Materials A and B are as follows:

	Material A	*Material B*
	(₹)	*(₹)*
Acquisition cost at the time of purchase	*100 per unit*	*₹ 10 per unit*
Net realizable value	*85 per unit*	*₹ 18 per unit*
Replacement cost	*90 per unit*	*-*

Alternative-2

Adopting the obsolete materials for use as a substitute for a sub-assembly that is regularly used within the firm. Details of the extra work and materials required are as follows:

Material C	*1,000 units*

Direct Labour:

4,000 hours unskilled

1,000 hours semi-skilled

4,000 hours highly skilled

1,200 units of the sub-assembly are regularly used per quarter at a cost of ₹ 900 per unit. The adaptation of material XY would reduce the quantity of the sub-assembly purchased from outside the firm to 900 units for the next quarter only. However, since the volume purchased would be reduced, some discount would be lost and the price of those purchased from outside would increase to ₹ 1,050 per unit for that quarter.

Material C is not available externally thought 1,000 units required would be available from stocks, it would be produced as extra production. The standard cost per unit of Material C would be as follows:

	(₹)
Direct labour, 6 hour unskilled labour	18
Raw materials	13
Variable overhead: 6 hours at ₹ 1	06
Fixed overhead: 6 hours at ₹ 3	18
	55

The wage rate and overhead recover rates for B Ltd. are:

Variable overhead	₹ 1 per direct labour hour
Fixed overhead	₹ 2 per direct labour hour
Unskilled labour	₹ 3 per direct labour hour
Semi-skilled labour	₹ 4 per direct labour hour
Highly skilled labour	₹ 5 per direct labour hour

The unskilled labour is employed on a casual basis and sufficient labour can be acquired to exactly meet the production requirements. Semi-skilled labour is part of the permanent labour force, but the company has temporary excess supply of this type of labour at the present time. Highly skilled labour is in short supply and cannot be increased significantly in the short-term, this labour is presently engaged in meeting the, demand for product L, which requires 4 hours of highly skilled labour. The contribution from the sale of one unit of product L is ₹ 24.

Required

Present cost information advising whether the stocks of Material XY should be sold, converted into a specialized product (Alternative 1) or adopted for use as a substitute for a sub-assembly (Alternative 2).

Solution

Alternative 1 – Conversion Vs Immediate Sale

	(₹)
Sales Revenue (900 units at ₹ 300 per unit) [Refer to W.N.-1]	2,70,000
Less: Relevant Costs	
Material XY Opportunity Cost [Refer to W.N.-2]	21,000
Material A (₹90 *per unit*) [Refer to W.N.-3]	54,000
Material B (1,000 units @ ₹ 45 per unit) [Refer to W.N.-4]	45,000
Direct Labour, Un-skilled (5,000 hours @ ₹3 *per hour*)	15,000
Direct Labour, Semi-skilled	Nil
Direct Labour, Highly-skilled (5,000 hours @ ₹11) [Refer to W.N.-5]	55,000
Variable Overheads (15,000 hours @ ₹1) [Refer to W.N.-6]	15,000
Extra Selling and Delivery Expenses	27,000
Extra Advertising	18,000
Fixed Advertising (Remain Same, Not Relevant)	---
Net Relevant Savings	20,000

Alternative 2 – (Adaptation Vs Immediate Sale)

	(₹)
Normal Spending (1,200 units @ ₹ 900 *per unit*)	10,80,000
Less: Revised Spending (900 units @ ₹ 1,050 *per unit*) [Refer to W.N.-7]	9,45,000
Saving on Purchase of Sub-Assembly	1,35,000
Less: Relevant Costs	
Material XY Opportunity Cost [Refer to W.N.-2]	21,000
Material C (1,000 units @ ₹37) [Refer to W.N.-8]	37,000
Direct Labour, Unskilled (4,000 hours @ ₹ 3 *per hour*)	12,000
Direct Labour, Semi-skilled	Nil
Direct Labour, Highly-skilled (4,000 hours @ ₹11 *per hour*) [Refer to W.N.- 5, 6]	44,000

Variable Overheads (9,000 hours @ ₹1 *per hour*) [Refer to W.N.-6]	9,000
Fixed Overheads	---
Net Relevant Savings	12,000

Evaluation

The evaluation of two alternatives clearly shows that Alternative 1, yields higher net revenue of ₹8,000 (₹20,000 – ₹12,000). Hence because of higher net revenue of Alternative 1, it is advisable to convert material XY into a specialized product.

Working Notes

1. There will be a additional sales revenue of ₹2,70,000 if Alternative 1 is chosen.

2. Acceptance of either Alternative 1 or 2 will mean a loss of revenue of ₹21,000 from the sale of the obsolete material XY and hence it is an opportunity cost for both of the alternatives. The original purchase cost of ₹75,000 is a sunk cost and thus not relevant.

3. Acceptance of Alternative 1 will mean that material A must be replaced at an additional cost of ₹54,000.

4. Acceptance of Alternative 1 will mean diversion of material B from the production of product Z. The excess of relevant revenues over relevant cost for product Z is ₹180 (₹390 – ₹210) and each unit of product Z uses four units of material B. The lost contribution (excluding the cost of material B which is incurred for both alternatives) will therefore be ₹45 for each unit of material B that is used for converting the obsolete materials into a specialised product.

5. Unskilled labour can be matched exactly to the company's production requirements. Hence acceptance of either alternative 1 or 2 will cause the company to incur additional unskilled labour cost at ₹3 for each hours. It is assumed that the semi-skilled labour will be able to meet the extra requirements of either alternatives at no extra cost to the company. Hence, cost of semi-skilled labour will not be relevant. Skilled labour is in short supply and can only be obtained by reducing the production of product L, resulting in a loss of contribution of ₹24 (given) or ₹6 per hour of skilled labour. Hence the relevant labour cost will be ₹6 (contribution lost per hour) + ₹5 (hourly rate of skilled labour) i.e. ₹11 per hour.

6. It is assumed that for each direct labour of input, variable overhead will increase by ₹1 hence for each alternative using additional direct labour hours, variable overheads will increase.

7. The cost of purchasing the sub-assembly will be reduced by ₹1,35,000 if the second alternative is chosen and so these savings are relevant to the decision.

8. The company will incur additional variable costs of ₹37 for each unit of material C that is manufactured, so the fixed overheads for material C viz. ₹18/- per unit is not a relevant cost.

Sale or Further Processing Decision

Problem-21

A process industry unit manufactures three joint products: A, B and C. C has no realisable value unless it undergoes further processing after the point of separation. The cost details of C are as follows:

	p.u.
	₹
Upto point of separation	
Marginal cost……………………………..	*30*
Fixed Cost…………………………………	*20*
After point of separation	
Marginal cost…………………..…………	*15*
Fixed cost…………………………………	*5*
	70

C can be sold at ₹ 37 per unit and no more.

(i) Would you recommend production of C?

(ii) Would your recommendation be different if A, B and C are not joint products?

Solution

(i) Cost incurred on Product 'C' *upto point of separation* is irrelevant for decision making as Product 'C' is a Joint Product. Joint Products are the result of same raw material & same process Operations.

Cost incurred *after point of separation* will be considered for decision making as *specifically* incurred for Product 'C'.

After further processing Product 'C' will *contribute* ₹17 per unit toward 'Joint Production Cost'.

Calculation is as follows

Particulars	**Amount (₹)**
Selling Price *per unit*	37.00
Less: Cost after separation:	
Marginal Cost *per unit*	15.00
Fixed Cost *per unit*	5.00
Contribution toward 'Joint Production Cost'	

Hence, *further processing* of Product 'C' is recommended.

(ii) If Product 'C' is not a joint product with same cost structure. In this case there will be *negative contribution* on production of Product 'C'. The calculation is as follows→

Particulars	Amount (₹)
Selling Price *per unit*	37.00
Less: Marginal Cost (₹30 + ₹15)	45.00
Contribution	(8.00)

Hence, production of Product 'C' will not be recommended.

Problem-22

A company processes different products from a certain raw material. The raw material is processed in process I (where normal loss is 10% of input) to give products A and B in the ratio 3 : 2. B is sold directly. A is processed further in process II (where normal loss is 12.5% of output) to give products C and D in the ratio 5:3. At this point C and D have sale values ₹ 55 and ₹ 40 per kg respectively. C can be processed further in process III with processing cost ₹ 3,95,600 and normal wastage 5% of input and then be sold at ₹ 66 per kg. D can be processed further in process IV with processing cost ₹ 3,82,500 and normal wastage 12.5% of output and then be sold at ₹ 55 per kg. The normal wastage of each process has no realizable value. During the production period, 2,00,000 kgs of raw material is to be introduced into Process I.

Required

Using incremental cost-revenue approach, advise whether sale at split off or further processing is better for each of the products C and D.

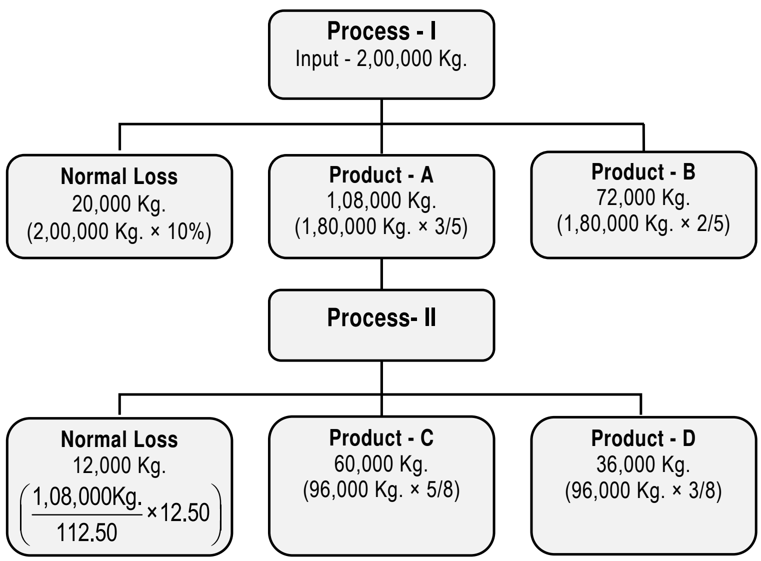
Solution

Statement Showing "Decision on Sale at - Split-off Point or After Further Processing"

Product	Product - C	Product - D
Quantity at Split off Point (Kg.)	60,000	36,000
Selling Price at Split off Point (₹)	55	40
Sales Revenue (₹) ... [A]	33,00,000 (60,000 Kg. × ₹55)	14,40,000 (36,000 Kg × ₹40)
Quantity if Processed Further (Kg.)	57,000 (60,000 Kg. × 95%)	32,000 $\left(\frac{36{,}000\text{Kg.}}{112.5}\times 100\right)$
Selling Price (₹) *per unit*	66	55

Sales Revenue (₹)	...[B]	37,62,000 (57,000 Kg. × ₹66)	17,60,000 (32,000 Kg. × ₹55)
Incremental Revenue	...[C] = [B] − [A]	4,62,000	3,20,000
Incremental Cost (₹)	...[D]	3,95,600	3,82,500
Profit / (Loss)	...[C] − [D]	66,400	(62,500)
Decision		**Process Further**	**Sale at Split-off Point**

Workings



It is not necessary *to show* above presentation.

Decision on Accepting / Quoting an Order

Problem-23

PQR Ltd., a manufacturer of tool kits has just completed XY's domestic order of 100 kits at a price of ₹ 1,650 per kit. The details of cost for XY's order are:

	Cost (₹)
Direct Material	*90,000*
Direct Labour	*32,000*
Tools and Consumables	*16,400*

Variable overheads	*9,600*
Fixed overheads (allocated)	*15,000*
Total	*1,63,000*

The company wishes to evaluate a special export order from Expo Ltd. of similar 300 kits at ₹ 1,600 per kit. For the export order, special packing has to be done at ₹ 20 per kit. An additional fixed inspection cost specific to this export order has to be incurred. The allocation of fixed overheads will be revised to increase by ₹ 25,000. Tools and Consumables above include special purpose tools costing ₹ 10,000 incurred for XY's order and these can be reused for the export order and the remaining portion is variable. PQR Ltd. wishes to accept the export order at 10% profit on the selling price.

Required

(i) What should be the maximum amount that can be incurred as inspection cost for making such an acceptance possible?

(ii) If Expo Ltd. offers to take the products without inspection, what is the maximum discount (as a percentage of the existing export price) that PQR Ltd. can offer to retain its 10% profit on the revised selling price? (Round off calculations to two decimal places).

Solution

Statement Showing "Permissible Cost *per kit*"

Items of Cost	**(₹)**
Direct Material $\left(\frac{₹90,000}{100\ kits}\right)$	900
Direct Labour $\left(\frac{₹32,000}{100 kits}\right)$	320
Consumables $\left(\frac{₹16,400 - ₹10,000}{100 kits}\right)$	64
Variable Overheads $\left(\frac{₹9,600}{100 kits}\right)$	96
Existing Variable Cost *per kit*	1,380
Add: Special Packing Cost *per kit*	20
Total Variable Cost *per kit*	1,400
Export Offer Price *per kit*	1,600
Less: Expected Profit (10% on Selling Price)	160
Total Permissible Cost *per kit*	1,440

Maximum Inspection Cost *per kit* for making export offer acceptable is ₹40

...(₹1,440 – ₹1,400)

As Total Cost excluding Inspection Cost is ₹1,400 so the Selling Price will be ₹1,555.56

$$\ldots\left(₹\,1{,}400 \times \frac{100}{90}\right)$$

Maximum Possible Discount on the Revised Selling Price is ₹ 44.44

... (₹1,600 – ₹1,555.56)

Percentage of Discount is 2.77%

$$\ldots\left(\frac{₹44.44}{₹1{,}600} \times 100\right)$$

Hence **Maximum Discount of 2.78 *percent*** can be offered to retain 10% Profit on the Revised Selling Price.

Allocated Fixed Overheads amounting to ₹ 25,000 and Reusable Special Tools amounting to ₹10,000 are *irrelevant* and hence ignored in the *decision making process*.

☞

This Problem can be solve by '**Total Cost & Revenue**' approach.

Problem-24

HTM Ltd., by using 12,00,000 units of a material M produces jointly 2,00,000 units of H and 4,00,000 units of T. The costs and sales details are as under:

	₹
Direct Material M @ ₹ 5 per unit	*60,00,000*
Other variable costs	*42,00,000*
Total fixed costs	*18,00,000*
Selling price of H per unit	*25*
Selling price of T per unit	*20*

The company receives an additional order for 40,000 units of T at the rate of ₹ 15 per unit. If this order has been accepted, the existing price of T will not be affected. However, the present price of H should be reduced evenly on the entire sale of H to market the additional units to be produced.

Required

Find the minimum average unit price to be charged on H to sustain the increased sales.

Solution

Product H & T are joint products and produced in the ratio of 1:2 from the same direct material- M.

Production of 40,000 additional units of T results in production of 20,000 units of H.

Statement Showing "Contribution under Existing Situation"

Particulars	Amount (₹)	Amount (₹)
Sales Value:		
H – 2,00,000 units @ ₹ 25 per unit	50,00,000	
T – 4,00,000 units @ ₹ 20 per unit	80,00,000	1,30,00,000
Less: Material- M (12,00,000 units @ ₹ 5 per unit)		60,00,000
Less: Other Variable Costs		42,00,000
Contribution		28,00,000

Let Minimum Average Selling Price *per unit* of H is ₹ X

Statement Showing "Contribution after Acceptance of Additional Order of 'T'"

Particulars	Amount (₹)	Amount (₹)
Sales Value:		
H – 2,20,000 units @ ₹ X per unit	2,20,000 X	
T – 4,00,000 units @ ₹20 per unit	80,00,000	
40,000 units @ ₹15 per unit	6,00,000	2,20,000 X + 86,00,000
Less: Material- M (12,00,000 units × 110%) @ ₹5 per unit		66,00,000
Less: Other Variable Costs (₹42,00,000 × 110%)		46,20,000
Contribution		2,20,000 X – 26,20,000

Minimum Average Selling Price *per unit* of H

Contribution after additional order of T = Contribution under existing production

2,20,000 X – 26,20,000 = 28,00,000

2,20,000 X = 54,20,000

X = ₹24.64

Minimum Average Selling Price *per unit* of H is ₹ 24.64

Problem-25

A company has prepared the following budget for the forthcoming year:

	(₹ in lakhs)
Sales	*20.00*
Direct materials	*3.60*
Direct labour	*6.40*
Factory overheads	
Variable	*2.20*
Fixed	*2.60*
Administration overheads	*1.80*
Sales commission	*1.00*
Fixed selling overheads	*0.40*
Profit	*2.00*

The policy of the company in fixing selling prices is to charge all overheads other than the prime costs on the basis of percentage of direct wages and to add a mark- up of one-ninth of total costs for profit.

While the company is confident of achieving the budget drawn up as above, a new customer approached the company directly for execution of a special order. The direct materials and direct labour costs of the special order are estimated respectively at ₹ 36,000 and ₹ 64,000. This special order is in excess of the budgeted sales as envisaged above. The company submitted a quotation of ₹ 2,00,000 for the special order based on its policy. The new customer is willing to pay a price of ₹ 1,50,000 for the special order. The company is hesitant to accept the order below total cost as, according to the company management, it will lead to a loss.

Required

State your arguments and advise the management on the acceptance of the special order.

Solution

Statement Showing "Analysis of Cost and Profit"

	(₹ in lakhs)	(₹ in lakhs)
Prime Cost		
Direct Material	3.60	

Direct Labour	6.40	10.00
Overhead		
Variable Factory Overhead	2.20	
Fixed Factory Overhead	2.60	
Administration Overheads	1.80	
Selling Commission	1.00	
Fixed Selling Overheads	0.40	8.00
Total Cost		18.00
Profit		2.00
Rate of Profit on Costs [₹2 / ₹18]		1 / 9

Overhead Absorption Rate *based on direct wages* 125% of Direct Wages (₹8.00 / ₹6.40 ×100)

Statement Showing "Break up of New Order"

	(₹)
Direct Materials	36,000
Direct Labour	64,000
Overheads 125% of Direct Wages	80,000
Total Costs	1,80,000
Profit (1/9 on Total Cost)	20,000
Selling Price	2,00,000

The following points emerge:

(i) Factory overheads only are to be recovered on the basis of direct wages.

(ii) The special order is a direct order. Hence commission is not payable.

(iii) The budgeted sales are achieved. Hence all fixed overheads are recovered. Hence, no fixed overheads will be chargeable to the special order.

Based on the above, the Factory Variable Overheads recovery rate may be calculated as under-

Total Variable Factory Overheads	₹2.20 lakhs
Direct Wages	₹6.40 lakhs
Factory Overhead Rate (₹2.20 / ₹6.40 × 100)	34.375%

Applying this rate the **Cost of the Special Order** will be as under-

	(₹)
Direct Materials	36,000
Direct Labour	64,000
Overheads (34.375% of Direct Wages)	22,000
Total Costs	1,22,000
Price Offered	1,50,000
Margin (More than 1/9)	28,000

Hence, the order is acceptable at the price of ₹1,50,000.

Problem-26

Satish Enterprises is a leading exporter of Kid's Toys. J Ltd. of USA has approached Satish Enterprises for exporting a special toy named "Jumping Monkey". The order will be valid for next three years at 3,000 toys per month. The export price of the toy will be $ 4.

Cost data per toy is as follows:

Materials…………………………………………………… ₹60
Labour……………………………………………………… ₹25
Variable overheads……………………………………… ₹20
Primary packing of the toy……………………………… ₹15

The toys will be packed in lots of 50 each. For this purpose a special box, which will contain the 50 toys will have to be purchased, cost being ₹ 400 per box.

Satish Enterprises will also have to import a special machine for making the toys. The cost of the machine is ₹ 24,00,000 and duty thereon will be at 12%. The machine will have an effective life of 3 years and depreciation is to be charged on straight-line method. Apart from depreciation, annual fixed overheads is estimated at ₹ 4,00,000 for the first year with 6% Increase in the second year. Fixed overheads are incurred uniformly over the year.

Assuming the average conversion rate to be ₹ 50 per $.

Required

(i) Prepare a monthly and yearly profitability statements for the first year and second year assuming the production at 3,000 toys per month.

(ii) Compute a monthly and yearly break-even units in respect of the first year.

(iii) In what contingency can there be a second break-even point for the month and for the year as a whole?

(iv) Have you any comments to offer on the above?

Solution

(i) Profit for First / Second Year on Monthly and Yearly Basis

(Amount in '000)

	First Year		Second Year	
	Monthly (₹)	**Yearly (₹)**	**Monthly (₹)**	**Yearly (₹)**
Sales Revenue	600 {3,000 units × ($4 × ₹ 50)}	7,200	600	7,200
Material	180 (3,000 units × ₹ 60)	2,160	180	2,160
Labour	75 (3,000 units × ₹ 25)	900	75	900
Variable Overheads	60 (3,000 units × ₹ 20)	720	60	720
Primary Packing	45 (3,000units × ₹15)	540	45	540
Boxes Cost	24 $\left(\frac{3{,}000\text{ units}}{50\text{ units}} \times ₹400\right)$	288	24	288
Total Fixed Overheads (W.N.-1)	108 $\left(\frac{₹\ 1{,}296}{12\text{ months}}\right)$	1,296	110 $\left(\frac{₹1{,}320}{12\text{ Months}}\right)$	1,320
Profit	108	1,296	106	1,272

(ii) Monthly Break-Even Units for the First Year

	Levels No. of Units (See W.N.-2)			
	1,351-1,400 (₹)	1,401-1,450 (₹)	1,451-1,500 (₹)	1,501-1,505 (₹)
Fixed Costs:				
Total Fixed Overheads *per month*	1,08,000	1,08,000	1,08,000	1,08,000

Semi-Variable Costs : (Special Boxes Cost) (W.N.-2)	11,200 (28 Boxes × ₹400)	11,600 (29 Boxes × ₹400)	12,000 (30 Boxes × ₹400)	12,400 (31 Boxes × ₹400)
Total Fixed and Semi Variable Costs	1,19,200	1,19,600	1,20,000	1,20,400
Break-even Level (in units)*	1,490 (₹1,19,200 / ₹ 80)	1,495 (₹1,19,600 / ₹ 80)	1,500 (₹1,20,000/ ₹ 80)	1,505 (₹1,20,400/ ₹ 80)

*

$$\left(\frac{\text{Total Fixed and Semi-Variable Cost}}{\text{Contribution per unit}}\right)$$

The above statement shows that the first and second break-even level of units, viz., 1,490 and 1,495 units falls outside the range of 1,351 -1,400 and 1,401 -1,450 units respectively. In the present case a monthly break-even level of units is 1,500 units which lies in the range of 1,451-1,500 units.

Yearly Break-Even Units for the First Year

	Levels No. of Units (See W.N.-3)			
	17,851-17,900 (₹)	17,901-17,950 (₹)	17,951-18,000 (₹)	18,001-18,050 (₹)
Fixed Costs	12,96,000	12,96,000	12,96,000	12,96,000
Semi-Variable Costs (Special Boxes Cost)	1,43,200 (358 Boxes × ₹400)	1,43,600 (359 Boxes × ₹ 400)	1,44,000 (360 Boxes × ₹ 400)	1,44,400 (361 Boxes × ₹ 400)
Total Fixed and Semi Variable Costs	14,39,200	14,39,600	14,40,000	14,40,400
Break-even Level (in units)	17,990 (₹14,39,200 / ₹80)	17,995 (₹14,39,600 / ₹80)	18,000 (₹14,40,000 / ₹80)	18,005 (₹14,40,400 /₹80)

The above table shows that yearly break-even of units is 18,000 units which lies in the range of 17,951-18,000 units. The other first two figures do not lie in the respect ranges. Hence, they are not acceptable.

(iii) In case the number of toys goes beyond *the* level of 1,500, one more box will be required to accommodate each 50 additional units of toys. In such a case the additional cost of a box will be ₹ 400. This amount can be recovered by the additional contribution of 5 toys. Thus, the second break-even point in such a contingency is 1,505 toys.

In case the number of toys goes beyond the level of 18,000 number, one more box will be required. The additional cost of this box will be ₹ 400; which can be recovered by the additional contribution of 5 toys. Thus, the second break-even point is 18,005 toys.

(iv) Yearly break-even point of 18,000 units of toys in the first year is equal to 12 times the monthly break-even point of 1,500 units. Thus, both the monthly and yearly figures of break-even point fall on the upper limit of their respective range.

In the second case, it is not so because the monthly and yearly break-even point fall within the range of 50 toys.

Working Notes

(1)

Fixed Overheads	1st Year	2nd Year
Depreciation $\left\{\frac{₹24,00,000 + ₹2,88,000\text{ (Duty)}}{3\text{ Years}}\right\}$	₹ 8,96,000	₹ 8,96,000
Other Fixed Overheads	₹4,00,000	₹4,24,000
Total Fixed Overheads	₹12,96,000	₹13,20,000

(2)

Fixed Overhead *in the first year* ₹12,96,000

Fixed Overhead *per month* ₹1,08,000

Contribution *per unit* (₹ 200 - ₹ 120) ₹80

Hence the Break-even Number of Units will be above 1,350 units $\left(\frac{₹\ 1,08,000}{₹80}\right)$

(3)

Fixed Overhead *in the first year* ₹12,96,000

Contribution *per unit* (₹200 – ₹120) ₹80

Hence the Break-even Number of Units *to recover fixed cost* will be above 16,200 units $\left(\frac{₹\ 12,96,000}{₹80}\right)$

But, at this Break -even Point another Fixed Cost will be incurred on Boxes.

Number of Boxes Required $\left(\frac{16,200\text{ units}}{50\text{ units}}\right)$ 324 units

Cost of Boxes (324units × ₹400)	₹1,29,600
Now the Total Fixed Cost (₹12,96,000 + ₹1,29,600)	₹14,25,600
Therefore, the new Break-even Point $\left(\frac{₹14,25,600}{₹80}\right)$	17,820 units

Problem-27

Souvenir Ltd. manufactures medals for winners of athletic events and other contests. Its manufacturing plant has the capacity to produce 10,000 medals each month. The company has current production and sales level of 7,500 medals per month. The current domestic market price of the medal is ₹150.

The cost data for the month of March, 2013 is as under:

	(₹)
Variable Costs (that vary with units produced):	
Direct Materials	*2,62,500*
Direct Manufacturing Labour	*3,00,000*
Variable Costs (that vary with number of batches):	
Set-ups; Materials Handling; Quality Control (150 batches × ₹500 per batch)	*75,000*
Fixed Costs:	
Manufacturing Costs	*2,75,000*
Marketing Costs	*1,75,000*

Souvenir Ltd. has received a special one-time-only order for 2,500 medals at ₹100 per medal. Souvenir Ltd. makes medals for its existing customers in batch size of 50 medals (150 batches x 50 medals per batch = 7,500 medals).

The special order for 2,500 medals requires Souvenir Ltd. to manufacture the medals in 25 batches of 100 each.

Required

(i) Should Souvenir Ltd. accept the special order? Why? Explain briefly.

(ii) Suppose the plant capacity was 9,000 medals instead of 10,000 medals each month. The special order must be taken either in full or rejected totally. Should Souvenir Ltd. accept the special order? Why? Explain briefly.

Solution

Stat. Showing "Contribution Margin – Accepting the Special Order of 2,500 Medals"

	(₹)
Sales Revenue (2,500 Medals × ₹100 *per medal*)	2,50,000
Less: Variable Costs	
Direct Material (2,500 Medals × ₹35 *per medal*)	87,500
Direct Manufacturing Labour (2,500 Medals × ₹40 *per medal*)	1,00,000
Set-ups; Materials Handling ; Quality Control (25 Batches × ₹500 *per batch*)	12,500
Contribution Margin	50,000

Decision

The above computations show that Souvenir Ltd. should accept the special order since its acceptance would increase the operating profit of the concern by ₹50,000.

Statement Showing "Acceptance of Special Order by Souvenir Ltd."
(When the Plant Capacity was 9,000 Medals)

	(₹)
Gain in Contribution Margin because of Special Order	50,000
Less: Loss of Contribution Margin on Reduction of 1,000 Medals Sales in the Internal Market (W.N.-1 & 2)	(65,000)
Loss of Contribution Margin	(15,000)

Decision

The above computations show that the special order of 2,500 medals (when the plant capacity was reduced to 9,000 medals) should not be accepted since this decision will result in a loss of contribution margin by ₹ 15,000.

Working Notes

W.N.-1

Statement Showing "Present Contribution on 7,500 Medals"

	(₹)
Sales Revenue (7,500 Medals × ₹150 *per medal*)	11,25,000
Less: Variable Costs	
Direct Material (7,500 Medals × ₹35 *per medal*)	2,62,500

Direct Manufacturing Labour (7,500 Medals × ₹40 *per medal*)	3,00,000
Set-up; Materials Handling; Quality Control (150 Batches × ₹500 *per batch*)	75,000
Contribution Margin	4,87,500

W.N.-2

Statement Showing "Contribution Margin on 6,500 Medals"

	(₹)
Sales Revenue (6,500 Medals × ₹150 *per medal*)	9,75,000
Less: Variable Costs	
Direct Material (6,500 Medals × ₹35 *per medal*)	2,27,500
Direct Manufacturing Labour (6,500 Medals × ₹40 *per medal*)	2,60,000
Set-up; Materials Handling; Quality Control (130 Batches × ₹500 *per batch*)	65,000
Contribution Margin	4,22,500

Make or Buy

Problem-28

X is a multiple product manufacturer. One product line consists of motors and the company produces three different models. X is currently considering a proposal from a supplier who wants to sell the company blades for the motors line.

The company currently produces all the blades it requires. In order to meet customer's needs, X currently produces three different blades for each motor model (nine different blades).

The supplier would charge ₹ 25 per blade, regardless of blade type. For the next year X has projected the costs of its own blade production as follows (based on projected volume of 10,000 units):

Direct materials...₹ 75,000
Direct labour.. ₹ 65,000
Variable overhead..₹ 55,000
Fixed overhead
Factory supervision.............................. ₹ 35,000
Other fixed cost.................................. ₹ 65,000
Total production costs.................................... ₹ 2,95,000

Assume (1) the equipment utilized to produce the blades has no alternative use and no market value, (2) the space occupied by blade production will remain idle if the company purchases rather than makes the blades, and (3) factory supervision costs reflect the salary of a production supervisor who would be dismissed from the firm if blade production ceased.

Required

(i) *Determine the net profit or loss of purchasing (rather than manufacturing), the blades required for motor production in the next year.*

(ii) *Determine the level of motor production where X would be indifferent between buying and producing the blades. If the future volume level were predicted to decrease, would that influence the decision?*

(iii) *For this part only, assume that the space presently occupied by blade production could be leased to another firm for ₹ 45,000 per year. How would this affect the make or buy decision?*

Solution

(i) This is a make or buy decision so compare the incremental cost to make with the incremental cost buy.

	Incremental Costs Per Unit (₹)
Direct Materials (₹75,000 ÷ 10,000 units)	7.50
Direct Labour (₹65,000 ÷ 10,000 units)	6.50
Variable Overhead (₹55,000 ÷ 10,000 units)	5.50
Supervision (₹35,000 ÷ 10,000 units)	3.50
Total Cost	23.00

Compare the cost to make the blades for 10,000 motors. ₹23.00, with the cost to buy, ₹ 25.00 There is a net loss of ₹2.00 if 'X' chooses to buy the blades.

(ii) 'X' will be indifferent between buying and making the blades when the total costs for making and buying will be equal at the volume level where:

Variable Cost per unit × No. of units + Avoidable Fixed Cost = Cost of Buy

Variable Cost per unit (DM + DL + VO) × No. of units + Factory Supervision Cost

= Buying Cost per unit × No. of units

Let No. of in units = U

(₹7.50 + ₹6.50 + ₹5.50) × U + ₹35,000 = ₹25.00 U

₹19.50 U + ₹35,000 = ₹25.00 U

₹25.00 U – ₹19.50 U = ₹35,000

₹5.50 U = ₹35,000

U = 6,364 units of blades

As volume of production decreases, the average per unit cost of in house production increases. If the volume falls below 6,364 motors, then 'X' would prefer to buy the blades from the supplier.

(iii) If the space presently occupied by blade production could be leased to another firm for ₹45,000 per year, 'X' would face an opportunity cost associated with in house blade production for the 10,000 units of ₹4.50 per unit.

New Cost to Make = ₹23.00 + ₹4.50
= ₹27.50

Now 'X' should buy because the cost to make, ₹27.50, is higher than the cost to buy, ₹25.00.

Problem-29

Agro caps Ltd., engaged in manufacturing agricultural machinery, is preparing its annual budget for the coming year. The company has a metal pressing capacity of 20,000 hours, which will be insufficient for manufacture of all requirements of components A, B, C and D.

The company has the following choices-

(i) Buy the components entirely from outside suppliers.

(ii) Buy from outside suppliers and / or use a partial second shift.

The data for the current year are given below-

Standard Production Cost per unit-

	A (₹)	B (₹)	C (₹)	D (₹)
Requirement (in units)	2,000	3,500	1,500	2,800
Variable Cost				
Direct Materials	37	27	25	44
Direct Wages	10	8	22	40
Direct Expenses	10	20	10	60
Fixed Overhead	5	4	11	20
Total Production Cost	62	59	68	164

Direct expenses relate to the use of the metal presses which cost ₹ 10 per hour, to operate. Fixed overheads are absorbed as a percentage of direct wages.

Supply of all or any part of the total requirement can be obtained following prices, each delivered to the factory-

Component (₹)

A..60

B………………………………………………….59

C…………………………………………………. 52

D…………………………………………………. 168

Second shift operations would increase direct wages by 25 percent over the normal shift and fixed overhead by ₹ 500 for each 1,000 (or part thereof) second shift hours worked.

Required

(i) Which component, and in what quantities should be manufactured in the 20,000 hours of press time available?

(ii) Whether it would be profitable to make any of the balance of components required on a second shift basis instead of buying them from outside suppliers.

Solution

(i) Components and Quantities to be Manufactured in 20,000 Hours of Press Time Available (Single Shift Operation)

	Hrs.
Available Capacity for Metal Pressing…………………………………………	20,000
First, Produce D, Hours Required (2,800 × 6)……………………………………	<u>16,800</u>
Balance Hours Available…………………………………………………………	3,200
Second, Produce A, Hours Required (2,000 × 1)………………………………	<u>2,000</u>
Balance Hours Available…………………………………………………………	1,200
Third, Produce B, for the Balance Hours Available (600 × 2)…………………..	<u>1,200</u>
Balance Hours Available………………………………………………………….	Nil

So, in 20,000 hours of press time available, all the requirements of components D and A and only 600 units of B can be manufactured. The balance requirement of component B i.e. 2,900 (3,500 – 600) units will have to be bought out or manufactured in the second shift.

(ii) Since the purchase price of Component C (i.e. ₹ 52) is lower than the marginal cost of manufacturing (i.e. ₹ 57) in even single shift, it will not be profitable to make it, hence it should be purchased from outside.

Now it is to be seen whether 2,900 units of B should be produced in the second shift or bought from outside. The comparative position is given below:

Cost of Producing 2,900 units of Component B in Second Shift

	(₹)
Variable Cost *per unit* on Single Shift Basis	55.00
Add: Increase in Direct Wages *per unit*	2.00
Variable Cost *per unit*	57.00
Total Variable Cost for 2,900 units (2,900 units × ₹57)	1,65,300
Additional Fixed Cost*	3,000
Total Cost for Producing 2,900 units of B in Second Shift ...(A)	1,68,300
Bought Out Price for 2,900 units of B (2,900 units × ₹59) ...(B)	1,71,100
Disadvantage in Buying ...(A) – (B)	(2,800)

(*) Additional Fixed Cost

5,800 hrs (2,900 units x 2 hrs.) are required for 2,900 units of B. Extra Fixed Cost for 5,800 hrs at ₹ 500 for every 1,000 hours (or part thereof) is ₹3,000.

Since the cost of manufacturing balance quantity of component B i.e. 2,900 units in second shift is less by ₹2,800, it is profitable to make it on a second shift basis instead of buying from outside suppliers.

Working Notes

(a) Process Hours Required

	A (₹)	B (₹)	C (₹)	D (₹)
Direct Expenses *per unit*	10	20	10	60
No. of Press Hours *per unit* (Direct Expenses *per press hour* being ₹10)	1	2	1	6

(b) Marginal Cost of Production *per unit* Vs Bought Out Price *per unit*

	A (₹)	B (₹)	C (₹)	D (₹)
Marginal Cost				
Direct Material	37	27	25	44
Direct Wages	10	8	22	40
Direct Expenses	10	20	10	60
Marginal Cost *per unit*	57	55	57	144

Bought Out Price	60	59	52	168
Excess of Bought Out Price over Marginal Cost	3	4	(5)	24
Press Hours *per unit*	1	2	1	6
Excess of Bought Out Price *per unit* of Limiting Factor (i.e. Press Hour)	3	2	(5)	4

The bought–out price for component C is lower by ₹5 than the marginal cost of production and so it should be purchased from outside.

In case the remaining components A, B, and D are bought, their ranking in terms of loss per unit of limiting factors (press hour) would be (highest loss per unit), A and B. The capacity available should, therefore, be deployed for making D first and then A and thereafter B.

Problem-30

Blue Bird Ltd. produces and sells Bicycles. It also manufactures the chains for its Bicycles. It expects to produce and sell 24,000 Bicycles during 2014 –15. It is considering an offer from an outside vendor to supply any number of chains at ₹ 12 per chains.

The accountant of Blue Bird Ltd. reports the following costs for producing 24,000 chains:

Particulars	***Cost per unit (₹)***	***Total Cost (₹)***
Direct material	*5.00*	*1,20,000*
Direct labour	*4.00*	*96,000*
Variable manufacturing overhead	*2.00*	*48,000*
Inspection, set up etc.	*1.00*	*24,000*
Machine rent	*1.00*	*24,000*
Allocated fixed overhead	*1.25*	*30,000*
Total	*14.25*	*3,42,000*

The following additional information is available:

(a) Inspection, set up etc. vary with the number of batches in which the chains are produced. Currently chains are being produced in the batch size of 2,000 units.

(b) Direct labour cost represents wages to four workers who are exclusively engaged in the manufacturing of chains. These workers are in permanent capacity and cannot be retrenched.

(c) if Blue Bird Ltd. procures all its chains from outside vendor it will not require the machine which it has hired for manufacturing chains.

Required

(i) *Assume that if Blue Bird Ltd. purchase chains from outside vendor, the facility (including workers) where the chains are currently manufactured will remain idle. Should Blue Bird Ltd. accept the offer from outside vendor at the anticipated production and sale volume of 24,000 units.*

(ii) *Whether your decision in (i) will change if facilities can be used to upgrade the Bicycle which will result in an incremental revenue of ₹ 22 per Bicycle. The variable cost for upgrading would be ₹ 18 and tooling cost would be ₹ 16,000.*

(iii) *Assume that facilities will be used as stated in (ii) above. Further, assume that with better planning Blue Bird Ltd. will be able to manufacture chains in the batch size of 4,000 units (instead of 2,000 units) if it decides to produce chains inside.*

Solution

(i) Deciding whether Blue Bird Ltd. should accept the offer from an outside vendor instead of manufacturing the chains inside.

	(₹)
Offered Bought Out Price *per chain* (if Purchased from Outside Vendor)	12
Less: Variable Cost *per unit* (if Chains were Produced inside)	7
Excess of Bought Out Price *per chain* over Variable Cost	5
Total Excess Amount if 24,000 Chains were Purchased	1,20,000
Less: Avoidable Costs	
Inspection Setup etc.	24,000
Machine Rent	24,000
Excess of Bought Out Price over Variable and Avoidable Cost	72,000

Blue Bird Ltd. should not accept the offer of an outside vendor because its acceptance would result in the reduction of profit by ₹ 72,000.

(ii) Deciding whether the use of internal facilities for upgrading the quality of chains the quality of chains would be beneficial in comparison to their purchase from an outside vendor.

	(₹)
Incremental Revenue per Bicycle	22
Less: Differential Cost per Bicycle	18

Contribution per Bicycle	4
Total Contribution (24,000 × ₹4)	96,000
Less: Tooling Cost	16,000
Net Contribution	80,000

Blue Bird Ltd. should accept the offer of alternative use of facilities for upgrading the Bicycle as its use, would produce, an incremental net contribution of ₹80,000, which is more than the excess of bought out price over variable and avoidable costs by ₹8,000.

(iii) Deciding whether the use of internal facilities for upgrading the Bicycle (Chain) internally would be profitable to the concern when the batch size becomes, 4,000 units in comparison to their purchases from an outside vendor.

When the batch size increases to 4,000 units of chains the concern would be producing 6 batches of output and such an action would reduce the inspection set up cost by ₹12,000. In this way there would be a saving of ₹12,000 towards inspection and set up costs.

Excess of Bought Out Price is ₹84,000 (₹72,000 + ₹12,000) [refer to (i)].

If Blue Bird Ltd. utilises internal facilities for producing / upgrading the quality of bicycle, then it would generate a net contribution of ₹ 80,000 [Refer to (ii)]. On the other hand buying chains from outside would reduce concern's profitability by ₹ 84,000.

Hence the use of facilities for upgrading the quality of Bicycle (Chains) is advocated.

Problem-31

A firm needs a component in an assembly operation. If it wants to do the manufacturing itself, it would need to buy a machine for ₹ 4 lakhs which would last for 4 years with no salvage value. Manufacturing costs in each of the four years would be ₹ 6 lakhs, ₹ 7 lakhs, ₹ 8 lakhs and ₹ 10 lakhs respectively. If the firm had to buy the component from a supplier the component would cost ₹ 9 lakhs, ₹ 10 lakhs, ₹ 11 lakhs and ₹ 14 lakhs respectively in each of the four years.

However, the machine would occupy floor space which could have been used for another machine. This latter machine could be hired at no cost to manufacture an item, the sale of which would produce net cash flows in each of the four years of ₹ 2 lakhs; it is impossible to find room for both the machines and there are no other external effects. The cost of capital is 10% and P/V factor for each of the 4 years is 0.909, 8.826, 0.751 and 0.683 respectively. Should the firm make the component or buy from outside?

Solution

(₹ in lakhs)

Year	Present Value Factor at 10%	When the Component is Manufactured		When the Component is Bought	
		Cash Outflows*	Present Value of Cash Outflows	Cash Outflows (Cost of Buying)	Present Value of Cash Outflows
0	1.000	4	4.000	-	-
1	0.909	6+2	7.272	9	8.181
2	0.826	7+2	7.434	10	8.260
3	0.751	8+2	7.510	11	8.261
4	0.683	10+2	8.196	14	9.562
			34.412		34.264

Cash Outflows* means Capital Cost *plus* Manufacturing Cost *plus* Opportunity Cost.

The above statement shows that there is a saving in buying the component amounting to ₹0.148 lakh (i.e. ₹34.412 lakhs – 34.264 lakhs).

Hence, it is beneficial to buy the component from outside.

Note

It may be noted that the loss of ₹ 2 lakhs of cash inflow for each of the 4 years due to inability of the firm to operate another machine when it manufactures the component has to be treated as an opportunity cost.

Problem-32

Aditya Ltd. manufactures four products A-1, B-2, C-3 and D-4 in Gurgaon and one product F-1 in Faridabad. Aditya Ltd. operates under Just-in-time (JIT) principle and does not hold any inventory of either finished goods or raw materials.

Company has entered into an agreement with M Ltd. to supply 10,000 units per month of each product produced from Gurgaon unit at a contracted price. Aditya Ltd. is bound to supply these contracted units to M Ltd. without any fail. Following are the details related with non contracted units of Gurgaon unit.

(Amount in ₹)

	A-1	*B-2*	*C-3*	*D-4*
Selling Price per unit	*360.00*	*285.00*	*290.00*	*210.00*
Direct Labour @ ₹ 45 per hour	*112.50*	*67.50*	*135.00*	*67.50*
Direct Material M-1 @ ₹ 50 per kg.	*50.00*	*100.00*	*---*	*75.00*
Direct Material M-2 @ ₹ 30 per litre.	*90.00*	*45.00*	*60.00*	*---*
Variable Overhead (varies with labour hrs)	*12.50*	*7.50*	*15.00*	*7.50*
Variable Overhead (varies with machine hrs)	*9.00*	*12.00*	*9.00*	*15.00*
Total Variable Cost	*274.00*	*232.00*	*219.00*	*165.00*
Machine Hours per unit	*3 hours*	*4 hours*	*3 hours*	*5 hours*
Maximum Demand per month (units)	*90,000*	*95,000*	*80,000*	*75,000*

The products manufactured in Gurgaon unit use direct material M-1 and M-2 but product F-1 produced in Faridabad unit is made by a distinct raw material Z. Material Z is purchased from the outside market at ₹ 200.00 per unit. One unit of F-1 requires one unit of material Z.

Material Z can also be manufactured at Gurgaon unit but for this 2 hours of direct labour, 3 hours of machine time and 2.5 litres of material M-2 will be required.

The Purchase manager has reported to the production manager that material M-1 and M-2 are in short supply in the market and only 6,50,000 Kg. of M-1 and 6,00,000 litre of M-2 can be purchased in a month.

Required

(i) Calculate whether Aditya Ltd. should manufacture material Z in Gurgoan unit or continue to purchase it from the market and manufacture it in Faridabad unit.

(ii) Calculate the optimum monthly usage of Gurgaon unit's available resources and make decision accordingly.

(iii) Calculate the purchase price of material Z at which your decision in (i) can be sustained.

Solution

(i) Manufacturing Cost of Material Z, if Manufactured in Gurgaon unit

	Amount (₹)
Direct Labour (2 hours × ₹45)	90.00
Direct Material M-2 (2.5 litre × ₹30)	75.00
Variable Overhead, Varies with Labour Hours (2hours × ₹5)	10.00
Variable Overhead, Varies with Machine Hours (3hours × ₹3)	9.00
Total Variable Cost	184.00

The purchasing cost of material Z from the outside market is ₹200, which is more than the cost to manufacture it in Gurgaon unit. Hence, it will be beneficial for the Aditya Ltd. to manufacture material Z in Gurgaon unit itself.

(ii) Monthly Requirement of Direct Material M-1 & M-2

For Contracted units

	A-1	B-2	C-3	D-4	Total
Units to be Supplied to M Ltd. (units)	10,000	10,000	10,000	10,000	40,000
Direct Material M-1 (in Kg) [W.N.-1]	10,000	20,000	---	15,000	45,000
Direct Material M-2 (in Litre) [W.N.-2]	30,000	15,000	20,000	---	65,000

For Non-Contracted units

	A-1	B-2	C-3	D-4	Total
Demand in Outside Market (units)	90,000	95,000	80,000	75,000	3,40,000
Direct Material M-1 (in Kg) [W.N.-1]	90,000	1,90,000	---	1,12,500	3,92,500
Direct Material M-2 (in Litre) [W.N.-2]	2,70,000	1,42,500	1,60,000	---	5,72,500

Availability and Demand Comparison

	Direct Material M-1 (in Kg)	Direct Material M-2 (in Litre)
Availability in Market	6,50,000	6,00,000
Requirement	4,37,500 (45,000+3,92,500)	6,37,500 (65,000+5,72,500)

Material M-2 is a limiting factor as its availability is less than its requirement to produce contracted as well as for non-contracted units.

To optimum usage of resources available in Gurgaon unit, prioritisation of production of products is necessary. The following is the comparison table of product A-1, B-2, C-3 and Z. Product D-4 is not taken into comparison as material M-2 is not required to produce product D-4.

Calculation of Contribution per litre of M-2

	A-1	B-2	C-3	Z
Contribution *per unit* (W.N-3 & 4)	₹ 86.00	₹ 53.00	₹ 71.00	₹ 16.00
Quantity of Material M-2 *per unit*	3 litre	1.5 litre	2 litre	2.5 litre
Contribution *per litre* of M-2	₹ 28.67	₹ 35.33	₹ 35.50	₹ 6.40
Rank	**III**	**II**	**I**	**IV**

Since, contribution per unit of material Z is lowest as compared to other products consuming material M-2. *Material –Z cannot be manufactured under the given resource constraint. Hence only existing products of Gurgaon units should be manufactured.*

Optimum Production Plan

Product	No. of Units	Quantity of M-2 Required (in Litre)	Balance Availability of M-2 (in Litre)
C-3	90,000	1,80,000 (90,000 units × 2 litre)	4,20,000 (6,00,000 – 1,80,000)
B-2	1,05,000	1,57,500 (1,05,000 units × 1.5 litre)	2,62,500 (4,20,000 – 1,57,500)
A-1	87,500*	2,62,500 (87,500 units × 3 litre)	0 (2,62,500 – 2,62,500)

(*) Units that can be produced with the help of available quantity of M-2 i.e. 2,62,500 litre.

(iii) Decision in requirement (i) will be changed as material Z cannot be manufactured in Gurgaon unit as noted in requirement (ii). *The minimum purchase price of material Z at which decision taken in (i) above can be sustained* is calculated as below:

	Amount (₹)
Existing Purchase Price	200.00
Add: Market Price *to be increased by* [W.N.-5]	55.68
Total	255.68

Working Notes

(1) Quantity of M-1 *required per unit of production*

	A-1	B-2	D-4
Cost *per unit*	₹50	₹100	₹75
Rate *per Kg.*	₹50	₹50	₹50
Quantity *per unit* of Production	1Kg.	2Kg.	1.5Kg.

(2) Quantity of M-2 *required per unit of production*

	A-1	B-2	C-3
Cost of *per unit*	₹90	₹45	₹60
Rate *per Kg.*	₹30	₹30	₹30
Quantity *per unit* of Production	3 litre	1.5 litre	2 litre

(3) Contribution *per unit* (₹)

	A-1	B-2	C-3	D-4
Selling Price *per unit*	360	285	290	210
Less: Variable Cost *per unit*	274	232	219	165
Contribution *per unit*	86	53	71	45

(4) Contribution (Benefit) *per unit* of Material Z

	(₹)
Purchasing Cost *per unit*	200
Less: Cost of Manufacture	184
Contribution *per unit*	16

(5) The next best product to material Z is A-1 {as calculated in (ii) above} which has a contribution of ₹28.67 per litre of M-2 which is ₹22.27 (₹28.67 – ₹6.40) higher than the contribution per litre of M-2 for material Z. Material Z required 2.5 litre of M-2, therefore, purchase price of material Z would have to ₹55.68 (2.5 litre × ₹22.27) higher than the existing market price.

Problem-33

Jupiter Ltd, a 'Fast-Moving Consumer Goods (FMCG)' company intends to diversify the product line to achieve full utilisation of its plant capacity. As a result of considerable research made, the company has been able to develop a new product called 'EXE'.

'EXE' is packed in cans of 100 ml capacity and is sold to the wholesalers in cartons of 24 cans at ₹120 per carton. Since the company uses its spare capacity for the manufacture of 'EXE', no additional fixed expenses will be incurred. However accountant has allocated a share of ₹1,12,500 per month as fixed expenses to be absorbed by 'EXE' as a fair share of the company's present fixed costs to the new product for costing purposes.

The company estimates the production and sale of 'EXE' at 1,50,000 cans per month and on this basis the following cost estimates (per carton) have been developed:

	₹
Direct Materials	*54*
Direct Wages	*36*
All Overheads	*27*
Total Costs	*117*

After a detailed market survey the economy is confident that the production and sales of 'EXE' can be increased to 1,75,000 cans per month and ultimately to 2,25,000 cans per month.

The company at present has a capacity for the manufacture of 1,50,000 empty cans and the cost of the empty cans if purchased from outside will result in a saving of 20% in material and

10% in other costs of 'EXE'. The price at which the outside firm is willing to supply the empty cans is ₹ 0.675 per empty can. If the company desires to manufacture empty cans in excess of 1,50,000 cans, a machine involving an additional fixed overhead of ₹ 7,500 per month will have to be installed.

Required

(i) *State by showing your workings whether the company should make or buy the empty* cans *at each of the three volumes of production of 'EXE' namely, 1,50,000, 1,75,000 and 2,25,000* cans.

(ii) *At what volume of sales will it be economical for the company to install the additional equipment for the manufacture of empty* cans*?*

(iii) *Evaluate the profitability on the sale of 'EXE' at each of the aforesaid three levels of output based on your decision and showing the cost of empty* cans *as a separate element of cost.*

Solution

(i) If the company increases production to 1,75,000 *cans* of 'EXE', 1,50,000 empty *cans* should be manufactured and additional 25,000 *cans* should be purchased at ₹16,875 **[Refer W.N. 5 & 6]**

If the company increases production to 2,25,000 *cans* of 'EXE', 1,50,000 empty *cans* should be manufactured and additional 75,000 *cans* should be purchased at a cost of ₹ 50,625. **[Refer W.N. 5 & 6]**

(ii) Additional fixed overheads to be incurred on a new machine: ₹7,500 Savings per unit if empty *cans* are made instead of buying:

₹ 0.675 – ₹ 0.6375 = ₹ 0.0375

Minimum additional quantity of empty *cans* to be made to recover the additional fixed costs:

₹7,500/ ₹0.0375 = 2,00,000 empty *cans*

Installation of the new machine for the manufacture of empty *cans* will be economical at production level of 3,50,000 *cans* per month.

(iii) **Evaluation of the Profitability on Sale of "EXE"** at the 3 Levels.

	Per *can* (₹)	**1,50,000 *can* (₹)**	**1,75,000 *can* (₹)**	**2,25,000 *can* (₹)**
Sales	5.0000	7,50,000.00	8,75,000.00	11,25,000.00
Less: Direct Material	1.8000	2,70,000.00	3,15,000.00	4,05,000.00
Direct Wages	1.3500	2,02,500.00	2,36,250.00	3,03,750.00

Variable Overheads	0.3375	50,625.00	59,062.50	75,937.50
Empty *can* made	0.6375	95,625.00	95,625.00	95,625.00
Empty *can* purchases	0.6750		16,875.00	50,625.00
Net Gain		1,31,250.00	1,52,187.50	1,94,062.50

Workings

(1) All Overheads for one carton or 24*cans* ₹27

Therefore, per *can* Overheads (₹27/24) 1.125

Fixed Overheads Allocated for 1,50,000 *cans* ₹112,500

Per *can* Fixed Overheads (₹1,12,500 / 1,50,000 *cans)* ₹0.75

Variable Overheads per *can* (₹1.125 – ₹0.75) ₹0.375

(2) Direct Wage per carton ₹36

Per *can* (₹36 / 24) ₹1.50

(3) Direct Materials per carton ₹ 54

Per *can* (₹54 / 24) ₹2.25

(4) Cost of making one empty *can*:

	Cost per *can* of 'EXE' (₹)	**Cost % empty *can***	**Cost empty *can* (₹)**	**Cost of per *can* of 'EXE' without empty *can* (₹)**
Direct Material	2.250	20	0.4500	1.8000
Direct Wages	1.500	10	0.1500	1.3500
Variable Overheads	0.375	10	0.0375	0.3375
Total	4.125		0.6375	3.4875

(5) Cost of manufacturing/buying of 1,50,000 empty *cans* of 'EXE':

	Empty *can* Cost (₹)	**If empty *can* made (₹)**	**If empty *can* purchased (₹)**
Direct Material	0.4500	67,500.00	-----
Direct Wages	0.1500	22,500.00	-----
Variable Overheads	0.0375	5,625.00	-----
Purchase Price	0.6750	-----	1,01,250.00
Total		95,625.00	1,01,250.00

Company should manufacture the empty *cans* for a production volume of 1,50,000 'EXE' *cans* as capacity is available and cost of manufacture is lower.

(6) After the level of 1,50,000 empty *cans*, the company has to install a new machine involving a total additional Fixed Overheads of ₹ 7,500. The cost of making and buying the additional *cans* of 25,000 and 75,000 will be as follows:

	Cost per *can* (₹)	**Make (₹)**	**Buy (₹)**	**Make (₹)**	**Buy (₹)**
		25,000 *cans*		**75,000 *cans***	
Direct Material	0.4500	11,250.00	-----	33,750.00	-----
Direct Wages	0.1500	3,750.00	-----	11,250.00	-----
Variable Overheads	0.0375	937.50	-----	2,812.50	-----
Additional Overheads		7,500.00	-----	7,500.00	-----
Purchase Price	0.6750	-----	16,875.00	-----	50,625.00
Total		23,437.50	16,875.00	55,312.50	50,625.00

The cost of buying additional empty *cans* at both the levels is lower than the cost of their manufacture.

Determination of Production Mix / Production Planning

Problem-34

A company is producing three products X, Y & Z. Relevant information is given below:

Product	***X***	***Y***	***Z***
Raw material per unit (kg)	*20*	*12*	*30*
Machine hours per unit (hours)	*3*	*5*	*4*
Selling price per unit (₹)	*500*	*400*	*800*
Maximum limit of production Unit	*1,500*	*1,500*	*750*

Only 9,200 hours are available for production at a cost of ₹20 per hour and maximum 50,000 kgs. of material @ ₹ 20 per kg., can be obtained.

(Only product mix quantities are to be shown, calculation of total profit at that product mix not required to be shown)

Required

On the basis of the above information determine the product-mix to give the highest profit if at least two products are produced.

Solution

Computation of Contribution per Key Factor(s) for Various Products

Particulars	Products		
	X	Y	Z
Selling Price p. u. (₹)	500	400	800
Variable Cost p. u. (₹):			
Material	400 (₹20 × 20 Kg.)	240 (₹20 × 12 Kg.)	600 (₹20 × 30 Kg.)
Machine Charge	60 (₹20 × 3 hrs)	100 (₹ 20 × 5 hrs)	80 (₹20 × 4 hrs)
Total Variable Cost p. u. (₹)	460	340	680
Contribution p. u. (₹)	40	60	120
Ranking	**III**	**II**	**I**
Requirement of Material (Kg.)	20	12	30
Contribution per Kg.(₹)	2.00	5.00	4.00
Ranking	**III**	**I**	**II**
Requirement of Machine Hours (Hrs.)	3	5	4
Contribution *per hour*(₹)	13.33	12.00	30.00
Ranking	**II**	**III**	**I**

It is clear from the above ranking(s):-

I. Contribution per Unit is maximum in case of product Y & Z.

II. Contribution per Kg. of Raw Material also maximum in case of product Y & Z.

III. Contribution per Machine Hour is maximum in case of product X & Z.

So product Z is common in all cases and priority shall be given for production of 'Z'. Balance resources should be divided between other two products X & Y.

Statement Showing Balance Resources for Product X & Y

Resources	Maximum Availability (a)	Maximum Production Z (b)	Consumption of Resources p.u. (c)	Total Cons. (d) = (b) x (c)	Balance (a) - (d)
Material	50,000 Kg.	750	30 Kg.	22,500 Kg.	27,500 Kg.
Machine Hrs.	9,200 Hrs.	750	4 Hrs.	3,000 Hrs.	6,200 Hrs.

The production of X & Y may be calculated with the help of following equations by utilizing balance resources: -

$$
\begin{aligned}
20X + 12Y &= 27,500 \quad \ldots\text{(i)}\\
3X + 5Y &= 6,200 \quad \ldots\text{(ii)}
\end{aligned}
$$

Then,

$$
\begin{aligned}
\cancel{30X} + 18Y &= 41,250 \quad \ldots\textit{equation (i) multiplied by 1.5}\\
\cancel{30X} + 50Y &= 62,000 \quad \ldots\textit{equation (ii) multiplied by 10}\\
- \quad\;\; - \qquad &\quad\;\; -\\
\hline
-32Y &= -20,750\\
Y &= 648.43 \text{ i.e. } 648 \text{ units}
\end{aligned}
$$

Putting the value of Y in equation (ii)

$$
\begin{aligned}
3X + (5 \times 648) &= 6,200\\
\textit{Or} \quad 3X &= 2,960\\
\textit{Or} \quad X &= 986 \text{ units}
\end{aligned}
$$

So the of Product Mix is

$$
\begin{aligned}
X &= 986 \text{ units}\\
Y &= 648 \text{ units}\\
Z &= 750 \text{ units}
\end{aligned}
$$

Problem-35

An agro-products producer company is planning its production for next year. The following information is relating to the current year:

Products/Corps	***A_1***	***A_2***	***B_1***	***B_2***
Area occupied (acres)	*250*	*200*	*300*	*250*
Yield per acre (ton)	*50*	*40*	*45*	*60*
Selling price per ton (₹)	*200*	*250*	*300*	*270*
Variable cost per acre (₹)				
Seeds	*300*	*250*	*450*	*400*
Pesticides	*150*	*200*	*300*	*250*
Fertilizers	*125*	*75*	*100*	*125*
Cultivations	*125*	*75*	*100*	*125*
Direct wages	*4,000*	*4,500*	*5,000*	*5,700*

Fixed overhead per annum ₹ 53,76,000.

The land that is being used for the production of B_1 and B_2 can be used for either crop, but not for A_1 and A_2. The land that is being used for A_1 and A_2 can be used for either crop, but not for B_1 and B_2. In order to provide adequate market service, the company must produce each year at least 2,000 tons each of A_1 and A_2 and 1,800 tons each of B_1 and B_2.

Required

(i) Prepare a statement of the profit for the current year.

(ii) Profit for the production mix by fulfilling market commitment.

(iii) Assuming that the land could be cultivated to produce any of the four products and there was no market commitment, calculate: Profit amount of most profitable crop and break-even point of most profitable crop in terms of acres and sales value.

Solution

(i) Calculation of Selling Price and Contribution *per acre*

Products	A_1	A_2	B_1	B_2	Total
Yield *per acre* (tones)	50	40	45	60	
Selling Price *per tones* (₹)	200	250	300	270	
Sales Revenue *per acre*	₹10,000	₹10,000	₹13,500	₹16,200	
Variable Cost *per acre* (₹)	4,700	5,100	5,950	6,600	
Contribution *per acre* (₹)	5,300	4,900	7,550	9,600	
Area (Acres)	250	200	300	250	
Total Contribution (₹)	13,25,000	9,80,000	22,65,000	24,00,000	69,70,000
Less: Fixed Cost					53,76,000
Profit (₹)					15,94,000

(ii) Profit Statement for Recommended Mix

Products	A_1	A_2	B_1	B_2	Total
Contribution per acre	5,300	4,900	7,550	9,600	
Rank	1	2	2	1	
Minimum Sales Requirement *in acres*		50 [2,000/40]	40 [1,800/45]		
Recommended Mix *in acres*	400	50	40	510	
Total Contribution (₹)	21,20,000	2,45,000	3,02,000	48,96,000	75,63,000
Less: Fixed Cost					53,76,000
Profit					21,87,000

(iii) Most Profitable Crop: Production should be concentrated on B_2 which gives highest contribution per acres – ₹9,600.

Overall Contribution if - Complete land is used for B_2 (1,000 × ₹9,600)	₹96,00,000
Less: Fixed Cost	₹53,76,000
Profit	₹42,24,000

Break- even Point *in acres* for B_2 = ₹53,76,000 ÷ ₹9,600

= 560 acres

Break -even Point *in sales value* = 560 acres × (₹270 × 60 tones)

= ₹90,72,000

Problem-36

A company manufactures and sells a product, the price of which is controlled by the Government. Raw material required for this product is also made available at a fixed controlled price. The following figures have been called for the previous two accounting years of the company:

	Year- I	*Year- II*
Quantity Sold (tones)	*1,26,000*	*1,44,000*
Price per tone	*₹ 185*	*₹ 185*
		(₹ In thousands)
Sales Value	*23,310*	*26,640*
Raw Materials	*11,340*	*12,960*
Direct Labour	*1,512*	*1,872*
Factory, Administration and Selling Expenses	*9,702*	*11,232*
Profit	*756*	*576*

During the year II direct labour rates increased by 8 $^1/_3$%. Increases in factory, administration and selling expenses during the year were ₹ 8,10,000 on account of factors other than the increased quantities produced and sold.

Required

The managing director desires to know, what quantity if they had produced and sold would have given the company the same net profit per tonne in Year II as it earned during the Year I Advise him.

Solution

	(₹)
Sales Price	185.00
Variable Cost:	
Material (W.N.-1)	90.00
Labour (W.N.-2)	13.00
Variable Overhead (W.N.-3)	40.00
Contribution *per tonne*	42.00
Profit Required (₹7,56,000 /1,26,000 tonnes)	6.00
Balance Contribution *per tonne* for meeting Fixed Costs	36.00
Fixed Costs (W.N.-4)	54,72,000
Quantity Required in tonnes (₹54,72,000 ÷ ₹36)	1,52,000

Working Notes

1. Materials Cost *per tonne* in Year II $\left(\frac{₹1{,}29{,}60{,}000}{1{,}44{,}000\text{tonnes}}\right)$ ₹90

2. Labour Cost *per tonne* in Year II $\left(\frac{₹18{,}72{,}000}{1{,}44{,}000\text{tonnes}}\right)$ ₹13

3. Variable portion of Factory, Administration and Sell. Expenditure, etc

	₹
Total in Year II	1,12,32,000
Increase *otherwise than on account of increased turnover*	8,10,000
	1,04,22,000
Amount Spent in Year I	97,02,000
Increase	7,20,000
Increase in Quantity Sold	18,000 tonnes
Variable Expenses *per tonne* $\left(\frac{₹7{,}20{,}000}{18{,}000\text{tonnes}}\right)$	₹40

4.

Fixed portion of Factory, Administration and Selling Expenses (Yr. 2)	₹1,12,32,000
Variable Expenses @ ₹ 40 *per tonne*	₹57,60,000
Fixed Portion	₹54,72,000

Problem-37

Aditya Limited manufactures three different products and the following information has been collected from the books of accounts:

	Products		
	S	***T***	***U***
Sales Mix	*35%*	*35%*	*30%*
Selling Price	*₹ 30*	*₹40*	*₹20*
Variable Cost	*₹ 15*	*₹20*	*₹12*
Total Fixed Costs			*₹ 1,80,000*
Total Sales			*₹ 6,00,000*

The company has currently under discussion, a proposal to discontinue the manufacture of Product U and replace it with Product M, when the following results are anticipated:

	Products		
	S	***T***	***M***
Sales Mix	*50%*	*25%*	*25%*
Selling Price	*₹ 30*	*₹40*	*₹30*
Variable Cost	*₹ 15*	*₹20*	*₹15*
Total Fixed Costs			*₹ 1,80,000*
Total Sales			*₹ 6,40,000*

Required

Will you advise the company to change over to production of M? Give reasons for your answer.

Solution

Aditya Limited
Evaluation of Change over to Product M from Product U

Existing Production

	Products			**Total**
	S	**T**	**U**	
Selling Price (₹)	30	40	20	
Less: Variable Cost (₹)	15	20	12	
Contribution per unit (₹)	15	20	8	
P/V Ratio	50%	50%	40%	
Sales Mix	35%	35%	30%	

Contribution *per rupee of sales* (P/V Ratio × Sales Mix)	17½%	17½%	12%	47%
Present Total Contribution (₹6,00,000 × 47%)				₹2,82,000
Less: Fixed Costs				₹1,80,000
Present Profit				₹1,02,000
Present Break Even Sales (₹1,80,000/0.47)				₹3,82,979

Proposed Production

	Products			
	S	T	M	Total
Selling Price (₹)	30	40	30	
Less: Variable Cost (₹)	15	20	15	
Contribution *per unit* (₹)	15	20	15	
P/V Ratio	50%	50%	50%	
Sales Mix	50%	25%	25%	
Contribution *per rupee of sales* (P/V Ratio x Sales Mix)	25%	12½%	12½%	50%
Proposed Total Contribution (₹6,40,000 x 50%)				₹3,20,000
Less: Fixed Costs				₹1,80,000
Proposed Profit				₹1,40,000
Proposed Break Even Sales (₹1,80,000/0.50)				₹3,60,000

Problem-38

Fairbilt Furniture Ltd. manufactures three products: Tables, Chairs and Cabinets. The company is in the process of finalizing the plans for the coming year; hence the executives thought it would be prudent to have a look at the product-wise performance during the current year. The following information is furnished:

	Tables	*Chairs*	*Cabinets*
Unit Selling Price	*80*	*60*	*36*
Direct Material	*28*	*24*	*16*
Direct Labour	*20*	*12*	*12*
Factory Overheads:			
Variable	*8*	*6*	*4*

Fixed	*8*	*6*	*1.28*
Selling, Distribution and General Administration Expenses:			
Variable	*4*	*2*	*2*
Fixed	*4*	*6*	*1.52*
Unit Cost	*72*	*56*	*36.80*
Unit Profit / (Loss)	*8*	*4*	*(0.80)*
Sales Volume (units)	*10,000*	*15,000*	*15,000*
Profit / (Loss)	*80,000*	*60,000*	*(12,000)*

For the coming period, the selling prices and the cost of three products are expected to remain unchanged. There will be an increase in the sales of tables by 1,000 units and the increase in sales of cabinets is expected to be 8,000 units. The sales of chairs will remain to be unchanged. Sufficient additional capacity exists to enable the increased demands to be met without incurring additional fixed costs. Some among the executives contend that it will be unwise to go for additional production and sale of cabinets, since it is already making losses at ₹ 0.80 per unit. The suggestion is that cabinets should be eliminated altogether.

Required

Do you agree? Substantiate with necessary analysis and determine the product wise and overall profits for the coming year.

Solution

Note

Reconciliation of the figures given for 'Cabinets' reveals the fact that the Selling Price is ₹36 (₹36.80 – ₹0.80)

Fairbilt Furniture Ltd.
Statement Showing "Product-wise Contribution and Total Profit"

Particulars	Tables		Chairs		Cabinets		Total
	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Sales Volume (units)		10,000		15,000		15,000	
Selling Price (₹)	80	800,000	60	900,000	36	540,000	22,40,000
Direct Material	28	280,000	24	360,000	16	240,000	880,000
Direct Labour	20	200,000	12	180,000	12	180,000	560,000

Variable Factory Overheads	8	80,000	6	90,000	4	60,000	230,000
Variable Selling, Distribution and Administration Overhead	4	40,000	2	30,000	2	30,000	100,000
Contribution	20	200,000	16	240,000	2	30,000	470,000
Fixed Factory Overheads		80,000		90,000		19,200	189,200
Fixed Selling, Distribution and Administration Overheads		40,000		90,000		22,800	152,800
Total Profit							128,000

The above analysis shows the cabinets make a contribution of ₹2 per unit. The loss sustained in the previous year is because of the falling sales volume below breakeven level.

Fairbilt Furniture Ltd.
Budgeted Performance for the Coming Year

	Tables	Chairs	Cabinets
Unit Contribution (₹)	20	16	2
Sales Volume (units)	11,000	15,000	23,000
Total Contribution (₹)	220,000	240,000	46,000
Less: Fixed Cost (₹)	120,000	180,000	42,000
Profit (₹)	100,000	60,000	4,000

The company makes a total profit of ₹164,000 if all the products are continued. However, if the production of cabinets is discontinued, there will be an adverse effect on the overall profit of the company. This is because cabinets also contribute toward meeting the fixed costs of the company.

Problem-39

Jaya-Surya Ltd. (JSL) manufactures and sells two products 'Jaya' and 'Surya'. Both Jaya and Surya use a regular machine while Surya uses another high-precision machine as well. The following information is available for the next quarter.

	Jaya	*Surya*
Selling Price per unit (₹)	*1,500*	*2,000*
Variable Manufacturing Cost per unit (₹)	*900*	*1,600*
Variable Marketing Cost per unit (₹)	*250*	*150*
Budgeted Allocation of Fixed Overhead Costs (₹)	*18,00,000*	*85,00,000*
Regular Machine Hours per unit	*2.0*	*1.0*

Further information is available as follows:

- *JSL faces a capacity constraint of 60,000 hours on the regular machine for the next quarter and there is no constraint on the high precision machine for the next quarter.*
- *Out of ₹ 85,00,000 budgeted allocation of fixed overhead costs to product Surya, ₹ 60,00,000 is payable for hiring the high precision machine. This cost is charged entirely to product Surya. The hiring agreement can be cancelled at any time without penalties.*
- *All other overhead costs are fixed and cannot be changed.*
- *A minimum quantity of 12,500 units per quarter of Jaya must be produced to fulfill a commitment to a customer.*
- *Any quantity of any product can be sold at the given prices.*

Required

(i) Calculate the product mix of Jaya and Surya which would maximise the relevant operating profit of JSL in the next quarter.

(ii) JSL can double the quarterly capacity of regular machine at a cost of ₹ 28,00,000. Calculate the new product mix and the amount by which the relevant operating profit will increase.

Solution

(i) Calculation of Contribution Margin *per machine hour*

	Jaya (₹)	**Surya (₹)**
Selling Price *per unit*	1,500	2,000
Less: Variable Manufacturing Cost *per unit*	(900)	(1,600)
Less: Variable Marketing Cost *per unit*	(250)	(150)
Contribution Margin *per unit*	350	250
Number of Regular Machine Hours	2.0	1.0
Contribution Margin *per machine hour*	175	250
Ranking	II	I

Based on the ranking above, manufacturing preference will be given to Surya but after the committed production of 12,500 units of Jaya.

Since to manufacture Surya, a hiring cost of ₹ 60,00,000 is also paid for high precision machine, so the result obtained through the above ranking may not be beneficial. For this purpose we solve this problem taking two options.

Option 1: 12,500 units of Jaya and 35,000* units of Surya:

*[60,000 hours – (12,500 units of Jaya × 2 hours) ÷ 1 hour to produce one unit of Surya]

	Amount (₹)
Contribution Margin on Jaya (12,500 units × ₹ 350)	43,75,000
Contribution Margin on Surya (35,000 units × ₹ 250)	87,50,000
Total Contribution Margin	1,31,25,000
Less: Hire Charges on High Precision Machine	(60,00,000)
Net Relevant Contribution	71,25,000

Option 2: Produce only Jaya i.e. 30,000 units :

Contribution Margin / Net Relevant Contribution (30,000 units×₹ 350) = ₹ 1,05,00,000

Even though Surya has the higher contribution margin per machine hour but net relevant contribution option 1 is lower than the option 2. Hence, JSL should produce 30,000 units of Jaya only to earn more profit.

(ii) Based on the above ranking, if preference is given to production of Surya after the production of committed units of Jaya i.e. 12,500 units of Jaya and 95,000 units of Surya.

Option 1: 12,500 units of Jaya and 95,000* units of Surya:

*[1,20,000 hours – (12,500 units of Jaya × 2 hours) ÷ 1 hour to produce one unit of Surya]

	Amount (₹)
Contribution Margin on Jaya (12,500 units × ₹ 350)	43,75,000
Contribution Margin on Surya (95,000 units × ₹ 250)	2,37,50,000
Total Contribution Margin	2,81,25,000
Less: Hire Charges on High Precision Machine	(60,00,000)
Less: Capacity Enhancement Cost	(28,00,000)
Net Relevant Contribution	1,93,25,000

Option 2: Produce only Jaya i.e. 60,000 units:

	Amount (₹)
Contribution Margin (60,000 units × ₹ 350)	2,10,00,000
Less: Capacity Enhancement Cost	(28,00,000)
Net Relevant Contribution	1,82,00,000

When capacity of the regular machine is doubled, the optimum product mix will be 12,500 units of Jaya and 95,000 units of Surya.

Increase in operating profit will be ₹ 88,25,000 (₹ 1,93,25,000 – ₹ 1,05,00,000).

☞

> While calculating relevant contribution from the option 1 and option 2 in requirements (i) and (ii) above, the contribution from the 12,500 units of Jaya may also be ignored as this is same under the two options.

Problem-40

The following is the trading summary of a manufacturing concern which makes two products, X and Y.

Trading Summary
For the 4 Months Period 30th April, 2013

	X (₹)		Y (₹)		Total (₹)
Sales		*10,000*		*4,000*	*14,000*
Less: Cost of Sales					
*Direct Cost**					
Labour	*3,000*		*1,000*		
Materials	*1,500*	*4,500*	*1,000*	*2,000*	*6,500*
Indirect Costs					
*Variable Expenses**		*2,000*		*1,000*	*3,000*
*Fixed Expenses***					
Common to both X and Y		*1,250*		*1,250*	*2,500*
		2,250		*(250)*	*2,000*

** These costs tend to vary in direct proportion to physical output.*

*** These costs tend to remain constant irrespective of the physical outputs of X and Y.*

It has been the practice of the concern to allocate these costs equally between X and Y. The following proposals have been made by the Board of Directors for your consideration as financial adviser:

(i) *Discontinue Product -Y.*

(ii) *As an alternative to (i), reduce the price of Y, by 20 per cent. It is estimated that the demand will then increase by 40 per cent.*

(iii) *Double the price of X. (It is estimated that this will reduce the demand by the three fifths.)*

Required

Recommend the proposals to be taken after evaluating each of these three proposals.

Solution

Evaluation of the Proposals

(i) Profit Statement When Product Y is Discontinued

In case Product Y is discontinued, Product *X* will also have to bear the Fixed Expenses previously borne by Product Y. The final position will be as follows:

Existing Net Profit of X……………………….₹ 2,250

Less: Fixed Expenses of Y…………………₹ 1,250

Final Net Profit………………………………₹ 1,000

(ii) Profit Statement When the Price of Y is Reduced by 20 per cent (It will result in 40% increase in Demand)

	(₹)
Sales (₹4,000 × $^{80}/_{100}$ × $^{140}/_{100}$)	4,480
Less: Direct Costs (₹2,000 + 40% of ₹2,000)	2,800
Less: Indirect Costs- Variable Expenses (₹1,000 + 40% of ₹1,000)	1,400
Less: Fixed Expenses (Old)	1,250
Net Loss	(970)
Less: Profit of X (Old)	2,250
Final Net Profit	1,280

(iii) Profit Statement When the Price of '*X*' is Doubled (this will reduce the Demand by three-fifths or 60%)

	(₹)
Sales (₹10,000 × $^{200}/_{100}$ × $^{2}/_{5}$)	8,000
Less: Direct Costs (₹4,500 − 60% of ₹4,500)	1,800
Less: Indirect Costs - Variable Expenses (₹2,000 − 60% of ₹2,000)	800
Contribution	5,400
Less: Fixes Expenses (Old)	1,250
Less: Net Loss of Y (Old)	250
Final Net Profit	3,900

The above analysis shows that the Net Profit is maximum under alternative (3) i.e. when the Price of X is doubled and the Demand reduces by three-fifths. This alternative will increase the present level of Net Profit from ₹2,000 to ₹3,900 for a four month period. It is, therefore, suggested that the concern should adopt alternative (3).

Problem-41

E Ltd. is engaged in the manufacturing of three products in its factory. The following budget estimates are prepared for 2014-15:

	Products		
	A	B	C
Sales (units)	10,000	25,000	20,000
Selling Price per unit (₹)	40	75	85
Less: Direct Materials per unit (₹)	10	14	18
Direct Wages per unit @ ₹ 2 per hour	8	12	10
Variable Overhead per unit (₹)	8	9	10
Fixed Overhead per unit (₹)	16	18	20
Profit / Loss	(2)	22	27

After the finalisation of the above manufacturing schedule, it is observed that presently only 80% capacity being utilised by these three products. The production activities are made at the same platform and it may be interchangeable among products according to requirement. In order to improve the profitability of the company the following three proposals are put for consideration:

(a) *Discontinue product A and capacity released may be used for either product B or C or equally shared. The fixed cost of product A is avoidable. Expected changes in material cost and selling price subject to the utilisation of product A's capacity are as under:*

Product B: Material cost increased by 10% and selling price reduced by 2%.

Product C: Material cost increased by 5% and selling price reduced by 5%.

(b) *Discontinue product A and divert the capacity so released and the idle capacity to produce a new product D for meeting export demand whose per unit cost data are as follows:*

	(₹)
Selling Price	60
Direct Material	28
Direct Wages @ ₹ 3 per hour	12
Variable Overheads	6
Fixed Cost (Total)	1,05,500

(c) *Product A, B and C are continuously run and hire out the idle capacity fixing a price in such a way that the same rate of profit per direct labour hour is obtained in the original budget estimates.*

Required

(i) *Prepare a statement of profitability of products A, B and C in existing situation.*

(ii) *Evaluate the above proposals independently and calculate the overall profitability of the company under each proposal.*

(iii) *What proposal should be accepted, if the company wants to maximise its Profit?*

Solution

(i) Budgeted Profitability Statement under Existing Situation

	A (₹)	B (₹)	C (₹)	Total (₹)
Selling Price	40	75	85	
Less: Total Variable Costs (Direct Material + Direct Labour + Variable Overhead)	26	35	38	
Contribution	14	40	47	
Sales (units)	10,000	25,000	20,000	
Contribution (₹)	1,40,000	10,00,000	9,40,000	20,80,000
Less: Fixed Cost (₹)	1,60,000	4,50,000	4,00,000	10,10,000
Profit / Loss (₹)	(20,000)	5,50,000	5,40,000	10,70,000

(ii) Proposal (a)

Alternative use of A's Capacity for Product B or C or B & C Equally

Hours Released from Discontinuance of A 40,000 hours (10,000 units × 4hrs.)

	Product B	Product C	B & C
No of Units Possible	6,666 $\left(\frac{40{,}000\text{hrs.}}{6\text{hrs.}}\right)$	8,000 $\left(\frac{40{,}000\text{hrs.}}{5\text{hrs.}}\right)$	B - 3,333 C - 4,000

Revised Contribution of Product B and Product C

Particulars	B (₹)	C (₹)
Selling Price	73.50	80.75

Less: Direct Material	15.40	18.90
Direct Wages	12.00	10.00
Variable Overheads	9.00	10.00
Contribution	37.10	41.85
Number of Hours	6	5
Contribution *per hour*	6.18	8.37

Decision

It is better to produce C.

Taking both changes in the selling price and material cost are for the entire production or the incremental production. Profitability is calculated below:

Proposal (a)

Profitability Statement if A's Capacity Utilized by C

Particulars	Option-1 Changes for Entire Production (₹)	Option-2 Changes for Incremental Production (₹)
Sales Volume	28,000	8,000
Contribution *per unit*	41.85	41.85
Total Contribution	11,71,800	3,34,800
Less: Fixed Cost	4,00,000	---
Profit	7,71,800	3,34,800
Existing Profit of B	5,50,000	5,50,000
Existing Profit of C	---	5,40,000
Total Profit	13,21,800	14,24,800

Proposal (b)

Existing Capacity = 2,90,000 hrs.

(4 hrs. × 10,000 units + 6 hrs. × 25,000 units + 5 hrs. × 20,000 units)

Idle Capacity = $\left(2{,}90{,}000\text{hrs.x}\frac{20\%}{80\%}\right)$

= 72,500 hours

Capacity for Product 'D'	=	Idle Capacity + A's Spare Capacity
	=	72,500 hrs. + 40,000 hrs.
	=	1,12,500 hrs.
No. of units 'D' (Produced)	=	28,125 units. $\left(\frac{1,12,500\text{hrs.}}{4\text{hrs.}}\right)$

Profitability Statement – Proposal (b)

	D (₹)
Selling Price	60
Less: Variable Cost: Direct Material	28
Direct Wages	12
Variable Overheads	6
Contribution	14
Contribution Amount (28,125 units × ₹14)	3,93,750
Less: Fixed Cost	1,05,500
Profit	2,88,250
Add: Existing Profit of B & C	10,90,000
Total Profit	13,78,250

Proposal (c) Hiring Out Idle Capacity

Particulars	(₹)
Idle Hours	72,500
Existing Profit *per hour* (₹10,70,000 / 2,90,000 hrs.)	3.69
Revenue from Hire Out	2,67,500
Existing Profit	10,70,000
Total Profit	13,37,500

Profit Summary of Alternatives (₹)

Existing	Proposal (a) Option- 1	Proposal (a) Option- 2	Proposal (b)	Proposal (c)
10,70,000	13,21,800	14,24,800	1,378,250	13,37,500

(iii) Decision on Option *on the basis of* Profitability

(i) If price and cost under proposal (a) is for entire production of C: Proposal (b) of Export, should be accepted.

(ii) If price and cost under proposal (a) is for incremental production C only: Proposal (a) – Option 2, should be accepted.

Problem-42

E Ltd. manufactures and sells four types of products under the brand names A, B, C and D. On a turnover of ₹ 30 crores in 2009, company earned a profit of 10% before interest and depreciation which are fixed. The details of product mix and other information are as follows:

Products	*Mix% to Total Sales*	*PV Ratio (%)*	*Raw Material as % on Sales Value*
A	*30*	*20*	*35*
B	*10*	*30*	*40*
C	*20*	*40*	*50*
D	*40*	*10*	*60*

Interest and depreciation amounted to ₹ 225 lakhs and ₹ 115.50 lakhs respectively. Due to increase in prices in the international market, the company anticipates that the cost of raw materials which are imported will increase by 10% during 2010. The company has been able to secure a license for the import of raw materials of a value of ₹ 1,535 lakhs at 2010 prices. In order to counteract the increase in costs of raw materials, the company is contemplating to revise its product mix. The market survey report indicates that the sales potential of each of the products: 'A', 'B' and 'C' can be increased upto 30% of total sales value of 2009. There was no inventory of finished goods or work in progress in both the year.

Required

Set an optimal product mix for 2010 and find the profitability.

Solution

Revised P/V Ratio and Ranking of Products

Product	Existing P/V Ratio (%)	Increase in Raw Material Cost as % of Sales Value	Revised P/V Ratio (%)	Revised Raw Material as % of Sale Value	Contribution per ₹ 100 of Raw Material (%)	Rank
A	20	3.5	16.5	38.50	42.86%	III

B	30	4	26	44.00	59.09%	II
C	40	5	35	55.00	63.64%	I
D	10	6	4	66.00	6.06%	IV

Maximum Sales Potential (₹ in lakhs)

A 900 (30 % of ₹3,000)
B 900 (30 % of ₹3,000)
C 900 (30 % of ₹3,000)
D 1,200 (40 % of ₹3,000)

Allocation of Raw Material

(Supply is Restricted to ₹ 1,535 lacs in Order of Raw Material Profitability)

Product	Rank	Sales (₹ in lakhs)	Raw Material per (₹ 100 lakhs Sales)	Raw Material Required	Balance Raw Material
C	I	900	55	495	1,040
B	II	900	44	396	644
A	III	900	38.5	346.5	297.5
D	IV	451**	66	297.5*	0

* Balancing figure, hence sales will be restricted to 451** lakhs [297.5 / 66%]

Profitability Statement

Product	Existing (2009) (₹ in Lakhs)			Proposed (2010) (₹ in Lakhs)		
	Sales	P/V Ratio	Contribution	Sales	P/V Ratio	Contribution
A	900	20	180	900	16.5	148.5
B	300	30	90	900	26	234
C	600	40	240	900	35	315
D	1,200	10	120	451	4	18.04
Less: Fixed Costs*			330	*Less:* Fixed Costs*		330
Profit before Depreciation and Interest			300	Profit before Depreciation and Interest		385.54
Less: Depreciation			225	*Less:* Depreciation		225.00
Less: Interest			115.5	*Less:* Depreciation		115.50
Profit before Tax			(40.5)	Profit before Tax		45.04

* Balancing Figure (Contribution – Profit before Depreciation & Interest)

The increase of contribution of ₹85.54 in 2010 will set off loss of ₹40.50 lakhs and result in profit of ₹ 45.04 lakhs.

Problem-43

V.C. Ltd. makes and sells two products, P and Q. The budgeted selling price of P is ₹ 1,800 and that of Q is ₹ 2,160. Variable costs associated with producing and selling the P are ₹ 900 and with Q ₹ 1,800. Annual fixed production and selling costs of V.C. Ltd. are ₹ 88,000.

The company has two production/ sales options. The P and Q can be sold either in the ratio of two P to three Q or in the ratio of one P to two Q.

Required

What will be the optimal mix and why?

Solution

Statement Showing "Contribution *per unit*"

	Products	
	P	**Q**
Budgeted Selling Price *per unit* (₹)	1,800	2,160
Less: Variable Cost *per unit* (₹)	900	1,800
Contribution *per unit* (₹)	900	360

Alternative-I

Production / Sales Option: 2 units of P and 3 units of Q

Total Contribution under 1st Option

= 2 units × ₹ 900 + 3 units × ₹ 360

= ₹1,800 + ₹1,080

= ₹2,880

Break- even Point = $\frac{\text{Annual Fixed Production \& Selling Costs}}{\text{Total Contribution under 1st Option}}$

= $\frac{₹\ 88,000}{₹\ 2,880}$

= 30.56 (Set of 5 units each)

	Products		Total
	P	**Q**	
Break- even Point (units)	61.12 units (30.56 × 2 units) *Or* 61 units (approx.)	91.68 units (30.56 × 3 units) *Or* 92 units (approx.)	₹ 3,08,520
Break-even Sales (₹)	₹1,09,800 (61 units × ₹1,800)	₹ 1,98,720 (92 units × ₹ 2,160)	

Alternative-II

Production / Sales Option: 1 unit of P and 2 units of Q

Total Contribution under 2nd Option

= 1 unit × ₹ 900 + 2 units × ₹ 360

= ₹ 900 + ₹ 720

= ₹ 1,620

Break-even point $= \frac{₹\ 88,000}{₹\ 1,620}$

= 54.32 (Set of 3 units each)

	Products		Total
	P	Q	
Break-even Point (units)	54 units (approx.) (54.32 × 1 unit)	109 units (approx.) (54.32 × 2 units)	
Break-even Sales (₹)	₹97,200 (54 units × ₹ 1,800)	₹2,35,440 (109 units × ₹ 2,160)	₹ 3,32,640

Note

The annual fixed production and selling cost given in the problem are such that it is not possible to determine the exact figure of break -even point under two options. As a result of the approximations made as above under option I, at break-even sales level there is over recovery of fixed, cost ₹20; whereas under option II there is an under recovery of fixed cost to the extent of ₹160.

Decision & Reasoning

The above computations disclose that Option I is preferable over Option II, as it results in a lower level of sales to reach break-even (because of higher average contribution per unit). The average contribution per unit under option I is ₹ 576 (₹ 2,880 / 5 units) while under option II it is ₹ 540 (₹ 1,620 / 3 units).

Problem-44

N.P. Ltd. produces two products P and Q. The draft budget for the next month is as under:

	P	*Q*
Budgeted Production and Sales (units)	*40,000*	*80,000*
Selling Price ₹ / unit	*25*	*50*

Total Costs ₹ / unit	*20*	*40*
Machine Hours / unit	*2*	*1*
Maximum Sales Potential (units)	*60,000*	*1,00,000*

The fixed expenses are estimated at ₹ 9,60,000 per month. The company absorbs fixed overheads on the basis of machine hours which are fully utilised by the budgeted production and cannot be further increased.

When the budget was discussed, the Managing Director stated that the product mix should be altered to yield optimum profit.

The Marketing Director suggested that he would introduce a new Product-C, each unit of which will take 1.5 machine hours. However, a processing vat involving a capital outlay of ₹ 2,00,000 is to be installed for processing Product -C. The additional fixed overheads relating to the processing vat was estimated at ₹ 60,000 per month. The variable cost of Product- C was estimated at ₹ 21 per Unit.

Required

(i) Calculate the profit as per draft budget for the next month.

(ii) Revise the product mix based on data given for P and Q to yield optimum profit.

(iii) The company decides to discontinue either Product- P or Q whichever is giving lower profit and proposes to substitute Product- C instead. Fix the selling price of product- C in such a way as to yield 15% return on additional capital employed besides maintaining the same overall profit as envisaged in (ii) above.

Solution

(i) Profit as per Draft Budget for the Next Month

	Products				
	P		**Q**		**Total**
Budgeted Production and Sales	40,000 units		80,000 units		1,20,000 units
	Per Unit (₹)	**Total (₹)**	**Per unit (₹)**	**Total (₹)**	**(₹)**
Sales	25	10,00,000	50	40,00,000	50,00,000
Less: Total Costs	20	8,00,000	40	32,00,000	40,00,000
Profit	5	2,00,000	10	8,00,000	10,00,000

(ii) Basic Calculations

(a)	Machine Hrs.	P: 40,000 units × 2 hrs. Q: 80,000 units × 1 hr.	1,60,000 hrs.
(b)	Fixed Overhead Rate *per machine hr.*	₹9,60,000 / 1,60,000 hrs.	₹6
(c)	Fixed Overhead *per unit*	P: 2 hrs. × ₹6 Q: 1 hr. × ₹6	₹12 ₹6
(d)	Contribution *per unit*	P: ₹12 + ₹5 Q: ₹6 + ₹10	₹17 ₹16
(e)	Product-wise Contribution *per machine hr*.	P: ₹ 17/2hrs. Q: ₹16/1 hr.	₹8.50 ₹16.00

Revised Product Mix to Yield Optimum Profit

Product Q has higher contribution per machine hour. Since machine hour is a limiting factor hence maximum units of product Q should be produced. However, maximum sales potentiality of Product Q is 1,00,000 units. This will take 1,00,000 machine hour. The balance 60,000 hours should be used to produce 30,000 units of P.

The Revised Product Mix to Yield Optimum Profit will be as follows-

Product Q (1,00,000 units × ₹ 16)	₹ 16,00,000
Product P (30,000 units × ₹ 17)	₹ 5,10,000
Total Contribution	₹ 21,10,000
Less: Fixed Expenses	₹ 9,60,000
Profit	₹ 11,50,000

(iii) Product - P gives lower contribution per machine hour, hence, it will be discontinued and Product - C will be manufactured in its place. The discontinuance of Product - P will make available 60,000 machine hours to produce 40,000 units of Product - C.

The computation of Selling Price of Product - C can be done as follows-

Computation of Selling Price of Product- C

	(₹)
Variable Cost (40,000 units × ₹21)	8,40,000
Additional Fixed Cost *per month*	60,000
Return on Capital (₹2,00,000 × ₹1.25%)	2,500
Present Contribution from Product P	5,10,000
Total Sales Value *to be recovered*	14,12,500
Selling Price *per unit* of C (₹14,12,500 / 40,000 units)	35.31

Problem-45

Venus Ltd. is engaged in the manufacture of four products in its factory. The production and sales volume is much lower than the normal volume and so there is a substantial unfavourable variance in the recovery of overheads. The sales and cost data for a year are as under:–

(₹ in lakhs)

	A	B	C	D	Total
Sales	400	500	200	100	1200
Direct Materials	64	70	32	7	173
Direct Wages	88	105	60	18	271
Factory Overheads	128	172	120	24	444
Selling & Admn. Overheads	80	100	40	20	240
Profit / Loss	40	53	(52)	31	72
Unabsorbed Overheads					48
Net Profit					24

50 percent of the factory overheads is variable at normal operating volume and the variable selling and administration overheads account for 5% of sales.

Of the total sales of product 'C' half of the volume is used in the market for applications in which product 'D' can be substituted. Thus if product 'C' is not available the sales of product 'D' can be increased by ₹ 100 lakhs without any change in the fixed selling expenses.

Of the total sales of product 'C' about 25% is sold in conjunction with product 'A'. The customers will not be able to substitute product 'D' and so the sales of product 'A' will be reduced by 12.5% of the present level if product 'C' is withdrawn.

In the event of total discontinuance of product 'C', the fixed factory and selling and administration overheads will be reduced by ₹ 20 lakhs. Alternatively if the production and sales of product 'C' is maintained to the extent of 25% of the present level as service to product 'A', there will be a reduction in the fixed costs to the extent of ₹ 10 lakhs.

Required

(i) *Prepare statements to show the financial implications of:*
   (a) *Continuance of Product 'C'*
   (b) *Total discontinuance of product 'C'*
   (c) *Continuance of product 'C' only as service to customers using product 'A' whose business will otherwise be lost.*

(ii) *Make your recommendations on the course of action to be taken by the company with such comments as you may like to offer.*

Solution

(i) (a) Workings

Computation of Total Fixed Overheads (₹ in lakhs)

Factory Overheads	444
Less: 50% Variable	222
Balance Fixed…(A)	222
Selling & Administrative Overheads	240
Less: 5% of Sales-Variable	60
Balance Fixed…(B)	180
Unabsorbed Overheads – Fixed …(C)	48
Total Fixed Overheads …(A) + (B) + (C)	450

Financial Implications of Continuance of Product 'C'

(₹ in lakhs)

	A	B	C	D	Total
Sales	400	500	200	100	1,200
Direct Materials	64	70	32	7	173
Direct Wages	88	105	60	18	271
Variable Factory Overheads (50%)	64	86	60	12	222
Variable Selling & Admn. Overheads (5% of Sales)	20	25	10	5	60
Contribution	164	214	38	58	474
Fixed Overheads					450
Profit					24

(b) Workings

Savings in Fixed Overheads = ₹20 lakhs

Hence Fixed Overheads (₹450 – ₹20) = ₹430 lakhs

Sales of Product 'D' = ₹200 lakhs

Reduction in Sales of Product 'A' by 12½% = ₹50 lakhs

Thus Sale of Product 'A' = ₹350 lakhs

Financial Implications of Total Discontinuance of Product 'C'

(₹ in lakhs)

	Products			
	A	B	D	Total
Sales	350	500	200	1,050
Direct Materials	56	70	14	140
Direct Wages	77	105	36	218
Factory Overheads Variable	56	86	24	166
Selling & Admn. Overheads Variable	17.5	25	10	52.5
Contribution	143.5	214	116	473.5
Fixed Overheads				430.0
Profit				43.5

(c) Workings

Saving in Fixed Overheads = ₹10 lakhs

Hence Fixed Overheads (₹450 – ₹10) = ₹440 lakhs

Financial Implications of Continuance of Product 'C' as Service to Product 'A'

(₹ in lakhs)

	Products				
	A	B	C	D	Total
Sales	400	500	50	200	1,150
Direct Materials	64	70	8	14	156
Direct Wages	88	105	15	36	244
Variable Factory Overheads	64	86	15	24	189
Variable Selling & Adm. Overheads	20	25	2.5	10	57.5
Contribution	164	214	9.5	116	503.5
Fixed Overheads					440.0
Profit					63.5

(ii) The above statements show that continuance of product 'C' as service to product 'A' increases the profitability to ₹63.5 lakhs because of the increase in sales of product 'D' which is the highest contribution yielding product. Therefore, the company should adopt this course i.e. producing product 'C' only as service to customers using product 'A' whose business will otherwise be lost. However, the company should ensure that the market will be able to absorb increased production of 'D' at the prevailing prices and the available machine capacity will be adequate for manufacture of increased volume of product 'D'.

Problem-46

Bloom Ltd. makes three products, A, B and C. The following information is available:

	(Figures in Rupees per unit)		
	A	***B***	***C***
Selling price (peak-season)	*550*	*630*	*690*
Selling price (off-season)	*550*	*604*	*690*
Material cost	*230*	*260*	*290*
Labour (peak-season)	*110*	*120*	*150*
Labour (off-season)	*100*	*99*	*149*
Variable production overhead	*100*	*120*	*130*
Variable selling overhead (only for peak-season)	*10*	*20*	*15*
Labour hours required for one unit of production	*8*	*11*	*7 (hours)*

Material cost and variable production overheads are the same for the peak-season and off-season. Variable selling overheads are not incurred in the off-season. Fixed costs amount to ₹ 26,780 for each season, of which ₹ 2,000 is towards salary for special technician, incurred only for product B, and ₹ 4,780 is the amount that will be incurred on after-sales warranty and free maintenance of only product C, to match competition.

Labour force can be interchangeably used for all the products. During peak-season, there is labour shortage and the maximum labour hours available are 1,617 hours. During off-season, labour is freely available, but demand is limited to 100 units of A, 115 units of B and 135 units of C, with production facility being limited to 215 units for A, B and C put together.

Required

(i) *Advise the company about the best product mix during peak-season for maximum profit.*

(ii) *What will be the maximum profit for the off-season?*

Solution

Bloom Ltd.
Peak Season
Statement of Contribution and BEP (in units)

(Figures in₹)

Product	A	B	C	Gen.
Selling Price *per unit*	550	630	690	
Variable Costs per unit				
Direct Material	230	260	290	
Direct Labour	110	120	150	
Variable Overhead - Production	100	120	130	
Variable Overhead - Selling	10	20	15	
Total Variable Cost	450	520	585	
Contribution / unit	100	110	105	
Direct Labour hours Required *per unit*	8	11	7	
Contribution per Labour Hour	12.5	10	15	
Ranking	II	III	I	
General Fixed Overhead	---	---	---	20,000
Specific Fixed Overhead	---	2,000	4,780	6,780
BEP (units) (for only 1 Product at a time)	$\left(\frac{₹20,000}{₹100}\right)$ 200 units	$\left(\frac{₹22,000}{₹110}\right)$ 200 units	$\left(\frac{₹24,780}{₹105}\right)$ 236 units	

Maximum 231 units $\left(\frac{1,617\text{hrs.}}{7\text{hrs.}}\right)$ can be produced of product C with limited labour hours 1,617. Since, 231units are less than break even units. Hence, Bloom Ltd. cannot produce C. Next Rank is of Product A.

Maximum 202 units $\left(\frac{1,617\text{hrs.}}{8\text{hrs.}}\right)$ can be produced of product A with limited labour hours. Break Even of A is 200 units. Profit if only A is produced –

	(₹)
Contribution (202 units × ₹100)	20,200
Less: Fixed Cost	20,000
Profit	200

Bloom Ltd.
Off Season
Statement of Contribution and Demand

(Figures in ₹ per unit)

Product	A	B	C
Selling Price	550	604	690
Less: Direct Material	230	260	290
Direct Labour	100	99	149
Production-Variable Overhead	100	120	130
Contribution *per unit*	120	125	121
Ranking	III	I	II
Maximum Demand	100	115	135

Statement of Profitability under Different Options
(Limit of Production, 215 units)

Particulars	A	B	C	Total	Fixed Cost	Profit / (Loss)
Contribution *per unit*	120	125	121	---		
Option 1:						
Units	---	115	100	215		
Contribution (₹)	---	14,375	12,100	26,475	26,780	(305)
Option 2:						
Units	100	115	---	215		
Contribution (₹)	12,000	14,375	---	26,375	22,000	4,375
Option 3:						
Units	80	---	135	215		
Contribution (₹)	9,600	---	16,335	25,935	24,780	1,155

Best strategy is to produce 100 units of product A and 115 units of product B during off season. Maximum profit is ₹4,375.

Problem-47

Dyal Dairies Ltd. has two processing and bottling plants, Danida and Danima, in adjoining districts. The comparative cost and revenue data budgeted per month are as below:-

	Danida	Danima
Production (Litres)	*1,00,000*	*75,000*
Variable Costs:	*(₹)*	*(₹)*
Bottles	*1,00,000*	*79,000*
Closures	*90,000*	*71,500*
Crates	*14,000*	*12,500*
Milk Loss	*30,000*	*47,000*
Electricity	*14,000*	*14,000*
Fuel	*40,000*	*46,000*
Water	*10,000*	*11,250*
Fixed Costs:	*(₹)*	*(₹)*
Electricity	*13,500*	*11,000*
Salaries & Wages	*90,000*	*60,000*
Depreciation	*50,000*	*20,000*
Total Costs (₹)	*4,51,500*	*3,72,250*
Sales Realisation (₹)	*7,00,000*	*5,25,000*
Profit (₹)	*2,48,500*	*1,52,750*

Danima's high cost, low margin status drawn management's attention. It is also observed that Danida can increase its production by 50 per cent with the existing plant capacity and without additional manpower.

Two proposals are under consideration:

(i) Cut down Danima's production by 25,000 litres and increase Danida's production by 25,000 litres.

(ii) Cut down Danima's production by 50,000 litres and increase Danida's production by 50,000 litres.

For the additional quantity produced in excess of 1,00,000 litres, Danida will incur ₹ 0.40 per litre towards group incentive. Transporting the additional output from Danida to Danima's region for sale will cost ₹ 10,000 in both cases.

Required

(i) Prepare a statement to show the contribution and the profit for Danida, Danima and for the company as a whole, for each proposal. Comment on the results.

(ii) *The management is keen that the cut in Danima's production should not result in its reporting loss, as that would demoralize its employees. If break–even production is to be retained in Danima and the balance alone is to be transferred to Danida. Show the contribution and the profit for Danida, Danima and the company as a whole.*

Solution

(i) Proposal 1

Statement Showing "Contribution and the Profit"

	Danida	Danima	Total
Production (Litres)	1,25,000	50,000	
Contribution *per litre*	₹4.02	₹3.25	
Total Contribution (₹)	5,02,500	1,62,500	6,65,000
Less: Group Incentive Payable (₹)	10,000	---	10,000
Less: Fixed Cost (₹)	1,53,500	91,000	2,44,500
Less: Transport Cost (₹)	10,000	---	10,000
Profit (₹)	3,29,000	71,500	4,00,500
Budgeted Profit (₹)	2,48,500	1,52,750	4,01,250

Comments

The Proposal, if implemented, will result in a drop in overall profit by ₹750 {₹4,01,250 – ₹4,00,500}.

Proposal 2

Statement Showing "Contribution and the Profit"

	Danida	Danima	Total
Production (Litres)	1,50,000	25,000	1,75,000
Contribution *per litre*	₹4.02	₹3.25	
Total Contribution (₹)	6,03,000	81,250	6,84,250
Less: Group Incentive Payable (₹)	20,000	---	20,000
Less: Fixed Cost (₹)	1,53,500	91,000	2,44,500
Less: Transport Cost (₹)	10,000	---	10,000
Profit (₹)	4,19,500	(9,750)	4,09,750
Budgeted Profit (₹)	2,48,500	1,52,750	4,01,250

Comments

The implementation of the proposal will increase profits for the company as a whole by ₹ 8,500 { ₹4,09,750 – ₹4,01,250} though Danima will be reporting loss.

(ii)	Contribution *per litre* for Danima	₹3.25
	Total Fixed Costs of Danima	₹91,000
	Break – even Production for Danima $\left(\frac{₹91,000}{₹3.25}\right)$	28,000 liters

The production that could be transfer from Danima to Danida, retaining break – even production in Danima, is 47,000 litres {75,000 litres – 28,000 litres}.

Statement Showing "Contribution and the Profit"

	Danida	Danima	Total
Production (litres)	1,47,000	28,000	1,75,000
Contribution *per litre*	₹4.02	₹3.25	
Total Contribution (₹)	5,90,940	91,000	6,81,940
Less: Group Incentive Payable (₹)	18,800	---	18,800
Less: Fixed Costs (₹)	1,53,500	91,000	2,44,500
Less: Transport Cost (₹)	10,000	---	10,000
Profit	4,08,640	---	4,08,640
Budgeted Profit	2,48,500	1,52,750	4,01,250

The Overall Profit will increase by ₹7,390 { ₹4,08,640 – ₹4,01,250} by transferring 47,000 litres of production to Danida.

Working Note

Sales Price Computation *per liter*

	Danida (₹)	Danima (₹)
Sales Price	7.00 $\left(\frac{₹7,00,000}{1,00,000\text{liters}}\right)$	7.00 $\left(\frac{₹5,25,000}{75,000\text{liters}}\right)$
Less: Variable Cost	2.98 $\left(\frac{₹2,98,000}{1,00,000\text{liters}}\right)$	3.75 $\left(\frac{₹2,81,250}{75,000\text{liters}}\right)$
Contribution	4.02	3.25

Problem-48

Future Ltd. manufactures product N using one unit each of three components named P, Q & R and sells it at ₹ 37.50 per unit. It has two divisions. In production division it produces all the types of components by using its full capacity of 42,000 machines hours. In assembly division the remaining job is performed by the workers manually before N is ready for sale:

Product N is manufactured in batches of 100 units and the data relating to the current production per batch are:

	Machine Hours	Variable Cost (₹)	Fixed Cost (₹)	Total Cost (₹)
Production Division:				
Component – P	15	375	150	525
Component – Q	25	450	175	625
Component – R	30	450	450	900
Assembly Division:				
Assembly---		800	325	1,125
		2,075	1,100	3,175

For the next year the company has estimated that its sale would go up by 50% more than the present sales and probably even by 75% if the production capacity is made available.

The machine capacity cannot be increased during the next year even though the workers in the assembly division can be increased as per requirement without any increase in fixed costs. To meet the increased demand, production can be taken up and processed in assembly division by procuring the components from the open market. The company has received the following price quotations for the purchase of components:

	P	Q	R
Price offered per component (₹)	5.55	7.00	8.40

Required

(i) Determine the production and profits being earned at present.

(ii) Indicate which of the component (s) should be purchased and in what quantities at the two estimated levels of output viz. increase by 50% and 75% of existing production.

(iii) Prepare a statement showing the company's profitability at both the estimated levels of output.

Solution

(i) Statement of Current Production of Product

Machine Hours Utilised *per batch of 100 units*

P	15
Q	25
R	30
Total (Hrs.)	70

Available Machine Hours 42,000

Current Year Production of P, Q and R *in batches of 100 units*

$$\left(\frac{42{,}000 \text{ hours}}{70 \text{ hours}}\right) = 600 \text{ Batches}$$

60,000 units (600 batches × 100 units) of Product -N produced.

Statement of Profit Earned *during current year*

(Sale of 60,000 units of Product – N)

	(₹)
Sales Revenue (60,000 units × ₹ 37.50)	22,50,000
Less : Variable Costs:	
Component P (600 batches × ₹375)	2,25,000
Component Q (600 batches × ₹450)	2,70,000
Component R (600 batches × ₹450)	2,70,000
Assembly (600 batches × ₹800)	4,80,000
Contribution	10,05,000
Less: Fixed Cost (600 batches × ₹1,100)	6,60,000
Profit	3,45,000

(ii) Contribution *per batch* and Ranking of Components

	Components		
	P	Q	R
Price Offered (₹)	555	700	840
Variable Costs (₹)	375	450	450

Contribution / Savings (₹)	180	250	390
Machine Hours Required	15	25	30
Contribution / Saving *per machine hour* (₹)	12	10	13
Rank to Manufacture	II	III	I

Quantities of Components to be purchased from the market at the quoted price when the estimated level of output increases by 50% and 75% of the existing production of 600 batches, (that is when the output level of production increases to 900 batches and 1,050 batches)

900 Batches					
Comp	**Required Prod. in Batches**	**Hrs/ Batch**	**Production Planned in Batches**	**Hours Utilized**	**Balance Hours**
1	**2**	**3**	**4**	**5= 3×4**	**6**
R	900	30	900	27,000	15,000 (42,000 – 27,000)
P	900	15	900	13,500	1,500 (15,000 – 13,500)
Q	900	25	60	1,500	– (1,500 – 1,500)
In this case 840 batches (900 batches – 60 batches) or 84,000 units of component Q should be purchased from the market.					

1,050 batches					
Comp	**Required Prod. in Batches**	**Hrs/ Batch**	**Production Planned in Batches**	**Hours Utilized**	**Balance Hours**
1	**2**	**3**	**4**	**5=3×4**	**6**
R	1,050	30	1,050	31,500	10,500 (42,000 – 31,500)
P	1,050	15	700	10,500	– (10,500 – 10,500)
Q	1,050	25	–	–	–
In this case 350 batches (1,050 batches – 700 batches) or 35,000 units of component P and 1,050 batches or 1,05,000 units component Q should be purchased.					

(iii) Statement of Profitability

Particulars	**900 Batches or 90,000 units (₹)**	**1,050 Batches or 1,05,000 units (₹)**
Sales Revenue (₹37.50 per unit)	33,75,000	39,37,500
Less: Variable Cost (Manufacturing*):		
P	3,37,500 (900 × ₹375)	2,62,500 (700 × ₹375)
Q	27,000 (60 × ₹450)	---
R	4,05,000 (900 × ₹450)	4,72,500 (1,050 × ₹450)
Less: Variable Cost (Purchasing):		
P	---	1,94,250 (350 × ₹555)
Q	5,88,000 (840 × ₹700)	7,35,000 (1,050 × ₹700)
Less: Assembly Cost	7,20,000	8,40,0000
Contribution	12,97,500	14,33,250
Less: Fixed Cost	6,60,000	6,60,000
Profit	6,37,500	7,73,250

** Refer to part (ii) of the answer.*

Problem-49

Gemini Publishers Ltd. is considering launching a new monthly magazine at a selling price of ₹ 10 per copy. Sales of the magazine are expected to be 5,00,000 copies per month, but it is possible that the actual sales could differ quite significantly from this estimate.

Two different methods of producing the magazine are being considered and neither would involve any additional capital expenditure. The estimated production cost for each of the two methods of manufacture, together with the additional marketing and distribution costs of selling the new magazine, are given below:

	Method A	***Method B***
Variable Costs	*₹ 5.50 per copy*	*₹ 5.00 per copy*
Specific Fixed Costs	*₹ 8,00,000 p.m.*	*₹ 12,00,000 p.m.*

Semi-Variable Costs:		
3,50,000 Copies	*₹ 5,50,000 p.m.*	*₹ 4,75,000 p.m.*
4,50,000 Copies	*₹ 6,50,000 p.m.*	*₹ 5,25,000 p.m.*

The following estimates have been available:

It may be assumed that the fixed cost content of the semi-variable cost will remain constant throughout the range of activity shown.

The company currently sells a magazine covering related topics to those that will be included in the new publication, and consequently, it is anticipated that sales of this existing magazine will be adversely affected. It is estimated that for every ten copies sold of the new publication, sales of the existing magazines will be reduced by one copy.

Sales and cost data of the existing magazines are as shown below:

Sales……………………………….. ₹ 2,20,000 copies p.m.
Selling Price……………………….. ₹ 8.50 per copy
Variable Costs…………………….. ₹ 3.50 per copy
Specific Fixed Costs…………….. ₹ 8,00,000 p.m.

Required

(i) Calculate, for each production the net increase in company profits which will result from the introduction of the new magazine, at each of the following levels of activity:

5,00,000 Copies p.m.
4,00,000 Copies p.m.
6,00,000 Copies p.m.

(ii) Calculate, for each production method, the amount by which sales volume of the new magazine could decline from the anticipated 5,00,000 copies per month, before the company makes an additional profit from the introduction of the new publication.

(iii) Briefly identify any conclusions which may be drawn from your calculation.

Solution

(i) Calculation of Net Increase in Company Profits

Method A

	Levels Activity		
Copies Sold	5,00,000	4,00,000	6,00,000
Contribution *per copy* (₹)	3.00	3.00	3.00
Total Contribution (₹)	15,00,000	12,00,000	18,00,000

Less: Total Fixed Costs (₹)	10,00,000	10,00,000	10,00,000
Net Increase in Profit (₹)	5,00,000	2,00,000	8,00,000

Method B

	Level of Activity		
Copies Sold	5,00,000	4,00,000	6,00,000
Contribution *per copy* (₹)	4.00	4.00	4.00
Total Contribution (₹)	20,00,000	16,00,000	24,00,000
Less: Total Fixed Costs (₹)	15,00,000	15,00,000	15,00,000
Net Increase in Profit (₹)	5,00,000	1,00,000	9,00,000

(ii) Break -even Point = Fixed Cost ÷ Contribution *per unit*

Method A = ₹10,00,000 ÷ ₹3

= 3,33,333 Copies

Method B = ₹15,00,000 ÷ ₹4

= 3,75,000 Copies

The margin of safety or the amount by which sales volume of the new magazine could decline is the difference between the anticipated sales and the breakeven point sales. This is calculated below-

Method A = 5,00,000 Copies – 3,33,333 Copies

= 1,66,667 Copies

Method B = 5,00,000 Copies – 3,75,000 Copies

= 1,25,000 Copies

(iii) The above calculations show that Method B has a higher breakeven point and a higher contribution per copy sold. Therefore, profits from method B are more vulnerable to a decline in sales volume. However, higher profits are obtained with method B.

The contribution per copy of the existing magazine is ₹5. Therefore, the breakeven point from the sales of the existing magazines is 1,60,000 copies (₹8,00,000 ÷ ₹ 5.00).

The current level of monthly sales is 2,20,000 copies. Therefore, sales can drop by 60,000 copies before breakeven point is reached. For every 10 copies sold of the new magazine, sales of the existing magazine will be reduced by one copy. Consequently, if more than 6,00,000 copies of the new magazine are sold, the existing magazine will make a loss. Therefore, if the sales of the new magazine are expected to consistently exceed 6,00,000 copies, then the viability of the existing magazine must be questioned.

Workings

1. Analysis of Semi-Variable Costs

Method A

Variable Element = Increase in Cost ÷ Increase in Activity
= ₹1,00,000 ÷ 1,00,000 Copies
= ₹1 *per copy*

Fixed Element = Total Semi-Variable Cost – Variable Cost (at an activity level of 3,50,000 copies)
= ₹5,50,000 – ₹3,50,000
= ₹2,00,000

Method B

Variable Element = Increase in Cost ÷ Increase in Activity
= ₹50,000 ÷ 1,00,000 Copies
= ₹0.50 *per copy*

Fixed Element = Total Semi-Variable Cost – Variable Cost (at an activity level of 3,50,000 copies)
= ₹4,75,000 – ₹1,75,000
= ₹3,00,000

Note

The analysis is based on a comparison of total costs and activity levels at 3,50,000 and 4,50,000 copies per month respectively.

2. Total Fixed Cost

Method A	(₹)
Specific Fixed Cost	8,00,000
Add: Fixed Element in Semi-Variable Cost	2,00,000
Total	10,00,000

Method B	(₹)
Specific Fixed Cost	12,00,000
Add: Fixed Element in Semi-Variable Cost	3,00,000
Total	15,00,000

3. Contribution *per copy* of New Magazine

	Method A	**Method B**
	(₹)	(₹)
Selling Price	10.00	10.00

Variables Cost (given)	5.50	5.00
Variable Element of Semi-Variable Cost	1.00	0.50
Lost Contribution from Existing Magazine		
(On 10 new copies, ₹5 will be lost)	0.50	0.50
Total Variable Costs	7.00	6.00
Contribution	3.00	4.00

Problem-50

Apex Limited manufacturer two products, P and Q, using the same production facility. The following information is available for a production period:

Particulars	*Product P*	*Product Q*
Demand (units)	*2,20,000*	*1,75,000*
Contribution (₹ / unit)	*10*	*12*
Machine hours required per 100 units	*15*	*25*

P and Q can be produced only in batches of 100 units, and whatever is produced has to be sold or discarded. Inventory build-up is not possible from one production period to another. The total fixed costs for each level of production and directly attributable to P and Q are given below:

Level of output	*Total Fixed Costs (₹)*	
	Product P	*Product Q*
Upto 1,00,000 units	*6,00,000*	*5,50,000*
1,00,001 to 2,00,000 units	*13,50,000*	*12,20,000*
2,00,001 to 3,00,000 units (maximum possible level)	*18,70,000*	*15,50,000*

75,000 machine hours are available in the production period.

Required

(i) Calculate the quantities of P and Q in the best product mix to achieve the maximum profit and compute the maximum profit.

(ii) What will be the opportunity cost of meeting P's demand fully?

Solution

(i) **Statement Showing "Contribution / Machine Hour"**

	'P'	'Q'
Demand (batches of 100 units)	2,200 $\left(\frac{2{,}20{,}000 \text{ units}}{100 \text{ units}}\right)$	1,750 $\left(\frac{1{,}75{,}000 \text{ units}}{100 \text{ units}}\right)$
Contribution (₹/ batch)	1,000 (₹10 × 100 units)	1,200 (₹12 × 100 units)
Machine Hours Required per batch	15	25
Contribution / Machine Hour	66.66…	48
Rank	I	II

Allocation of Machine Hours ***on the basis of ranking***

Produce 'P' *as much as possible*	=	2,200 batches
Hours Required	=	33,000 hrs (2,200 batches × 15 hrs.)
Balance Hours Available	=	42,000 hrs (75,000 hrs. – 33,000 hrs.)
Produce 'Q' (the Next Best)	=	1,680 batches $\left(\frac{42{,}000 \text{ hrs.}}{25 \text{ hrs.}}\right)$

Statement Showing "Maximum Possible Contribution"

Product	Batches	Cont./Batch (₹)	Total (₹)
'P'	2,200	1,000	22,00,000
'Q'	1,680	1,200	20,16,000
Maximum Possible Contribution			42,16,000

Statement Showing "Incremental Fixed Cost"

	'P' (₹)	'Q' (₹)
Up to 1,000 batches	6,00,000	5,50,000
Next 1,000 batches	7,50,000	6,70,000
Next 1,000 batches	5,20,000	3,30,000

For producing additional batches above 2,000 batches of Product 'P' Apex Limited have to incur additional fixed cost of ₹5,20,000 to earn additional contribution of

₹2,00,000 (200 batches × ₹1,000) which is not beneficial. However, hours saved on 200 batches i.e. 3,000 hrs (200 batches × 15 hrs.) can be utilized for production of 'Q' to the extent of 70 batches (1,750 batches i.e. maximum demand of 'Q'– 1,680 batches).

The contribution from producing additional 70 batches of Product 'Q' will be ₹84,000 (70 batches × ₹1,200). Accordingly best product mix will be 2,000 batches of 'P' and 1,750 batches of 'Q'.

Statement Showing "Maximum Profit"

Product	Batches	Cont./Batch	Total
'P'	2,000	1,000	20,00,000
'Q'	1,750	1,200	21,00,000
Contribution			41,00,000
Less: Fixed Cost – 'P'			13,50,000
Less: Fixed Cost – 'Q'			12,20,000
Net Profit			15,30,000

(ii) **Statement Showing "Opportunity Cost"**

[Benefit Denied in the Next Best Alternative i.e. (i)]

Particulars	Total
Additional Fixed Cost Not Covered by Producing 'P' in the Maximum Range (₹5,20,000 – ₹2,00,000)	3,20,000
Add: Loss of Contribution (Not Producing 70 batches of 'Q')	84,000
Total Opportunity Cost	4,04,000

Decision on Subcontracting

Problem-51

Lee Electronic manufactures four types of electronic products, A, B, C and D. All these products have a good demand in the market. The following figures are given to you:

	A	*B*	*C*	*D*
Material Cost (₹/u)	*64*	*72*	*45*	*56*
Machining Cost (₹/u @ ₹8 per hour)	*48*	*32*	*64*	*24*
Other Variable Costs (₹/u)	*32*	*36*	*44*	*20*
Selling Price (₹/u)	*162*	*156*	*173*	*118*
Market Demand (Units)	*52,000*	*48,500*	*26,500*	*30,000*

Fixed overhead at different levels of operation are:

Level of Operation (in production hours)	***Total Fixed Cost (₹)***
Upto 1,50,000……	*10,00,000*
1,50,000 – 3,00,000……	*10,50,000*
3,00,000 – 4,50,000……	*11,00,000*
4,50,000- 6,00,000……	*11,50,000*

At present, the available production capacity in the company is 4,98,000 machine hours. This capacity is not enough to meet the entire market demand and hence the production manager wants to increase the capacity. The company wants to retain the customers by meeting their demands through alternative ways. One alternative is to sub-contract a part of its production. The sub-contract offer received as under:

	A	***B***	***C***	***D***
Sub-contract Price (₹/u)	*146*	*126*	*155*	*108*

Required

The company seeks your advice in terms of products and quantities to be produced and/or sub-contracted, so as to achieve the maximum possible profit. Also compute the profit expected from your suggestion.

Solution

	Demand (Units)			
	52,000	**48,500**	**26,500**	**30,000**
	A	**B**	**C**	**D**
Selling Price	162	156	173	118
Direct Material	64	72	45	56
Manufacturing Cost	48	32	64	24
Other Variable Cost	32	36	44	20
Contribution (₹/u)	18	16	20	18
Machine Hours *per unit*	6	4	8	3
Contribution (₹/ M/c hr.)	3	4	2.5	6
Ranking	III	II	IV	I
Sub-Contract Cost ₹/ u)	146	126	155	108
Contribution (₹ / u) on (Sub-Contract)	16	30	18	10

Decision

It is more profitable to **sub-contract B**, since contribution is higher sub-contract.

1st Level of Operations

Produce D *as much as possible*	=	30,000 units
Hours Required	=	90,000 hrs (30,000 units × 3hrs.)
Balance Hours Available	=	60,000 hrs
Produce the Next Best	=	10,000 units of A* $\left(\frac{60,000\text{ hrs}}{6\text{ hrs / u}}\right)$

**Since B is better to be outsourced.*

Product	Particulars	Contribution/ unit	Contribution (₹)
A	Produce: 10,000 units	18	1,80,000
	Outsource: 42,000 units	16	6,72,000
B	Outsource Fully: 48,500 units	30	14,55,000
C	Outsource Fully: 26,500 units	18	4,77,000
D	Fully Produce: 30,000 units	18	5,40,000
Total Contribution			33,24,000
Less: Fixed Cost			10,00,000
Net Gain			23,24,000

2nd Level of Operation

Both A and C increase contribution by own manufacture only by ₹2/- per unit. 1,50,000 hrs can produce 25,000 units of A.

Contribution increases by ₹50,000 (25,000 units × ₹2) [Difference in Contribution *sub-contract* and *own manufacturing* is ₹ 2]

But increase in Fixed Cost by ₹50,000.

At the 2nd level of operation, the *increase in contribution* by own manufacturing is *exactly set up* by *increase in fixed costs* by ₹ 50,000/-. It is a *point of financial indifference*, but other conditions like reliability or possibility of the sub-contractor increasing his price may be considered and decision may them but towards own manufacture.

3rd Level of Operation

Additional Hrs Available	=	1,50,000 hrs.
Unit of A that are Needed	=	[52,000 – 25,000 (2nd Level) – 10,000 (1st Level)]
	=	17,000 units

Hrs. Required for A	=	17,000 units × 6 hrs/u
	=	1,02,000 hrs.
Balance Hours Available for C	=	1,50,000 hrs. – 1,02,000 hrs.
	=	48,000 hrs.
Units of C can be Produced	=	6,000 units
Increase in Contribution over Level 1st or 2nd	=	₹46,000
		(A: 17,000 units × ₹2 + C: 6,000 units × ₹2)
Increase in Fixed Cost	=	₹50,000
Additional Loss	=	₹50,000 − ₹46,000
	=	₹4,000

4th Level of Operation

Additional Hrs Available	=	1,50,000 hrs.
Additional 1,50,000 can give	=	18,750 units of C
		$\left(\frac{1{,}50{,}000\text{hrs.}}{8\text{hrs.}}\right)$
Increase in Contribution	=	₹37,500
		(C: 18,750 units × ₹2)
Increase in Fixed Cost	=	₹50,000
Additional Loss	=	₹50,000 − ₹37,500
	=	₹12,500
Level 1st Profit will *go down by*	=	₹12,500 + ₹4,000
	=	₹16,500

Advice

Do not Expand Capacities.

Summary

Product	Produce (Units)	Sub-Contract (Units)	Contribution (Production)	Contribution (Sub-Contract)	Total Contribution
A	10,000	42,000	1,80,000	6,72,000	8,52,000
B	---	48,500	---	14,55,000	14,55,000
C	---	26,500	---	4,77,000	4,77,000
D	30,000	---	5,40,000	---	5,40,000
Total Contribution					33,24,000
Less: Fixed Cost					10,00,000
Profit					23,24,000

Problem-52

AXE Ltd. manufactures four products A, B ,C and D. The following details are available for a production period:

	A	B	C	D
Selling price	100	109	121	124
Material cost	40	42	46	40
Labour cost				
Assembly Dept. @ ₹ 10 per hour	15	20	15	20
Machine Dept. @ ₹ 12 per hour	18	24	36	30
Variable overheads @ ₹ 4 per labour hour in assembly dept.	6	8	6	8
Maximum external demand (units)	40,000	55,000	36,000	30,000

Total fixed cost is dependent on the output level and is tabulated below at different levels of output:

Production units (any combination of one or more of any A, B, C or D)	Total fixed cost (₹)
Zero to 1,00,000 units	8,43,000
1,00,001 to 1,50,000 units	12,50,000
1,50,001 to 2,00,000 units	16,00,000

Production facilities can be interchangeably used among the products.

Labour availability in the assembly department is limited to 2,20,000 hours for the production period. A local firm has offered to make any quantity of any of the products on a sub-contract basis at the following rates:

	A	B	C	D
Sub-contract Price (₹ /unit)	85	95	101	100

Required

(i) Advise the management on how many units of each product are to be manufactured or subcontracted to fulfill maximum market demand. What would be the corresponding profits?

(ii) What is the minimum number of units to be produced to achieve break-even point?

(iii) What would you advise as the best strategy to maximize profits if assembly labour is not a limiting factor and if there is no compulsion to fulfill market demand?

(Only relevant figures need to be discussed. A detailed profitability statement is not required).

Solution

(i) Assembly Labour is a Limiting Factor & to fulfill Maximum Market Demand

Contribution *per unit* as well as Contribution *per assembly hour*

	Demand (Units)			
	40,000	55,000	36,000	30,000
	A	B	C	D
Selling Price (₹/u)	100	109	121	124
Material Cost (₹/u)	40	42	46	40
Labour Cost (₹/u)				
Assembly Dept.	15	20	15	20
Machine Dept.	18	24	36	30
Variable Overheads (₹/u)	6	8	6	8
Contribution (₹/u)	21	15	18	26
Assembly Hours *per unit*	1.5	2	1.5	2
Contribution (₹/hr.)	14	7.5	12	13
Rank [Contribution (₹/hr.)]	I	IV	III	II
Sub-Contract Price (₹/u)	85	95	101	100
Contribution (₹/u) [Sub-Contract]	15	14	20	24

It is more profitable to ***sub-contract C***, since contribution is higher in sub -contracting.

Allocation of Assembly Hours *on the basis of ranking*

Produce A *as much as possible* = **40,000 units**

Hours Required = 60,000 hrs (40,000 units × 1.5 hrs.)

Balance Hours Available = 1,60,000 hrs (2,20,000 hrs. − 60,000 hrs.)

Produce the Next Best = **30,000 units of D**

Hours Required = 60,000 hrs (30,000 units × 2 hrs.)

Balance Hours Available = 1,00,000 hrs (1,60,000 hrs. − 60,000 hrs.)

Produce the Next Best = **50,000 units of B** $\left(\frac{1,00,000 \text{ hrs}}{2 \text{ hrs / u}}\right)$

Profit *on the basis of ranking*

Product	Particulars	Contribution/unit (₹)	Contribution (₹)
A	Produce: 40,000 units	21	8,40,000
	Subcontract: NIL units	15	---
B	Produce: 50,000 units	15	7,50,000
	Subcontract: 5,000 units	14	70,000
C	Produce: NIL units	18	---
	Subcontract: 36,000 units	20	7,20,000
D	Produce: 30,000 units	26	7,80,000
	Subcontract: NIL units	24	---
Total Contribution			31,60,000
Less: Fixed Cost			12,50,000
Net Profit			19,10,000

Decision

However AXE Ltd. can save fixed cost of ₹ 4,07,000 (₹ 12,50,000 − ₹ 8,43,000) if it keeps its production limited to 1,00,000 units. But in this case AXE Ltd. has to subcontract 20,000 units of B to fulfill maximum market demand. Contribution Lost from subcontracting of 20,000 units is amounting to ₹ 20,000 [20,000 units × (₹ 15 − ₹ 14)]. Hence optimum profit would be ₹ 22,97,000 [₹ 19,10,000 + ₹ 4,07,000 − ₹ 20,000].

Production Vs Sub Contract (units) and Profit – Best Strategy

Prod	Produced [Units]	Sub-Contract [Units]	Contribution [Production] (₹)	Contribution [Sub-Contract] (₹)	Total Contribution (₹)
A	40,000	---	8,40,000	---	8,40,000
B	30,000	25,000	4,50,000	3,50,000	8,00,000
C	---	36,000	---	7,20,000	7,20,000
D	30,000	---	7,80,000	---	7,80,000
Total Contribution					31,40,000
Less: Fixed Cost					8,43,000
Net Profit					22,97,000

(ii) Break Even Point

Recovery of Fixed Cost

Particulars	**Amount (₹)**
Fixed Cost (at Best Strategy)	8,43,000
Less: Recovered from Product 'D' (₹26 × 30,000 units)	7,80,000
Balance	63,000
Less: Recovered from Product 'A' $\left(\frac{₹63{,}000}{₹21} = 3{,}000\text{units}\right)$	63,000

Minimum number of units to be produced to achieve break-even point:

Product D = 30,000 units

Product A = 3,000 units

Accordingly, earliest BEP at 33,000 units

(iii) Assembly Labour is Not a Limiting Factor & No Requirement to Fulfil Maximum Market Demand

Comparison of Contribution *per unit* (Make Vs Sub-Contracting)

	Demand (Units)			
	40,000	**55,000**	**36,000**	**30,000**
	A	**B**	**C**	**D**
Contribution (₹/u) [Make]	21	15	18	26
Contribution (₹/u) [Sub-Contract]	15	14	20	24
Best Strategy	Make	Make	Sub Contracting	Make
Ranking for Production	II	III	---	I

Decision

From the above comparison table it can be seen manufacturing of product A, B and D gives higher contribution per unit as compared to sub-contracting. Therefore, AXE Ltd. should manufacture the entire quantity of product A, B and D and Subcontract the production of product C. However AXE Ltd. can save fixed cost of ₹4,07,000 (₹12,50,000 − ₹8,43,000) by limiting its production level to 1,00,000 units only. In this case AXE Ltd. will make 30,000 units, 40,000 units and 30,000 units of product D, A and B respectively. But in this case AXE Ltd. has to subcontract 25,000 units of B to earn maximum profit.

Production Vs Sub Contract (units) and Profit – Best Strategy

Prod.	Produced [Units]	Sub-Contract [Units]	Contribution [Production] (₹)	Contribution [Sub-Contract] (₹)	Total Contribution (₹)
A	40,000	---	8,40,000	---	8,40,000
B	30,000	25,000	4,50,000	3,50,000	8,00,000
C	---	36,000	---	7,20,000	7,20,000
D	30,000	---	7,80,000	---	7,80,000
Total Contribution					31,40,000
Less: Fixed Cost					8,43,000
Net Profit					22,97,000

☞

It may not be necessary to prepare '**Statement Showing Production Vs Sub Contract (units) and Profit – Best Strategy**' for part (iii), but only relevant figures need to be shown.

Problem-53

Golden Pet Ltd. specialises in the manufacture of one litre plastic bottles. The firm's customers include dairy processors, fruit juice manufacturers and manufacturers of edible oils. The bottles are produced by a process called blow moulding. A machine heats plastic to the melting point. A bubble of molten plastic is formed inside a mould, and a jet of hot air is forced into the bubble. This blows the plastic into the shape of the mould. The machine releases the moulded bottle, an employee trims off any flashing (excess plastic around the edge) and the bottle is complete.

The firm has four moulding machines, each capable of producing 100 bottles per hour. The firm estimates that the variable cost of producing a plastic bottle is 20 paise. The bottles are sold for 50 paise each.

Management has been approached by a local toy company that would like the firm to produce a moulded plastic toy for them. The toy company is willing to pay ₹ 3.00 per unit for toy. The variable cost to manufacture the toy will be ₹ 2.40. In addition, Golden Pet Ltd. would have to incur a cost of ₹ 20,000 to construct the needed mould exclusively for this order. Because the toy uses more plastic and is of a more intricate shape than a bottle, a moulding machine can produce only 40 units per hour. The customer wants 1,00,000 units. Assume that Golden Pet Ltd. has the total capacity of 10,000 machine hours available during the period in which the toy company wants the delivery of toys. The firm's fixed costs, excluding the costs to construct the toy mould, during the same period will be ₹ 2,00,000.

Required

(i) *If the management predicts that the demand for its bottles will require the use of 7,500 machine hours or less during the period, should the special order accepted? Give reasons.*

(ii) *If the management predicts that the demand for its bottles will be higher than its ability to produce bottles, should the order be accepted? Why?*

(iii) *If the management has located a firm that has just entered the moulded plastic business. This firm has considerable excess capacity and more efficient moulding machine and is willing to subcontract the toy job, or any portion of it, for ₹ 2.80 per unit. It will construct its own toy mould. Determine Golden Pet Ltd 's minimum expected excess machine hour capacity needed to justify producing any portion of the order itself rather than subcontracting it entirely.*

(iv) *The management predicted that it would have 1,600 hours of excess machine hour capacity available during the period. Consequently, it accepted the toy order and subcontracted 36,000 units to the other plastic company. In fact, demand for bottles turned out to be 9,00,000 units for the period. The firm was able to produce only 8,40,000 units because it had to produce the toys. What was the cost of the prediction error failure to predict demand correctly?*

Solution

(i) The Golden Pet Ltd. has a surplus of 2,500 machine hours. The special order for supply of 1,00,000 toys also requires 2,500 hours of machine time (1,00,000 toys / 40 units). In case the Golden Pet Ltd. accepts the order, it will make an extra profit of ₹ 40,000 as given below-

	(₹)
Sales Revenue (1,00,000 toys × ₹3)	3,00,000
Less: Variable Costs (1,00,000 toys × ₹2.40)	2,40,000
Contribution	60,000
Less: Fixed Costs	20,000
Profit	40,000

The Golden Pet Ltd. will thus make an extra profit of ₹ 40,000 find therefore, it should accept the order.

(ii) In case of Golden Pet Ltd., the machine time is a limiting factor and hence it will be appropriate to calculate the contribution per machine hour for both capacities as shown below-

	Contribution *per hour* from Bottle		**Contribution *per hour* from Toys**	
Production *in one hour*	100 bottles	(₹)	40 toys	(₹)
Sales Value *for one hour production*	(100 × ₹ 0.50)	50	(40 × ₹ 3)	120
Less: Variable Cost	(100 × ₹ 0.20)	20	(40 × ₹ 2.40)	96
Contribution *per hour*		30		24

The above computation shows that the contribution per hour is higher in case of bottles. Hence, if the management predicts that the demand for bottles will be higher than its capacity to produce them, it should not accept the special order for toys. Rather, it should use the total available machine hours for production of bottles.

(iii) The point of indifference (cost break-even point) between the two alternatives, i*.e.,* producing toys by the Golden Pet Ltd. itself or sub-contracting their production, can be determined as follows:

Let the number of toys to be produced be 'x'.

In case the firm uses the surplus time available for producing toys, the total cost would amount to ₹20,000 + 2.4x

In case the Golden Pet Ltd. decides in favour of sub-contracting the production of toys, the total cost of toys would amount to 2.80x. On the basis of the above equations, the point of difference can be ascertained as follows:

$$2.80x = 20,000 + 2.4x$$

Or $$x = 50,000 \text{ units}$$

This means that as long as the Golden Pet Ltd. has the surplus time available to produce more than 50,000 toys, it is better to produce them than to buy them from outside. However, if the firm has time to produce less than 50,000 toys, it would be better give the job to a sub-contractor and thus, avoid the fixed cost of ₹20,000. Thus, Golden Pet Ltd. must have more than 1,250 hours (50,000/40 units per hour) of machine time to justify the production of toys by itself as compared to sub-contracting the job.

(iv) **(a)** The firm decided to manufacture 64,000 toys and sub-contract the manufacture of 36,000 toys. This has resulted in production of only 8,40,000 bottles. The economics of this decision would be as under:

Particulars	Bottles Produced 8,40,000 units	Toys Produced 64,000 units	Toys Sub-Cont. 36,000 units	Total
	(₹)	(₹)	(₹)	(₹)
Sales	4,20,000	1,92,000	1,08,000	7,20,000
Less: Variable Costs				
(8,40,000 × ₹0.20)	1,68,000	---	---	
(64,000 × ₹2.40)	---	1,53,600	---	
(36,000 × ₹2.80)	---	---	1,00,800	4,22,400
Contribution	2,52,000	38,400	7,200	2,97,600
Less: Fixed Costs	2,00,000	20,000	---	2,20,000
Profit	52,000	18,400	7,200	77,600

(b) In case the Management is of the opinion that the demand for bottles would be 9,00,000 it would have realised that only 1,000 machine hours would be available. In such a case, since the contribution per hour from bottles is higher as compared to that of toys, the management would have produced 9,00,000 bottles requiring 9,00,000 hours. The entire order for supply of 1,00,000 toys would have been given to the sub-contractor as per analysis in *(iii)* above. The economics of such alternative would be as under:

Particulars	Bottles Made 9,00,000 units	Toys Sub-contracted 1,00,000 units	Total
	(₹)	(₹)	(₹)
Sales	4,50,000	3,00,000	7,50,000
Less: Variable costs			
(9,00,000 × ₹0.20)	1,80,000		
(1,00,000 × ₹2.80)		2,80,000	4,60,000
Contribution	2,70,000	20,000	2,90,000
Less: Fixed Costs	2,00,000	---	2,00,000
Profit	70,000	20,000	90,000

Thus, the Cost of the Prediction Error of ₹ 12,400, Calculated as under-

Net Profit of Optimal Action [as per (iv) (b)]	₹ 90,000
Net Profit of Actual Production [as per (iv) (a)]	₹ 77,600
Cost of Prediction Error	₹ 12,400

Decision on Capacity Utilization

Problem-54

AB Ltd. manufactures product 'X'. the company operates single shift of 8 hours for 300 days in a year. The capital employed in the business is ₹ 18 crores.

The manufacturing operations of the company comprise of four production departments. The company at present produces 9,000 units of product 'X' at maximum capacity. However, the capacity utilization of all the four departments are not equal and the present individual capacity utilizations are as under:

Department	Capacity Utilisation (%)
A	75
B	100
C	70
D	50

The present return on capital of the company has gone down to 10% from the earlier cut-off rate of 15% due to increased cost of production.

As the company cannot operate more than one shift, the management is considering two alternative proposals to increase the return on capital employed.

Alternative I

To hire out the surplus capacity of departments A, C and D. The cost and revenue projections are as under:

Department	Hire Charges per Hour	Incremental Cost per Hour
A	2,500	2,000
C	1,800	1,500
D	1,600	1,200

Alternative II

To increase the installed capacity of the factory to 12,000 units by adding plant and machinery in department B at a capital cost of ₹ 4 crore. Any Balance surplus capacity in other departments after meeting the increased volume to be hired out as per alternative I. The additional units would fetch incremental revenue of ₹ 1,600 per unit.

Required

Evaluate the two proposals and suggest to the management, which of the two proposals is to be accepted.

Solution

Alternative-I

Statement Showing "Net Revenue"

Production	Surplus Capacity Hours	Hire Charges *per hour*	Total Revenue (₹ Lacs)	Incremental Costs *per hour* (₹)	Total Cost (₹ Lacs)	Net Revenue (₹ Lacs)
	(a)	(b)	(c)=(a)×(b)	(d)	(e)=(a)×(d)	(f)=(c)-(e)
A	600	2,500	15.00	2,000	12.00	3.00
B	720	1,800	12.96	1,500	10.80	2.16
D	1,200	1,600	19.20	1,200	14.40	4.80
Add: Present Income (10% of ₹1,800 lacs)						180.00
Total return						189.96

Return on Investment $= \frac{\text{Total Return}}{\text{Total Investment}} \times 100$

$= \left(\frac{189.96\text{lacs}}{1{,}800\text{lacs}}\right) \text{x}100$

$= 10.553\%$

Alternative-II

Statement Showing "Net Revenue"

Production	Surplus Capacity Hours	Hire Charges *per hour*	Total Revenue (₹ Lacs)	Incremental Costs *per hour* (₹)	Total Cost (₹ Lacs)	Net Revenue (₹ Lacs)
	(a)	(b)	(c)=(a)×(b)	(d)	(e)=(a)×(d)	(f)=(c)-(e)
C	160	1,800	2.88	1,500	2.40	0.48
D	800	1,600	12.80	1,200	9.60	3.20
Add: Revenue Earned on Additional Units (3,000 units × ₹1,600)						48.00
Add: Present Income on Investment (10% × ₹1,800 lacs)						180.00
Total Return						231.68

Return on Investment = $\left(\frac{231.68 \text{ lacs}}{2,200 \text{ lacs}}\right)$x100

= 10.53%

Evaluation of two alternative proposals-

Since the return on investment under Alternative-I is more than that under Alternative- II; therefore it should be accepted.

Working Notes

1. Statement of total available, utilized and surplus capacity hours when 9,000 units of product 'X' are produced.

Departments	Available Capacity Hours	Capacity Utilized		Surplus Capacity Hours
		(in %)	(in hours)	
(1)	(2)	(3)	(4) = (2) × (3)	(5)=(2) - (4)
A	2,400 (300 days × 8 hours)	75	1,800	600
B	2,400	100	2,400	NIL
C	2,400	70	1,680	720
D	2,400	50	1,200	1,200

2. Statement of total available, utilized and surplus capacity hours when 12,000 units of product 'X' are produced.

Production Department	Available Capacity (Hours)	Capacity Utilization on 9,000 Units		Balance Capacity Hours	Unit per Hour	Hours Required for 3,000 Additional Units	Surplus Capacity Hours
		(%)	(Hours)				
A	2,400	75	1,800	600	5 $\left(\frac{9,000 \text{ units}}{1,800 \text{ hrs.}}\right)$	600	Nil
B	2,400	100	2,400	Nil	3.75 $\left(\frac{9,000 \text{ units}}{2,400 \text{ hrs.}}\right)$	800	Nil
C	2,400	70	1,680	720	5.36	560	160

					$\left(\frac{9{,}000\text{ units}}{1{,}680\text{ hrs.}}\right)$		
D	2,400	50	1,200	1,200	7.5 $\left(\frac{9{,}000\text{ units}}{1{,}200\text{ hrs.}}\right)$	400	800

Decision on Choice of Supplier / Customer

Problem-55

A manufacturing company produces a chemical product which passes through two processes factory and finishing. It has the capacity to process an input of 1,00,000 kgs. of raw material. Normal scrap will be 10% and 5% of input in factory and finishing process respectively. The realisable volume of such scrap is ₹ 4 and ₹ 8 per kg. respectively for factory and finishing process to be credited against the cost of respective process.

Relevant cost data for the coming year are:-

	Factory Process	***Finishing Process***
	(₹)	***(₹)***
Direct Wages	*6,00,000*	*5,50,000*
Overheads	*2,28,000*	*4,22,900*

There are three possible sources of purchase of raw – materials:

Supplier	***Purchase Price per kg. (₹)***	***Maximum Quantity (kgs.)***
X	*5.00*	*60,000*
Y	*5.60*	*80,000*
Z	*5.30*	*Provided entire quantity of 1,00,000 kgs is ordered, otherwise at ₹ 5.80 per kg.*

In each case the company is required to collect the raw – materials from the Godown of supplier. Variable transport cost depends upon the distance involved. The same are as under:

Supplier	***X***	***Y***	***Z***
Transport cost (per kg)	*30 paise*	*25 paise*	*25 paise*

Fixed transport cost would be ₹ 1,00,000 per annum irrespective of the supplier to be contacted. The output of the finishing process can be sold to three prospective customers, their offer being as follows-

Customer	***Price per kg. of Output (₹)***	***Trade Discount (%)***	***Conditions***
A	*32.50*	*2*	*Maximum quantity 40,000 kgs.*
B	*32.00*	*2*	*Maximum quantity 80,000 kgs.*
C	*30.90*	*-*	*Provided the entire output is sold to him*

In case of supplies to customers A and B, the fixed delivery costs will be ₹ 1,500 per month and the variable delivery costs will be 65 paise and 36 paise per kg. respectively.

Customer C will collect the entire output from the warehouse of the company.

Required

Indicate with reasoning-

(i) *Choice of supplier with comparative cost tables.*

(ii) *Choice of customer with comparative tables of net realisation.*

Also prepare the statements showing process costs and overall results.

Solution

(i) Choice of Suppliers

Comparative Cost Tables of Suppliers

Particulars	**X**	**Y**	**Z**	
	Up to 60,000 kgs.	**Up to 80,000 kgs.**	**Less than 1,00,000 kgs.**	**1,00,000 kgs.**
	(₹)	**(₹)**	**(₹)**	**(₹)**
Purchase Price *per kg.*	5.00	5.60	5.80	5.30
Variable Transportation Cost *per kg.*	0.30	0.25	0.25	0.25
Total Cost *per kg.*	5.30	5.85	6.05	5.55

Alternatives Available

Either

To purchase 60,000 kgs. from X as the rate offered is cheapest and the balance of 40,000 kgs. from Y.

Or

To purchase the entire quantity of 1,00,000 kgs. from Z.

Cost of Purchase for Above Alternatives

Supplier	Quantity (kgs.)	Rate (₹)	First Alternative (₹)	Second Alternative (₹)
X	60,000	5.30	3,18,000	---
Y	40,000	5.85	2,34,000	---
Z	1,00,000	5.55	---	5,55,000
			5,52,000	5,55,000

Recommendation

Raw-materials should be purchased 60,000 kgs. from X and 40,000 kgs. from Y as the cost of purchase as per first alternative is less than that of the second alternative.

(ii) Choice of Customer

Output to be Sold

	Kgs
Input in Factory Process	1,00,000
Less: Normal Scrap (10% of input)	10,000
Output of Factory Process	90,000
Less: Normal scrap in Finishing Process (5% of 90,000)	4,500
Output of Finishing Process	85,500

Relevant Data of Selling Price

Particulars	Customers		
	A	B	C
	Up to 40,000 Kgs.	Up to 80,000 Kgs.	Up to 85,500 Kgs.
	(₹)	(₹)	(₹)
Selling Price *per kg.*	32.50	32.00	30.90
Less: Trade Discount (2%)	0.65	0.64	---
Net Price	31.85	31.36	30.90
Less: Variable Cost of Delivery *per kg.*	0.65	0.36	---
Net Realization *per kg.*	31.20	31.00	30.90

Alternatives Available

Though the rates of customers A and B are favourable in comparison with C, there are fixed costs in case the output is sold to A and B; so alternatives available are-

Either

To supply 40,000 kgs. to A and balance quantity of 45,500 kgs. to B.

Or

To supply the entire quantity of 85,500 kgs. to C.

Net Realisation Based on Above Alternatives

First Alternative

Customer	Quantity (kgs.)	Rate (₹)	Amount (₹)
A	40,000	31.20	12,48,000
B	45,500	31.00	14,10,500
Less: Fixed Delivery Costs (₹1,500 × 12)			18,000
Net Realisation			26,40,500

Second Alternative

Customer	Quantity (kgs.)	Rate (₹)	Amount (₹)
C	85,500	30.90	26,41,950

Recommendation

The entire output be sold to C as the net realisation as per second alternative is better than that under the first alternative.

(iii) Statement Showing "Process Cost"

Factory Process	Quantity (kgs.)	Rate (₹)	Amount (₹)
Raw – Materials	1,00,000		5,52,000
Direct Wages			6,00,000
Fixed Transport Cost			1,00,000
Overhead			2,28,000
Total	1,00,000		14,80,000
Less: Wastage [(10%), ₹4 per kg.]	10,000		40,000
Cost of Factory Process (transferred to finishing process)	90,000	16.00*	14,40,000

$$* \left[\left(\frac{₹14,40,000}{90,000\text{kgs.}}\right) = ₹16\right]$$

Finishing Process	Quantity (kgs.)	Rate (₹)	Amount (₹)
Transferred from Factory Process	90,000	16.00	14,40,000
Direct Wages			5,50,000
Overhead			4,22,900
Total	90,000		24,12,900
Less: Wastage [(5%), ₹8 per kg.]	4,500		36,000
Cost of Output	85,500	27.80*	23,76,900

$$* \left[\left(\frac{₹23,76,900}{85,500\text{kgs.}}\right) = ₹27.80\right]$$

(iv) Overall Results for 85,500 Kgs.

	Rate (₹)	Amount (₹)
Sale to Customer C	30.90	26,41,950
Less: Cost of Output	27.80	23,76,900
Net Results (Profit)	3.10	2,65,050

Problem-56

Tista Ltd. has set up a treatment plant at Surat. The company uses raw material 'X' to convert into finished product 'XA' after treatment in its plant having a capacity to treat 60,000 tonnes of 'X' per annum. There is no loss of raw material in the treatment process. The variable costs of treatment are ₹ 5 per tonne and the annual fixed costs amount to ₹ 7,50,000.

The company owns a fleet of vehicles to transport 260 lakhs tonnes–kms. of 'X' to the factory site. The fixed costs of maintaining these vehicles amount to ₹ 10,40,000 per annum and the variable costs amount to 8 paise per tonne–km. The company delivers 'XA' to customers through another transport agency at 15 paise per tonne–km., subject to a minimum annual payment of ₹ 1,25,000. facilities for hiring the transport for incoming of 'X' and outgoing of 'XA' are also available through Chamba Transport Co. at a cost of 18 paise per tonne –km.

The company has three sources of procurement of raw material 'X', the relevant details being :

	Source of Procurement		
	Town A	*Town B*	*Town C*
Quantity Available (tonnes p.a.)	*9,000*	*8,000*	*45,000*
Distance from Surat (kms.)	*300*	*250*	*500*
Price Offered (per tonne) (₹)	*90*	*110*	*78*

The company has demand of its finished product 'XA' from the following customers :

Customer	*Demand (tonnes p.a.)*	*Price (per tonne) (₹)*	*Delivery Terms*	*Distance from Surat (kms.)*
L	*6,000*	*200*	*At Customer's Site*	*9*
M	*6,000*	*188*	*Ex – Factory Surat*	*-*
N	*15,000*	*170*	*Ex – Factory Surat*	*-*
O	*9,000*	*150*	*Ex – Factory Surat*	*-*
P	*10,000*	*192*	*At Customer's Site*	*22*
Q	*9,000*	*220*	*At Customer's Site*	*14*
R	*10,000*	*200*	*At Customer's Site*	*25*

Required

(i) Recommend the best proposal for the purchase of raw material 'X'; the break – up of sale of finished product 'XA'; and transport plan for incoming and outgoing goods with a view to maximise the profit.

(ii) Present a statement to show net profit as per above recommendation.

Solution

(i) Transport Plan for Incoming Good (Refer to W.N. 1 & 2)

Sources	Quantities to be Transported (tonnes)	Distance of Source Town from Surat (kms)	Tonnes – km (Lakhs)
Town A	9,000	300	27
Town B	8,000	250	20
Town C	42,600	500	213*
	59,600		260

Total capacity of own fleet is 260 tonnes – km. Therefore, balancing figure form town C would be 213 lakhs tonnes – km or 42,600 tonnes (213,00,000/500 km).

(ii) Best Proposal for the Purchase of Raw Material 'X':

On the basis of the ranking as suggested under working note 2 and (i), the best proposal for the purchase of raw material X, indicating sources of procurement along with their quantities is as under:

Sources	**Annual Quantity *to be purchased* (Tonnes)**
Town A	9,000
Town B	8,000
Town C (Balancing Figure)	42,600
Total	59,600

(iii) Break – up Sales of Finished Product 'XA'

Customer	**Demand Tonnes (p.a.)**	**Price / Tonne (₹)**	**Sales Value (₹ in '000)**
Q	9,000	220	1,980
R	10,000	200	2,000
L	6,000	200	1,200
P	10,000	192	1,920
M	6,000	188	1,128
N	15,000	170	2,550
O	3,600*	150	540
	59,600		11,318

(iv) Transportation Plan *for outgoing goods*

	Alt.1 (₹)	**Alt.2 (₹)**
Cost of 6,50,000 tonne–km, 15p /18p *per tonne–km* (W.N.- 3)	97,500	1,17,000
Minimum Payment Guaranteed	1,25,000	-
Transportation Cost	1,25,000	1,17,000

So Alternative-2, of M/s Chamba Transport Co. is Cheapest.

Statement of Net Profit *based on above statement*

	(₹ in '000)
Sales [Refer to (iii)]	11,318.00
Less: Cost of Material ₹8,10,000 (9,000 tonnes × ₹90); ₹8,80,000 (8,000 tonnes × ₹110); ₹33,22,800 (42,600 tonnes × ₹78)	5,012.80

Less: Transportation Cost (260 lakhs tonnes km × 0.08 + ₹10,40,000)	3,120.00
Less: Processing (treatment) Cost (59,600 × ₹ 5 + ₹ 7,50,000)	1,048.00
Less: Outward Transportation Cost [Refer to (iv)]	117.00
Net Profit	2,020.20

Working Notes

1. Choice of Transportations Plan for Incoming Goods with a view to Maximise the Profit

	(₹)
Variable Cost *per tonne – km.*	0.08
Share of Fixed Costs *per tonne – km.*	
(₹ 10,40,000/2,60,00,000 tonnes km.)	0.04
Cost *per tonne – km* (by using own vehicle)	0.12

Since per tonne–km. cost of using own vehicles is less than that of other proposal of 18 paise per tonne–km. of Chamba Transport Co., the concern should continue to transport raw material 'X' by using its own fleet of vehicles.

2. Ranking for the Purchase of Raw Material 'X'

	Town A	Town B	Town C
Distance from Surat (kms.)	300	250	500
Price Offered *per tonne* (₹)	90	110	78
Transportation Cost (₹) (Distance × ₹0.08)	24 (300 km × 0.08)	20 (250 km × 0.08)	40 (500 km × 0.08)
Total Procurement Cost *per tonne* (₹)	114	130	118
Minimum Selling Price *per tonne* (₹) (Offered by Customer 'O')	150	150	150
Contribution *per tonne* (₹)	36	20	32
Contribution *per km.* (₹)	0.12	0.08	0.064
Ranking	I	II	III

3. Total Tonne–Kms. of Transportation for Outgoing Goods

Customer	Demand Tonnes (p.a.)	Distance from Surat Ex –Factory (km.)	Total (tonne–kms)
Q	9,000	14	1,26,000

R	10,000	25	2,50,000
L	6,000	9	54,000
P	10,000	22	2,20,000
M	6,000	---	---
N	15,000	---	---
O	3,600	---	---
	59,600		6,50,000

Problem-57

A and B are members of a cartel producing the same product arrangement, they cater to the entire needs of the market.

	A	*B*
Installed Capacity	*20,000 units*	*15,000 units*
Normal Working Efficiency	*80%*	*75%*
Details of Fixed Costs:		
- *Up to 50% of Installed Capacity*	*₹ 1,40,000*	*₹ 1,60,000*
- *Between 51 % and 75% of Installed Capacity*	*₹ 1,50,000*	*₹ 1,75,000*
- *Beyond 75% of Installed Capacity*	*₹ 1,80,000*	*₹ 2,00,000*
Variable Costs	*₹ 50 per unit*	*₹ 45 per unit*

Selling Price ₹ 80 per unit
Market Demand is 25,000 units *(The Demand is Satisfied by A and B in the Ratio of 3 : 2)*

In 2014, it is anticipated that a recession will set in and consequently, the total market demand for the product will only be 50% of the present position. Market price will suffer a reduction by 20%. The members agree that either of them will cater to the needs of the market fully, paying the other 40% of the profits from sales.

You are informed that the additional costs of improving machine efficiency beyond the present limits will be ₹ 15,000 and ₹ 25,000 for A and B respectively.

Required

Ascertain which of the members will find it profitable to work? Workings must form part of your answer.

Solution

Statement Showing "Anticipated Profits from Sales of 12,500 Units"
(When A and B Individually Cater the Needs of the Market Fully)

	A	B
Selling Price at ₹ 64 per unit (after *20%* price reduction)	₹8,00,000	₹8,00,000
Less: Variable Costs		
A (₹50 per unit)	6,25,000	---
B (₹45 per unit)	---	5,62,500
Contribution	1,75,000	2,37,500
Less: Fixed Costs {W.N.-(ii) & (iii)}	1,50,000	2,25,000
Profits	25,000	12,500

The above statement shows that it is profitable for A to work. In case A is authorized to work, he will contribute ₹10,000 (being 40% of ₹25,000) from the profits to B and retain the balance for himself.

Similarly, if B is authorized to work, he will pay ₹5,000 (being 40% of ₹12,500) to A and retain the balance for himself.

Note

It has been assumed that the party not operating during recession will be able to make profitable use of the installed capacity for recovering minimum fixed costs by resorting to an alternative use.

Working Note

Position in 2014

(i) Expected Demand is to be 50% of 25,000 units i.e. 12,500 units.

(ii) Working Efficiency (of installed capacity) required for independent operation to produce 12,500 units:

A	B
$\left[\left(\frac{12{,}500\text{units}}{20{,}000\text{units}}\times 100\right) = 62.5\%\right]$	$\left[\left(\frac{12{,}500\text{units}}{15{,}000\text{units}}\times 100\right) = 83.33\%\right]$

(iii) Fixed Cost *to be incurred*:

	A (₹)	B (₹)
Between 51 % and 75% of Installed Capacity	1,50,000	-
Beyond 75% of Installed Capacity	-	2,00,000
Additional Cost *on improving machine efficiency*	-	25,000
Total Fixed Cost	1,50,000	2,25,000

Marketing Decision

Problem-58

Better and Best Ltd. manufacture only one product. Production is regular throughout the year and the capacity of the factory is 1,50,000 units per annum. The summarized Profit and Loss Account for the year ended 31st December is being reviewed by the Board of Directors.

	₹
Sales @ ₹ 10 per unit	*10,00,000*
Cost of sales:	
Direct materials	*2,50,000*
Direct labour	*1,50,000*
Production overheads:	₹
Variable	*30,000*
Fixed	*2,30,000*
Administrative overheads:	
Fixed	*1,00,000*
Selling and distribution overhead:	
Variable	*50,000*
Fixed	*1,50,000*

(i) *The Production Director proposed to reduce selling price to ₹ 9 in order to utilize full capacity.*

(ii) *The Sales Director proposed to increase selling price by 20 percent. By spending ₹ 2,25,000 on advertisement, sales will be increased to 1,20,000 units per annum.*

(iii) *The Personnel Director pleaded for a change in the method of wage payment. For the present piece rate of ₹ 1.50 per unit, a bonus scheme (for each 2% increase in production over the target, there would be an increase of 1% in the basic wage of each*

employee) will be implemented. A target of 2,000 units per week for the company will be set for 50 week year. Selling price increase by 10%. With an additional advertisement cost of ₹ 1,60,000, 20% increase in present sales will be achieved.

(iv) *The Chairman felt that the packaging of the product required improvement. He wanted to know the sales required to earn a target profit of 10% on turnover with the introduction of an improved packing at an additional cost of 20 paise per unit (no change in selling price).*

Required

Evaluate individually the proposals of each of the board member and give your recommendation.

Solution

Workings

Full Capacity: ₹1,50,000 units p.a.

Current Capacity: ₹1,00,000 units p.a. which is equals to 66.67% of full capacity.

Existing Situation

Particulars	**Amount (₹)**	**Per Unit (₹)**
Sales (1,00,000 units × ₹10)	10,00,000	10.00
Less: Variable Cost		
Direct Material	2,50,000	2.50
Direct Labour	1,50,000	1.50
Production Overheads	30,000	0.30
Selling and Distribution Overhead	50,000	0.50
Contribution	5,20,000	5.20
Less: Fixed Cost		
Production Overheads	2,30,000	2.30
Administrative Overheads	1,00,000	1.00
Selling and Distribution Overhead	1,50,000	1.50
Profit	40,000	0.40

Proposal (i) –

Reduce Selling Price to ₹ 9, Capacity Utilization 100%

Particulars	Amount (₹)
Sales (1,50,000 units × ₹ 9)	13,50,000
Less: Variable Cost (1,50,000 units × ₹4.80)	7,20,000
Contribution	6,30,000
Less: Fixed Cost	4,80,000
Profit	1,50,000

Proposal (ii) –

Increase in Selling Price by 20%, Additional Advertising Cost ₹ 2,25,000, Sales Volume 1,20,000 units per annum

Particulars	Amount (₹)
Sales (1,20,000 units × ₹12)	14,40,000
Less: Variable Cost (1,20,000 units × ₹4.80)	5,76,000
Contribution	8,64,000
Less: Fixed Cost	4,80,000
Less: Advertising Cost	2,25,000
Profit	1,59,000

Proposal (iii) –

Increase in Selling Price by 10%, Additional Advertising Cost ₹ 1,60,000, 20% Increase in Present Sales and Bonus Scheme (for each 2% increase in production over the target, there would be an increase of 1% in the basic wages of each employee)

Particulars	Amount (₹)
Sales (1,20,000 units × ₹ 11)	13,20,000
Less: Variable Cost [1,20,000 units × ₹(2.50 + 1.65* + 0.30 + 0.50)]	5,94,000
Contribution	7,26,000
Less: Fixed Cost	4,80,000
Less: Advertising Cost	1,60,000
Profit	86,000

Workings

Present Labour Rate = ₹1.50 *per unit*

Target Production Volume = 2,000 units × 50 weeks

= 1,00,000 units

Production above the target volume	=	1,20,000 units – 1,00,000 units
	=	20,000 units

Or 20% of Target Production Volume

Bonus (for each 2% increase in production over the target, there would be an increase of 1% in the basic wages of each employee)

$$= \frac{1\%}{2\%} \times 20\%$$

= 10% increase in basic wages.

It means wages would be ₹ 1.65 (₹ 1.50 × 1.10) per unit.

Proposal (iv) –

Target Profit 10% on Turnover, Additional Packing Cost 0.20 paise per unit, No Change in Selling Price, Sales Volume =?

Let Sales Volumes is K units.

Particulars	Amount (₹)
Sales (K units × ₹ 10)	10K
Less: Variable Cost [K units × ₹(4.80 + 0.20)]	5K
Contribution	5K
Less: Fixed Cost	4,80,000
Profit	5K-4,80,000

Profit equals to 10% of Turnover. It means-

5K – 4,80,000	=	10% of 10K
4K	=	4,80,000
K	=	1,20,000 units
Turnover	=	1,20,000 units × ₹ 10
	=	₹12,00,000
Profit	=	10% of ₹ 12,00,000
	=	₹1,20,000

Particulars	Capacity Utilization	Profit (₹)
Existing Situation	66.67%	40,000
Proposal (i)	100.00%	1,50,000
Proposal (ii)	80.00%	1,59,000
Proposal (iii)	80.00%	86,000
Proposal (iv)	80.00%	1,20,000

Problem-59

Neelgagan Ltd. manufactures a range of products which it sells through manufacturer's agents to whom it pays commission of 20% of the selling price of the products. Its budgeted profit and loss statement for 2013 is as follows:

	(₹)
Sales	22,50,000
Prime Costs and Variable Overhead	7,87,500
Fixed Overhead	3,62,500
Selling Costs:	
Commission to Manufacturer's Agents	4,50,000
Sales Office Expenses (Fixed)	20,000
Administration Costs (Fixed)	3,00,000
Profit	3,30,000

Subsequent to the preparation of the above budgeted profit and loss statement, the company is faced with a demand from its agents for an increase in their commission to 22% of selling price. As a result, the company is considering whether it might achieve more favourable results it were to discontinue the use of manufacturer's agents and, instead employ its own sales force. The costs that this could involve are budgeted as follows:

	(₹)
Sales Manager (Salary and Expenses)	75,000
Salesmen's Expenses (including Travelling Costs)	20,000
Sales Office Costs (additional to Present Costs)	50,000
Interest and Depreciation on Sales Department Cars	35,000

In addition to the above, it will be necessary to hire four salesmen at a salary of ₹ 40,000 per annum each plus commission of 5% on sales plus car allowance of ₹1 per kilometre to cover all costs except interest and depreciation.

On the assumption that the company decide to employ its own sales force on the above terms.

Required

(i) What is the maximum average kilometre per annum that salesmen could travel if the Company is to achieve the same budgeted profit as would have obtained by retaining the manufacturer's agents and granting them the increased commission they had requested. Assume that sales in each case would be as budgeted.

(ii) *At what level of sales would the original budgeted profit be achieved if each salesman were to travel an average of 14,000 kilometres per annum. Assume that all other assumptions inherent in the budgets were maintained.*

(iii) *What is the maximum level of commission on sales that the company could afford to pay if it wished to achieve a 10% increase in its original budgeted profit and expected a 16% increase in sales (at budgeted selling prices) and average of 16,000 kilometres per annum to be travelled by each salesman.*

Solution

(i) The economics of employing company's own sales force can be determined as under:

		(₹)
Savings:		
Saving in Existing Commission (20% of Sales)		4,50,000
Saving in Proposed Increase in Commission (2% of Sales)		45,000
Total Savings in Commission	…(i)	4,95,000
Additional Costs (excluding Salesman's Car Allowance):		
Commission 5% on Sales		1,12,500
Sales Manager (Salary and Expenses)		75,000
Salesmen's Expenses (including Travelling Costs)		20,000
Sales Office Costs		50,000
Interest and Depreciation on Sales Department Cars		35,000
Salesmen's Salary (4 × ₹40,000)		1,60,000
Total Costs	…(ii)	4,52,500
Net Savings prior to paying Car Allowance	…(i) – (ii)	42,500

The above computations show that there would be a net saving (excluding salesmen's car allowance) to achieve the same budgeted profit as company would have obtained by retaining the manufacturer's agents and granting them increased commission. Since the car allowance of salesmen is ₹1 per km., the maximum total kilometers to be travelled by all the salesmen would amount to 42,500.The number of salesman being 4, the maximum average kilometers per salesman would amount to 10,625 (i.e. 42,500 / 4).

(ii) Computation of P/V Ratio after employing own sales force:

	(₹)
Sales	22,50,000

Less: Variable Production Costs	7,87,500
Commission (5%)	1,12,500
Contribution	13,50,000

P/V Ratio:

$$= \frac{\text{Contribution}}{\text{Sales}} \times 100$$

$$= \frac{₹13,50,000}{₹22,50,000} \times 100$$

$$= 60\%$$

The Fixed Cost and Profit to be covered are:

	(₹)
Original Fixed Costs (₹3,62,500 + ₹20,000 + ₹3,00,000)	6,82,500
Additional Fixed Cost (₹75,000 + ₹20,000 + ₹50,000 + ₹35,000 + ₹1,60,000)	3,40,000
Total Fixed Costs	10,22,500
Car Allowance [(14,000 km × 4) × ₹1]	56,000
Profit	3,30,000
Total Contribution Required	14,08,500

Total Required Level of Sales:

$$= \frac{\text{Required Contribution}}{\text{P / V Ratio}}$$

$$= \frac{₹14,08,500}{60} \times 100$$

$$= ₹23,47,500$$

(iii) Percentage of Variable Production Cost of Sales:

$$= \frac{₹7,87,500}{₹22,50,000} \times 100$$

$$= 35\%$$

Economics of New Plan (before commission):

	(₹)
Sales (₹22,50,000 + 16% of ₹22,50,000)	26,10,000
Less: Variable Production Cost (35%)	9,13,500
Contribution	16,96,500
Less: Fixed Costs	10,22,500
Car Allowance [(16,000 km × 4) × ₹1]	64,000
Margin Available	6,10,000
Profit Required (₹3,30,000 + 10% of ₹3,30,000)	3,63,000
Amount Available for Commission	2,47,000

Maximum Level of Commission on Sales

$$= \frac{₹\ 2{,}47{,}000}{₹\ 26{,}10{,}000} \times 100$$

$$= 9.46\%$$

Problem-60

The financial controller of ACE Ltd. has prepared the following estimates of working results for the year ending 31st March, 2013:

	Year ending 31.3.2013
Direct Material (₹ / unit)	*16.00*
Direct Wages (₹ / unit)	*40.00*
Variable Overheads (₹ / unit)	*12.00*
Selling Price (₹ / unit)	*125.00*
Fixed Expenses (₹)	*6,75,000 per annum*
Sales (₹)	*25,00,000 per annum*

During the year 2013-14, it is expected that the material prices and variable overheads will go up by 10% and 5% respectively. As a result of re-engineering of business processes, the overall direct labour efficiency will increase by 12%, but the wage rate will go up by 5%. The fixed overheads are also expected to increase by ₹ 1,25,000.

The Vice-President Manufacturing states that the same level of output as obtained in 2012-13 should be maintained in 2013-14 also and efforts should be made to maintain the same level of profit by suitably increasing the selling price.

The Vice-President-Marketing states that the market will not absorb any increase in the selling price. On the other hand, he proposes that publicity involving expenses as given below will increase the quantity of sales as under:

Advertisement Expenses (₹)	*80,000*	*1,94,000*	*3,20,000*	*4,60,000*
Additional units of sales	*2,000*	*4,000*	*6,000*	*8,000*

Required

(i) *Present an Income Statement for 2013-14*

(ii) *Find the Revised Price and the Percentage of increase in the price for 2013-14, if the views of the Vice-President-Manufacturing are accepted.*

(iii) *Evaluate the four alternative proposals put-forth by the Vice-President-Marketing. Determine the best output level to be budgeted and prepare an over-all Income Statement for 2013-14 at that level of output.*

Solution

(i) Statement of Income for the Year 2013- 14

	(₹)
Sales Revenue (20,000 units × ₹ 125) (W.N.-1)	25,00,000
Less: Variable Cost (20,000 units × ₹ 67.70) (W.N.- 2)	13,54,000
Total Contribution	11,46,000
Less: Fixed Expenses	8,00,000
Profit	3,46,000

(ii) Statement of Revised Price - the Proposal of Vice-President - Manufacturing

	(₹)
Variable Cost (20,000 units × ₹ 67.70)	13,54,000
Fixed Expenses	8,00,000
Profit (W.N.-4)	4,65,000
Desired Sales Revenue	26,19,000
Revised Selling Price *per unit*	130.95
Percentage Increase in Selling Price $\left(\frac{₹130.95 - ₹125.00}{₹125.00} \times 100\right)$	4.76%

(iii) Evaluation of Alternative Proposals of Vice-President - Marketing

Additional Units of Sales:	2,000 (₹)	4,000 (₹)	6,000 (₹)	8,000 (₹)
Total Contribution (W.N.-3)	1,14,600 (2,000 × ₹57.30)	2,29,200 (4,000 × ₹57.30)	3,43,800 (6,000 × ₹57.30)	4,58,400 (8,000 × ₹57.30)
Less: Advertisement Expenses	80,000	1,94,000	3,20,000	4,60,000
Additional Profit/(Loss)	34,600	35,200	23,800	(1,600)

Evaluation of Four Alternatives

The Additional Profit is maximum at the Additional Sales of 4,000 units. Hence, the Second Alternative is the best out of the four Alternatives proposed by the Vice-President-Marketing. The concern should Produce and Sell 24,000 units during the year 2013-14.

Overall Income Statement for 2013-14 (Output and Sales: 24,000 units)

	(₹)
Sales Revenue (24,000 units × ₹125)	30,00,000
Less: Variable Cost (24,000 units × ₹67.70)	16,24,800
Contribution	13,75,200
Less: Advertisement Expenses	1,94,000
Less: Fixed Expenses	8,00,000
Profit	3,81,200

Working Note

1. Number of units produced and sold for the year ending 31st March, 2013

$$= \frac{\text{Total Sales Revenue upto 31st March, 2013}}{\text{Selling Price per unit}}$$

$$= \frac{₹25,00,000}{₹125 \text{ per unit}}$$

$$= 20,000 \text{ units}$$

2. Variable Cost *per unit*

Particulars	2012-13 (₹)	2013 -14 (₹)
Direct Material	16	17.60 (₹16 + 10% × ₹16)

Direct Wages	40	37.50 (₹40 x 100/112 × 105/100)
Variable Overheads	12	12.60 (₹12 + 5% × ₹12)
Variable Cost *per unit*	68	67.70

3. Contribution *per unit* during 2013-14 = ₹125 – ₹67.70
= ₹57.30

4. Profit in 2012 - 13

Contribution *per unit* = ₹125 – ₹68
= ₹57

Total Contribution (20,000 units x ₹ 57 per unit) = ₹11,40,000

Less: Fixed Expenses = ₹ 6,75,000

Profit = ₹4,65,000

Problem-61

Thar Ltd. manufactures and markets three products A, B and C in the State of Haryana and Rajasthan. At the end of first half of 2011-12 the following absorption based profit statement has been drawn by the accountant.

(₹ in '000)

	Haryana	***Rajasthan***	***Total***
Sales	*3,000*	*900*	*3,900*
Manufacturing Cost of Sales	*2,331*	*699*	*3,030*
Gross Profit	*669*	*201*	*870*
Administration Expenses (A)	*120*	*36*	*156*
Selling Expenses (B)	*184*	*169*	*353*
Total Expenses	*304*	*205*	*509*
Net Profit	*365*	*(-)4*	*361*

(a) The expenses are constant and common to both the States. They stand allocated on the basis of sales.

(b) The expenses are semi fixed but specifically relate to the respective State.

The management is worried to note that the decision taken to market the products in Rajasthan to utilise idle capacity has proved wrong and wish to cover only Haryana State. The incharge marketing division is not satisfied with the above way of profit presentation. He is of the firm opinion that sales effected in the State of Rajasthan is contributing profits. For the *next half year he expects no increase in demand in Haryana while for Rajasthan he anticipates to sell B or C more by 50% of existing sales. This will utilise the idle capacity in full.*

The product wise relevant details for the first half of 2011-12 are:

	A	*B*	*C*
Sales (in ₹ '000)			
Haryana	*1,200*	*900*	*900*
Rajasthan	*300*	*300*	*300*
Variable Costs (as a % on sales) :			
Manufacturing	*40*	*35*	*30*
Selling	*3*	*2*	*2*
Specific Fixed Manufacturing Expenses (in ₹ '000)	*570*	*470*	*610*

Required

(i) *Prepare a State-wise profit statement for the first half of 2011-12 using contribution approach. Also offer your views on the contention of the management and opinion expressed by in charge marketing division.*

(ii) *Prepare a product wise profit statement for the same period using contribution approach.*

(iii) *Submit your well throughout recommendation as to which product should be produced to utilise idle capacity.*

Solution

(i) State-wise Profit Statement for the First Half of 2011-12 using Contribution Approach

(₹'000)

	Haryana	**Rajasthan**	**Total**
Sales (W.N.-1)	3,000	900	3,900
Less: Variable Costs:			
Manufacturing Cost (W.N.-1)	1,065	315	1,380
Selling Costs (W.N.-1)	72	21	93
Contribution:	1,863	564	2,427
Less: Specified Fixed Cost:			

Manufacturing Cost (W.N.-2)	1,266	384	1,650
Selling Cost (W.N.-2)	112	148	260
Net Contribution	485	32	517
Less: Common Fixed Costs (Administration)			156
Net Profit			361
P/V Ratio (in %)	62.10	62.67	62.23

View

The contention of the management is not valid i.e. the state of Rajasthan shows ₹ 32,000 as contribution to meet the common fixed costs. In case only Haryana state is covered the net profit of the concern would go down from ₹3,61,000 to ₹3,29,000

In view of the above position, the statement made by the in charge of the marketing division appears to be correct.

(ii) Product-wise Profit Statement for the First Half of 2011 – 12 using Contribution Approach (₹ in '000)

	A	B	C	Total
Total Sales of Haryana and Rajasthan	1,500	1,200	1,200	3,900
Less: Variable Costs:				
Manufacturing Cost	600 (1,500 x40%)	420 (1,200x35%)	360 (1,200x30)	1,380
Selling Cost	45 (1,500 x3%)	24 (1,200 x2%)	24 (1,200 x2%)	93
Contribution	855	756	816	2,427
Less: Specified Fixed Costs:				
Manufacturing Cost	570	470	610	1,650
Selling Cost (W.N.-3)	100	80	80	260
Net Contribution	185	206	126	517
Less: Common Fixed Administration Exp.				156
Net Profit				361
P/V Ratio	57%	63%	68%	62.23%

(iii) Recommendation for Utilising Idle Capacity

A review of the above P/V Ratio's shows that the increase of output of Product - C in Rajasthan is the best. The increase of production after utilising the idle capacity in Rajasthan to the extent of ₹1,50,000 (i.e. 50% of ₹3,00,000) would increase the contribution of the company in the state of Rajasthan by ₹1,02,000 (68% x ₹1,50,000).

Working Notes

1. Variable Manufacturing and Selling Costs (in ₹'000)

Products	Sales		Mfg. Costs			Selling Costs		
	Har	Raj	%	Har	Raj	%	Har	Raj
A	1,200	300	40	480	120	3	36	9
B	900	300	35	315	105	2	18	6
C	900	300	30	270	90	2	18	6
Total	3,000	900		1,065	315		72	21

** Percentage of Sales*

2. Specified Fixed Expenses (in ₹'000)

	Manufacturing			Selling		
	Har	Raj	Total	Har	Raj	Total
Total Manufacturing Cost of Sales	2,331	699	3,030	184	169	353
Less: Variable Manufacturing and Selling Costs (Refer to W.N.-1)	1,065	315	1,380	72	21	93
Specified Fixed Costs	1,266	384	1,650	112	148	260

3. Product Wise Specified Fixed Selling Expenses (in ₹'000)

	Total	A	B	C
Fixed Selling Expenses of Haryana and Rajasthan *apportioned in proportion of their sales*, viz. (15:12:12)	260	100	80	80

Selling Strategy

Problem-62

Ret Ltd., a retail store buys computers from Comp Ltd. and sells them in retail. Comp Ltd. pays Ret Ltd. a commission of 10% on the selling price at which Ret sells to the outside market. This commission is paid at the end of the month in which Ret Ltd. submits a bill for the *commission. Ret Ltd. sells the computers to its customers at its store at ₹ 30,000 per piece. Comp Ltd. has a policy of not taking back computers once dispatched from its factory. Comp Ltd. sells a minimum of 100 computers to its customers.*

Comp Ltd. charges prices to Ret Ltd. as follows:

₹ 29,000 per unit, for order quantity 100 units to 140 units.

₹ 26,000 per unit, for the entire order, if the quantity is 141 to 200 units. Ret Ltd. cannot order less than 100 or more than 200 units from Comp Ltd.

Due to the economic recession, Ret Ltd. will be forced to offer as a free gift, a digital camera costing it ₹ 4,500 per piece, which is compatible with the computer. These cameras are sold by another company, Photo Ltd. only in boxes, where each box contains 50 units. Ret Ltd. can order the cameras only in boxes and these cameras cannot be sold without the computer.

In its own store, Ret Ltd. can sell 110 units of the computer. At another far of location, Ret Ltd. can sell upto 80 units of the computer (along with its free camera), provided it is willing to spend ₹ 5,000 per unit on shipping costs. In this market also, the selling price that each unit will fetch is ₹ 30,000 per unit.

Required

(i) State what is Ret's best strategy along with supporting calculations.

(ii) Compute the break-even point in units, considering only the above costs.

Solution

	Particulars	Order Qty 100-140 (₹)	Order Qty 141-200 (₹)
I	Selling Price / unit	30,000	30,000
II	Commission @ 10%	3,000	3,000
III	Sales Revenue *p. u.* [I + II]	33,000	33,000
IV	*Less*: Variable Purchase Cost	29,000	26,000
V	Contribution / unit *before shipping* [III – IV]	4,000	7,000
VI	*Less*: Shipping Cost (Sales > 110 units)		5,000
VII	Contribution/ units after Shipping [V – VI]		2,000

(i) Upto 110 units, Ret Ltd. will earn a contribution of ₹4,000 per unit.

(ii) Between 110 & 140 units, contribution of ₹4,000 will be wiped out by ₹5,000 on shipping costs. Hence we should not consider 110 – 140 range.

(iii) 101 – 110 not to be considered since additional costs of ₹2,25,000 on purchase of cameras will not be covered by 10 units.

(iv) Valid consideration, 100 units or 141 to 190 units.

		100 Units	141 Units	150 Units	190 Units
A	No. of Camera Boxes	2	3	3	4
B	Cost of Cameras (₹)	4,50,000	6,75,000	6,75,000	9,00,000
C	Contribution (₹4,000/u)	400,000	---	---	---
D	Contribution on first 110 units @ ₹7,000/u	---	7,70,000	7,70,000	7,70,000
E	Contribution on balance units @ ₹2,000/u	---	62,000	80,000	1,60,000
F	Total Contribution ...(C)+(D+(E)	4,00,000	8,32,000	8,50,000	9,30,000
G	Profit (₹) ...(F) – (B)	(50,000)	1,57,000	1,75,000	30,000

Best strategy will be to buy 150 units from Comp. Ltd., and sell 110 units at store and remaining 40 units in outside.

Break –even Point (BEP) should be between 151 – 191 units:

Extra Camera Box Cost beyond 150 units	₹2,25,000
Less: Profit for 150 units	₹1,75,000
Extra Profit to be earned	₹50,000

No. of units to cover this additional costs at contribution 25 units $\left(\frac{₹50,000}{₹2,000}\right)$.

BEP 175 units (150 units + 25 units)

Alternative Solution

The problem involves fixed cost of 50 Cameras i.e. ₹2,25,000 for incremental sale of 50.

	Units sold			
	110	**140**	**150**	**190**
Margin *per unit* (₹) (Sales Price – Buying Price + Commission)	4,000	4,000	7,000	7,000
Margin *excluding shipping cost* (₹)	4,40,000	5,60,000	10,50,000	13,30,000
Shipping Cost *for sale beyond 110 units* (₹)	---	1,50,00 (30 × ₹5,000)	2,00,000 (40 × ₹5,000)	4,00,000 (80 × ₹5,000)
Contribution (₹)	4,40,000	4,10,000	8,50,000	9,30,000

Fixed Cost (Cost of Cameras)	(₹)	6,75,000	6,75,000	6,75,000	9,00,000
Profit / (Loss)	(₹)	(2,35,000)	(2,65,000)	1,75,000	30,000

Best Strategy will be to sale 150 units.

The variations of profit are due to incremental fixed cost.

From the profits at different levels, it is seen that the BEP lies between 151units and 190 units.

Let	Break-even Point (BEP)	=	X units
	Margin	=	7,000 X
	Shipping Cost	=	(X – 110) × ₹5,000
	Cost of Cameras	=	₹9,00,000
We have,	7,000 X	=	(X – 110) × ₹ 5,000 + ₹ 9,00,000
Or	7X	=	5X – 550 + 900
Or	2X	=	350
Or	X	=	175
Thus,	BEP	=	175 units

Labour Related Decisions

Problem-63

MFG Ltd. is producing a component called 'KDK'. Estimated costs are:

	Fixed Cost per year (₹ '000)	*Variable Cost per 'KDK' (₹)*
Production	*32,000*	*3,600*
Distribution	*2,000*	*200*

Direct labour costs are 40% of the variable production costs. In the production department machining and assembling of 'KDK', 90 men work 8 hours per day for 300 days in a year. Each worker can machine and assemble 1 'KDK' per uninterrupted 180 minutes time frame. In each 8 hours working day, 20 minutes are allowed for coffee-break, 30 minutes on an average for training and 22 minutes for supervisory instructions. Besides 10% of each day is booked as idle time to cover checking in and checking out changing operations, getting materials and other miscellaneous matters.

MFG Ltd. has been facing industrial relations problem as the workers of company have a very strong union. Company is faced with the possibility of a strike by direct production workers *engaged on the assembly of 'KDK'. The trade union is demanding an increase of 15%, back-dated from the beginning of financial year, but the company expects that if a strike does take place, it will last 25 Days after which the union will settle for an increase of 10% similarly back-dated. The only product of the company is being sold at ₹6,000.*

If the strike takes place, Sales of 1,300 'KDK' would be lost. The balance that would ordinarily have been produced during the strike period could, however be sold, but these 'KDK' would have to be made up in overtime working which would be at an efficiency rate of 90% of normal. This would entail additional fixed cost of ₹1,00,000 and wage payments at time and one-half.

Required

Give necessary advice to the management to allow the strike to go ahead or to accept the union's demand.

Solution

Alternative-1 with No Strike: (Refer W.N.-2, 3)

Cost of Settlement is 15% Increase i.e. ₹216 per unit

Annual Cost of Settlement

= 54,000 units × ₹216

= ₹1,16,64,000

Alternative 2 i.e. if Strike Goes Ahead: (Refer W.N.-1, 2, 3)

Extra Cost	(₹)
Annual Incremental Labour Cost (Ex. Strike Days Production) [{54,000 units – (25Days × 180 units per Day)} × ₹144.00]	71,28,000
Loss of Contribution *due to loss of sales* [1,300 units × ₹ 2,200]	28,60,000
Incremental Labour Cost for Balance 3,200 units [(25 Days × 180 units per Day) – 1,300 units} × ₹144.00]	4,60,800
Overtime Premium [3,200 units × 1,584 × 0.5]	25,34,400
Payment for Efficiency [3,200 units × 1/9 × 1,584 × 1.5]	8,44,800
Additional Fixed Cost	1,00,000
	1,39,28,000

If there is no strike, it will yield a financial benefit of ₹22,64,000 (₹1,39,28,000 – ₹ 1,16,64,000). Management should accept union's demand.

Working Note

(1) Statement Showing Contribution *per unit* of 'KDK'

	(₹)
Selling Price	6,000
Less: Variable Costs:	
Labour Cost	1,440
Production Ex. Wages (₹3,600 – ₹1,440)	2,160
Distribution	200
Contribution	2,200

(2) Calculation of Labour Cost

Direct Labour (40% of production costs of ₹3,600) = ₹1,440 *per unit*

With 15% Increase, Revised Labour Cost (₹1,440 + ₹216) = ₹1,656

With 10% Increase, Revised Labour Cost (₹1,440 + ₹144) = ₹1,584

(3) Statement Showing Budgeted Production

Total Time in a Day: (8hrs. × 60 minutes)	=	480 minutes
Less: Idle Time	=	48 minutes
Coffee Break	=	20 minutes
Instructions	=	22 minutes
Training	=	30 minutes
Productive Time *per day*	=	360 minutes
Therefore, 'KDK' to be produced per man per day: (360/180 × 1)	=	2 units

Since 'KDK' are produced at the rate of 2 'KDK' per man day, so total yearly production will be 54,000 units (2 units × 90 men × 300 days) of 'KDK'

☞

This problem has been solved by comparing **'Existing Situation'** with both **'Alternatives (Strike or Non-Strike)'** *independently*. However this problem can also be solved by comparing **'Alternatives (Strike or Non-Strike)'** *only* and final answer would be the same.

Students may also solve this problem by taking **'Total Approach'** instead of **'Incremental Approach'**.

Problem-64

The details of the output presently available from a manufacturing department of Hitech Industries Ltd. are as follows:

Average output per week 48,000 units from 160 employees

Saleable value of output..₹ 6,00,000

Contribution made by the output towards fixed expenses and profit.....................₹ 2,40,000

The Board of Director plans to introduce more automation in the department at a capital cost of ₹ 1,60,000. The effect of this will be to reduce the number of employees to 120, but to increase the output per individual employee by 60%. To provide the necessary incentive to achieve the increased output the Board intends to offer a 1% increase in the piece work rate of one rupee per article for every 2% increase in average individual output achieved. To sell the increased output, it will be necessary to decrease the selling price by 4%.

Required

Calculate the extra weekly contribution resulting from the proposed change and evaluate, for the Board's information, the worth of the project.

Solution

Evaluation of the Project & Computation of Extra Weekly Contribution from Automation

Sales (units) [W.N.-1]	57,600
	(₹)
Sales Value (57,600 units × ₹12) [W.N.-3]	6,91,200
Less: Marginal Cost Excluding Wages (57,600 units × ₹6.50) [W.N.-4]	3,74,400
Wages (57,600 × ₹1.30) [W.N.-2]	74,880
Marginal Contribution	2,41,920
Less: Present Contribution	2,40,000
Extra Weekly Contribution	1,920

Payback Period *for recovering the capital cost* is 83.33 Weeks (₹1,60,000 / ₹1,920)

Recommendation

The project can be taken up presuming that increase in overhead, if any, will be less than the increase in contribution as computed above.

Working Notes

1. Present Output *per employee* and Total Future Expected Output:

Present Output *per employee* = $\frac{\text{Total Present Output}}{\text{Total Number of Present Employees}}$

$$= \frac{48,000 \text{ units}}{160 \text{ employees}}$$

= 300 units

Estimated Future Output = Total Number of Future Employees × Present Output per employee + 60 % of Present Output

= 120 × (300 units + 60% × 300 units)

= 57,600 units

2. Present and Proposed Piece Work Rate:

Present Piece Work Rate = ₹1 *per unit*

Proposed Piece Work Rate = Present Piece Work Rate + 30%

= ₹1 + 0.30

= ₹1.30 per unit.

3. Present and Proposed Selling Price *per unit*:

Present Selling Price *per unit* = ₹12.50 (₹6,00,000 / 48,000 units)

Proposed Selling Price *per unit* = ₹12 (₹ 12.50 – 4% × ₹ 12.50)

4. Present Marginal Cost Excluding Wages *per unit*:

$$= \frac{\text{Present Sales Value - Contribution towards (Fixed Expenses \& Profit) - Present Wages}}{\text{Present Output (units)}}$$

$$= \frac{₹6,00,000 - ₹2,40,000 - ₹48,000}{48,000 \text{ units}}$$

= ₹6.50 per unit

Problem-65

In its round of talks with the representatives of the Trade Union, Maxima Ltd. is faced with a Union demand for an increase of 15% on the hourly wage rates, in response to a management offer of 5%.

The management is most reluctant to agree to such a demand but is willing to consider making an increased offer provided that it influences productivity. The suggestion is to offer 5% on basis of hourly rates plus ₹ 0.15 for every standard hour of output produced. If this is agreed to, it is expected that production would increase by 10% within the budgeted hours (normal factory capacity).

In order to sell the increased output, it would become necessary to effect a reduction of 2.5% in the selling price.

The draft budget for the forthcoming year, excluding the wages and sales increase, are:

(Amount in ₹)

Sales (15,00,000 units)	*60,00,000*
Direct Material	*12,00,000*
Direct Wages	*18,00,000*
Variable Production Overhead	*3,00,000*
Fixed Production Overhead	*10,00,000*
Variable Sales Overhead (5% of turnover)	*3,00,000*
Fixed Sales Overhead	*6,00,000*
Variable Distribution Overhead	*1,00,000*
Fixed Distribution Overheads	*1,00,000*
Fixed Administration Overhead	*2,00,000*
Profit	*4,00,000*

Required

Work out the alterations in the budget:

(i) If the trade union demand is accepted by management.

(ii) If the management's proposal of wage increase linked to productivity is accepted by the trade union.

Also work out the minimum output necessary for the management's proposal to be more rewarding to the labour force than a 15% wage increase.

Solution

(i) Revised Budget If the Trade Union's Demand is Accepted

(Amount in ₹)

Sales (15,00,000 units)	60,00,000
Variable Costs:	
Direct Material	12,00,000
Direct Wages (₹18 lakh + 15% of ₹18 lakhs)	20,70,000

Variable Production Overhead	3,00,000
Variable Sales Overhead	3,00,000
Variable Distribution Overhead	1,00,000
Fixed Costs:	
Fixed Production Overhead	10,00,000
Fixed Sales Overhead	6,00,000
Fixed Distribution Overheads	1,00,000
Fixed Administration Overheads	2,00,000
Total Costs	58,70,000
Profit	1,30,000

(ii) Revised Budget If the Proposal of the Management is Accepted

(Amount in ₹)

Sales (16,50,000 units at ₹3.90)	64,35,000
Variable Costs:	
Direct Material (16,50,000 units at ₹0.80)	13,20,000
Direct Wages (₹ 18 lakhs × 1.05 + 16.5 lacs × ₹0.15)	21,37,500
Variable Production Overhead	3,30,000
Variable Sales Overhead (5% of ₹64,35,000)	3,21,750
Variable Distribution Overhead	1,10,000
Fixed Costs:	19,00,000
Profit	3,15,750

Minimum Output necessary for the management's proposal to be more rewarding to the labour force than a 15% wage increase:

Direct Wages at 115% of basic hourly rate	20.7
Direct Wages 105% of basic hourly rate	18.9
Difference between the two	1.8

Break-even Production = 12 lakh units $\left(\frac{1.8\,\text{lakhs}}{0.15}\right)$

This is the minimum output desired.

Note

It has been presumed that one unit of output denotes one standard hour of output.

Working Notes

1. Budgeted Selling Price *before increment* $= \dfrac{₹60,00,000}{15,00,000 \text{ units}}$

$= ₹4$

Selling Price *after reduction of 2.5%* $= ₹4 – 2.5\% \text{ of } ₹4$

$= ₹3.90$

2. Direct Material Cost per unit $= \dfrac{₹12,00,000}{15,00,000 \text{ units}}$

$= ₹0.80$

Problem-66

Marvellous Manufacturers produce a single product. The Company's annual normal production is 5 lakhs units of output on a single shift of eight-hour a day basis in terms of a standard input of 1 lakh direct labour hours. Last year's income statement is given below:

	(₹)
Sales (7 lakh units @ ₹ 2.50)	*17,50,000*
Less: Variable Expenses	
Direct Material	*2,80,000*
Direct Labour (1,40,000 hours @ ₹ 3.50)	*4,90,000*
Overtime Premium	*1,40,000*
Miscellaneous	*2,10,000*
Contribution Margin	*6,30,000*
Less: Fixed Expenses	*5,30,000*
Net Income	*1,00,000*

Management is concerned about the overtime working done last year (overtime is paid at double the normal rate) and wants to investigate the possibility of working a second shift. The cost accountant of the company estimates that a second shift would increase costs as follows: an additional factory supervisor at ₹ 30,000 per annum, a night shift allowance of 60 paise per direct labour hour and an increase in security and administrative costs of ₹ 40,500 a year.

Required

Management requires you as their consultant to answer these questions with supporting figures:

(i) *If instead of working overtime a second shift had been introduced at the beginning of last year itself, would profits have been better? If so by how much?*

(ii) *At what capacity level it would be advantageous to the company to change from overtime working to a second shift?*

(iii) *This year it is estimated that there will be, on last year's figures, 20% increase in units sold, 10% increase in selling price, 5% increase in direct material cost per unit and a direct labour rate increase of ₹ 0.30 per hour. Assuming that the overtime working would be continued, prepare an income statement for the year based on the current estimates; if a second shift working were to be introduced, with an increase in night shift allowance of 6 paise per direct labour hour, what would have been the savings in cost?*

Solution

(i) Comparative Statement of Profitability of Second Shift Overtime Working

(₹)

Overtime Premium Paid (40,000 hrs @ ₹3.50)	1,40,000
Less: Costs of Second Shift	
- Factory Supervisor	30,000
- Security and Administrative Costs	40,500
- Night Shift Allowance (40,000 hrs @ ₹ 0.60 paise per hour)	24,000
Excess of Overtime Premium Over Costs of Second Shift	45,500

Profit would have been higher by ₹45,500, if instead of working overtime, a second shift had been introduced at the beginning of last year itself.

Working Note

Overtime Worked = Actual Direct Labour Hours Worked − Standard Input of Direct Labour Hours

= 1,40,000 hours − 1,00,000 hours

= 40,000 hours

(ii) Capacity Level at which it would be advantageous to change from Overtime Working to a Second Shift.

Let ‘M’ be the capacity level (in hours) over 1,00,000 hours at which overtime premium and second shift costs are equal.

Then M × ₹ 3.50 = ₹30,000 + ₹40,500 + ₹0.60 × M

2.90 M = ₹70,500

Or, M = 24,310.34 hours

The break-even is at 24,310.34 hours.

Thus, at a capacity level of 1,24,311 (i.e., 1,00,000 + 24,311) direct labour hours and above, it would be advantageous to the company to change from overtime working to second shift.

(iii) (a)

Income Statement for the Current Year
(Assuming that the Overtime Working is to be continued...)

	(₹)
Sales (8,40,000 units × ₹ 2.75)	23,10,000
Less: Variable Expenses	
Direct Material (8,40,000 units × ₹ 0.42)	3,52,800
Direct Labour $\left(\frac{1,40,000 \text{ hrs.}}{7,00,000 \text{units}} \times 8,40,000 \text{units} \times ₹3.80\right)$	6,38,400
Overtime Premium (68,000 hrs. × ₹3.80)	2,58,400
Miscellaneous: $\left(\frac{₹2,10,000}{7,00,000 \text{ units}} \times 8,40,000 \text{ units}\right)$	2,52,000
Contribution Margin	8,08,400
Less: Fixed Expenses	5,30,000
Net Income	2,78,400

(b) **Computation of Savings in Cost**
(Assuming that Second Shift Working is to be introduced...)

(₹)

Overtime Premium (68,000 hrs @ ₹3.80)	2,58,400
Less: Costs of Second Shift	
- Factory Supervisor	30,000
- Security and Administrative Costs	40,500
- Night Shift Allowance (68,000 hrs @ ₹ 0.66 paise per hr.)	44,880
Savings in Cost	1,43,020

Working Note

Computation of Overtime Hours:

Direct Labour Hrs. Required to Produce 8,40,000 units

$$= \left(\frac{1{,}40{,}000 \text{ hrs.}}{7{,}00{,}000 \text{ units}} \times 8{,}40{,}000 \text{units}\right)$$

= 1,68,000 hrs.

Overtime Hrs. = 1,68,000 hrs. – 1,00,000 hrs.

= 68,000 hrs.

Preventive Maintenance Vs Break-Down Maintenance

Problem-67

A company has continuous manufacturing process involving an output of 6 tonnes per hour valued at ₹ 70 per tonne. Process wages cost ₹ 60 per hour and raw material, ₹ 35 per tonne of product. Regular maintenance works out to ₹ 750 per week.

The company is experiencing breakdown due to mechanical reason averaging 25 hours a week, costing ₹ 7,500 to repair. It is estimated that these breakdown can be reduced or eliminated if additional maintenance on the following scale were undertaken:-

Breakdown per week (hours)	*0*	*5*	*10*	*15*	*20*
Maintenance Cost (₹)	*23,000*	*13,000*	*6,500*	*3,000*	*1,500*
Repair Costs (₹)	*0*	*2,500*	*3,000*	*5,000*	*6,500*

Process labour during stoppages can be used elsewhere upto 10 hours per week.

Required

(i) Present, in tabular form, the optimum amount of maintenance to be undertaken each week.

(ii) What is the additional revenue that will be resulting from the optimal level, compared with the present situation?

Solution

(i) Statement of Comparative Cost of Repairs and Maintenance *to ascertain the optimum amount of maintenance each week*

	Breakdown Hours (per week)					
	0	**5**	**10**	**15**	**20**	**25***
	(₹)	**(₹)**	**(₹)**	**(₹)**	**(₹)**	**(₹)**
Maintenance Costs	23,000	13,000	6,500	3,000	1,500	750
Repairs Cost	0	2,500	3,000	5,000	6,500	7,500

Total	23,000	15,500	9,500	8,000	8,000	8,250
Cost of Idle Time (Breakdown hrs - 10 hrs) x ₹60	---	---	---	300	600	900
Total Cost	23,000	15,500	9,500	8,300	8,600	9,150

** At present*

It is seen from the above table that the optimum amount of maintenance is for break-down of 15 hours a week.

(ii) Additional Revenue that will Result from the Optimal Level; Compared with Present Situation

	(₹)
Value of Additional Output (10 hours saved × 6 tonnes × ₹70)	4,200
Less: Wages (10 hours × ₹60)	600
Less: Material (10 hours saved × 6 tonnes × ₹35)	2,100
Add: Saving in Maintenance and Repairs Cost (₹9,150 – ₹8,300)	850
Total Additional Revenue	2,350

Shut Down or Continue

Problem-68

Paints Ltd. manufactures 2,00,000 tins of paint at normal capacity. It incurs the following manufacturing costs per unit:

	(₹)
Direct material	*7.80*
Direct labour	*2.10*
Variable overhead	*2.50*
Fixed overhead	*4.00*
Production cost / unit	*16.40*

Each unit is sold for ₹ 21, with an additional variable selling overhead incurred at ₹ 0.60 per unit.

During the next quarter, only 10,000 units can be produced and sold. Management plans to shut down the plant estimating that the fixed manufacturing cost can be reduced to ₹ 74,000 for the quarter.

When the plant is operating, the fixed overheads are incurred at a uniform rate throughout the year. Additional costs of plant shut down for the quarter are estimated at ₹ 14,000.

Required

(i) To advise whether it is more economical to shut down the plant during the quarter rather than operate the plant.

(ii) Calculate the shut down point for the quarter in terms of numbering units.

Solution

Contribution *per tin* = Selling Price – Variable cost

= ₹21 – (₹7.8 + ₹2.1+ ₹2.5 + ₹0.6)

= ₹8 *per tin*

Loss on Operation

Fixed Cost *per annum* = 8 lakhs (2,00,000 units × 4 per unit)

Fixed Cost for 1 Quarter = 2 lakhs (8 lakhs / 4)

	(₹)
Fixed Cost for the quarter	2,00,000
Less: Contribution on operation (₹8 × 10,000 units)	80,000
Expected Loss on operation	(1,20,000)

Loss on Shut Down

	(₹)
Unavoidable Fixed Cost	74,000
Additional Shut Down Cost	14,000
Loss on Shut Down	(88,000)

Conclusion

Better to Shut Down and Save ₹ 32,000.

Shut Down Point (number of units) $= \frac{\text{Avoidable Fixed Cost}}{\text{Contribution per unit}}$

$= \frac{₹2,00,000 - ₹88,000}{₹8}$

= 14,000 units

Problem-69

G Ltd. produces and sells 95,000 units of 'X' in a year at its 80% production capacity. The selling price of product is ₹ 8 per unit. The variable cost is 75% of sales price per unit. The fixed cost is ₹ 3,50,000. The company is continuously incurring losses and management plans to shut-down the plant. The fixed cost is expected to be reduced to ₹ 1,30,000. Additional costs of plant shut-down are expected at ₹ 15,000.

Should the plant be shut-down? What is the capacity level of production of shut-down point?

Solution

	If Plant is Continued	If Plant is Shutdown
Sales	7,60,000	---
Less: Variable Cost	5,70,000	---
Contribution	1,90,000	---
Less: Fixed Cost	3,50,000	1,30,000
Additional Cost	---	15,000
Operating Loss	1,60,000	1,45,000

A comparison of loss figures indicated as above points out that loss is reduced by ₹15,000 (₹16,000 - ₹14,500) if plant is shut down.

Shut Down Point $= \dfrac{₹3,50,000 - ₹1,45,000}{₹8 - ₹6}$

$= 1,02,500$ units

Capacity Level of Shut Down Point

At 100% Level Production $= 1,18,750 \left(\dfrac{95,000\text{units}}{0.80}\right)$

Capacity Level at Shut Down $= 86.32\% \left(\dfrac{1,02,500\text{units}}{1,18,750\text{units}}\right)$

Problem-70

If Moonlite Limited operates its plant at normal capacity it produces 2,00,000 units from the plant 'Meghdoot'. The unit cost of manufacturing at normal capacity is as under:

	₹
Direct material……………………………………………	*65*
Direct labour……………………………………………	*30*

Variable overhead……………………………………...33
Fixed overhead…………………………………………...7
135

Direct labour cost represents the compensation to highly-skilled workers, who are permanent employees of the company. The company cannot afford to lose them. One labour hour is required to complete one unit of the product.

The company sells its product for ₹ 200 per unit with variable selling expenses of ₹ 16 per unit. The company estimates that due to economic down turn, it will not be able to operate the plant at the normal capacity, at least during the next year. It is evaluating the feasibility of shutting down the plant temporarily for one year.

If it shuts down the plant, the fixed manufacturing overhead will be reduced to ₹ 1,25,000. The overhead costs are incurred at a uniform rate throughout the year. It is also estimated that the additional cost of shutting down will be ₹ 50,000 and the cost of re-opening will be ₹ 1,00,000.

Required

Calculate the minimum level of production at which it will be economically beneficial to continue to operate the plant next year if 50% of the labour hours can be utilized in another activity, which is expected to contribute at the rate of ₹ 40 per labour hour. The additional activity will relate to a job which will be off-loaded by a sister company only if the company decides to shut down the plant.

(Assume that the cost structure will remain unchanged next year. Ignore income tax and time value of money)

Solution

Contribution *per unit*

Particulars	**(₹)**
Selling Price	200
Variable Cost (₹ 65 + ₹ 33 + ₹ 16)	114
Contribution per unit (Excluding direct labour, considered irrelevant and fixed)	86

Savings and Earnings if the Plant is Shut Down

Particulars	**(₹)**
Savings in Fixed Cost (₹ 14,00,000* – ₹ 1,25,000)	12,75,000
Contribution from Alternate Activity (₹ 40 × 50% of 2,00,000 hrs)	40,00,000
Shutting Down and Reopening Cost (₹ 50,000 + ₹100,000)	(1,50,000)
Total	51,25,000

* [2,00,000 units x ₹ 7]

Indifference Point: ₹51,25,000 / ₹86 = 59,593 units

Minimum level of production to justify continuation = 59,594 units

Problem-71

Rabi Ltd. is considering the discontinuance of Division C. The following information is given:

Particulars	*Divisions A & B*	*Division C*	*Total*
Sales (Maximum achievable)	*41,40,000*	*5,17,500*	*46,57,500*
Less: Variable cost	*20,70,000*	*2,76,000*	*23,46,000*
Contribution	*20,70,000*	*2,41,500*	*23,11,500*
Less: Specific avoidable fixed cost	*14,49,000*	*4,14,000*	*18,63,000*
Divisional Income	*6,21,000*	*(1,72,500)*	*4,48,500*

The rates of variable costs are 90% of the normal rates due to the current volume of operation. There is adequate market demand.

For any lower volume of operation, the rates would go back to the normal rates.

Facilities released by discontinuing Division C cannot be used for any other purpose.

Required

Evaluate the decision to discontinue Division C using relevant cost approach.

Solution

As given in the problem Rabi Ltd. is considering to discontinue the Division C perhaps by seeing the Division C's income as it is a loss of ₹1,72,500. Discontinuance of Division C might be saving ₹4,14,000 on specific fixed costs to the company but due to this decision company will not only be losing ₹2,41,500 contribution from the Division C but also an additional burden of variable cost of ₹2,30,000 to Divisions A & B and Rabi Ltd. as a whole.

Let evaluate the decision of the Rabi Ltd. with the help of the **Relevant Cost** approach.

Particulars	**Amount (₹)**
Savings Due to Discontinuance	
Specific Fixed Cost	4,14,000
Total ..(A)	4,14,000
Loss/ Increase in Cost Due to Discontinuance	
Loss of Contribution	2,41,500

Increase in Variable Cost $\left(\frac{₹20,70,000}{90}\times 10\right)$		2,30,000
Total	…(B)	4,71,500
Excess of Loss Over Savings	…(B) – (A)	57,500

In a nutshell considering the above analysis we can conclude that the decision of discontinuing Division C will not be beneficial for the Rabi Ltd and it should review its decision on the basis of relevant cost approach to reach at right decision.

Problem-72

Cold Drinks Ltd. bottles and distributes 'Cola' brand cold drinks. It operates its distribution division as a cost centre. Budgeted cost for the year ending 31st March, 2013 is as follows:

	(₹)
Cash Operating Costs	*21,00,000*
Depreciation on Fleet of Vehicles (8 x ₹ 52,500)	*4,20,000*
Apportioned Corporate Costs	*3,00,000*
	28,20,000

Distribution division has started operation on 1st April, 2011. Each vehicle of the fleet was acquired at a cost of ₹ 2,40,000 and had an estimated economic life of four years. Salvage value of each vehicle at the end of four years (March 31, 2015) was estimated at ₹ 30,000.

Native Distributors Ltd. which has countrywide network for the distribution of food and beverages has offered Cold Drinks Ltd. a three year distribution contract for ₹ 19,50,000 each year. The contract will start on 1st April, 2012.

If Cold Drinks Ltd. accepts the offer, it will close down its own distribution division, and will sell the delivery vehicles. Current (April 1, 2012) disposal price of each vehicle is estimated at ₹ 75,000. Cold Drinks Ltd. will avoid cash operating cost of ₹ 21,00,000.

Security analysts have recommended the purchase of share of Cold Drinks Ltd., security analysts are forecasting a net profit of ₹ 6,60,000 for 2012 – 13 as against an estimated Profit of ₹ 6,30,000 for 2011 – 12, the forecast assumes that the company will continue operation of its distribution division.

Required

(i) Tabulate a comparison of all relevant cost for next three years (2012 – 13 to 2014 – 15) for the two alternatives – use of own distribution division or use of Native distributors Ltd. Recommend whether Cold Drinks Ltd. should accept the offer of Native distributors Ltd.

(ii) Why might Cold Drinks Ltd. be reluctant to accept the offer of Native distributors Ltd?

(Ignore Income – tax and time value of money. Wherever appropriate, suitable assumption to be made by you)

Solution

(i) Statement of Relevant Costs, Showing Comparison of Two Alternatives

(₹ in '000)

Alternatives Particulars	Own Distribution			Native Distributors		
	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
Annual Relevant (Cash Out Flows)						
(i) Cash Operating Costs	2,100	2,100	2,100	---	---	---
(ii) Sub Contract Costs	---	---	---	1,950	1,950	1,950
Total: (A)	2,100	2,100	2,100	1,950	1,950	1,950
One Time Relevant Cash Inflows Sale of Delivery Vehicles on :						
(i) 01.04.2012	---	---	---	600	---	---
(ii) 31.03.2015	---	---	240	---	---	---
Total: (B)	---	---	240	600	---	---
Net Relevant Cash Outflows:(A) − (B)	2,100	2,100	1,860	1,350	1,950	1,950
Total	6,060			5,250		

Recommendation

Cold Drinks Ltd. should accept the offer of Native Distributors Ltd. because the acceptance of the offer will reduce cash outflows by ₹8,10,000 (₹60,60,000 – ₹52,50,000).

Assumption

No portion of the common corporate cost of which ₹3,00,000 is apportioned to distribution division will be avoided even if the distribution division is closed down.

(ii) Cold Drinks Ltd. may be *reluctant to accept the offer* of Native Distributors Ltd. due to-

(a) The impact of recognizing book loss on the disposal of the delivery vehicles. The figure of book loss will be as below-

	(₹)
Cost of Fleet (8 Vehicles) on 01.04.2011	19,20,000
Less: Depreciation for 2011 – 12	4,20,000
Book Value as on 01.04.2012	15,00,000
Less: Sales Realization (8 Vehicles x ₹ 75,000)	6,00,000
Book Loss	9,00,000

(b) Reduction in reported net income, as per the forecast of security Analysis, if the offer of Native Distributors Ltd is accepted. The expected operating income figures based on the forecast of Security Analysts are-

(₹ '000)

	2011-12	**2012-13**
Estimated Profit (when Cold Drinks Ltd. uses its own distribution division)	630	660
Net Income (if the offer of Native Distributors Ltd is accepted)	630	330*

*Estimated Profit *as projected*	660
Add: Depreciation Avoided	420
Add: Saving in Operating Cost (₹2,100 – ₹1,950)	150
Less: Book Loss on the Disposal of Delivery Vehicles	900
Net Income on the Acceptance of Offer	330

Hence according to the analysis of Security analyst in capital market, there will be a reduction in the reported net income to the tune of ₹3,30,000 (₹6,60,000 – ₹3,30,000) in the short run if Native Distributors Ltd.'s offer is accepted.

Security analysts did not recognised the long term benefits of accepting the offer of Native Distributors Ltd.

(c) Management of Cold Drinks Ltd. may feel that they can better focus on customer needs by operation the distribution function themselves.

(d) Management of Cold Drinks Ltd. thinks that Native Distributors may acquire its own soft drink subsidiary and they possibly de–emphasize its services to their product.

Problem-73

Tuscan Reel Ltd. manufacturers a range of films extensively used in the Cinema industry. The films, once manufactured, are packed in circular containers and stored in specially constructed *crates lined with "Protecto". These crates are manufactured and maintained by a special department within the company and the departmental costs last year are as under:*

	(₹)
Direct Materials (including "Protecto")	*1,40,000*
Direct Labour	*1,00,000*
Overheads:	
Department Manager	*16,000*
Depreciation of Machine	*30,000*
Maintenance of Machine	*7,200*
Rent (Portion of Warehouse)	*9,000*
Other Miscellaneous Costs	*31,500*
Administration Overhead (20% of Direct Costs)	*48,000*

Max Associates have approached the Tuscan Reel Ltd., offering to make all the crates required on a four-year contract for ₹ 2,50,000 per annum and/or to maintain them for further ₹ 50,000 per annum.

The following data are relevant:

(i) The machine used in the department cost ₹ 2,40,000 four years ago and will last for four more years. It could be currently sold for ₹ 50,000.

(ii) The stock of "Protecto" was acquired last year for ₹ 2,00,000 and one-fifth was used last year and included in the material cost. Its originally cost was ₹ 1,000 per ton, but the replacement cost is ₹ 1,200 per ton; and it could be currently sold for ₹ 800 per ton.

(iii) The department has acquired warehouse space for ₹ 18,000 per annum. It uses only one-half of the space; the rest is idle.

(iv) If the department were closed, the manager will be transferred to another department; but all the labour force will be made redundant, and the terminal benefits to be met with amount to ₹ 15,000 per annum. In that event,

Max Associates will undertake to manufacture and maintain the crates.

If Tuscan Reel Ltd. continued to maintain the crates, but left their manufacture to Max Associates:

(i) The machine will not be required.

(ii) The manager will remain in the department.

(iii) The warehouse space requirements will not be reduced.

(iv) Only 10% of all materials will be used.

(v) Only one worker will be dispensed with and taking the terminal benefit to be met into account, the saving will be ₹ 5,000 per annum.

(vi) The miscellaneous costs will be reduced by 80%.

If Tuscan Reel Ltd. continued to manufacture the crates but left their maintenance to Max Associates:

(i) The machine will be required.

(ii) The manager will remain in the department.

(iii) The warehouse space will be required.

(iv) 90% of all the materials will be required.

(v) The labour force will continue.

(vi) The miscellaneous cost will be reduced by 20%.

Assuming that for the four-year period, there is no significant change envisaged in the pattern of other costs.

Required

Evaluate the alternate courses of action with supporting figures of each flows over the four-year per and advise accordingly.

Solution

Evaluation of the Three Alternative Courses of Action

Alternative I - Dept. is closed and Max Associates undertake to manufacture and maintain the Crates.

Alternative II - Tuscan Reel Ltd. continue to maintain the Crates, but leave their manufacture to Max Associates.

Alternative III - Tuscan Reel Ltd. continue to manufacture the Crates but leave their maintenance to Max Associates.

	Alternative I (₹)	**Alternative II (₹)**	**Alternative III (₹)**
INFLOW:			
Cost Avoided *in terms of cash flows:*			
Direct Material Other than "Protecto" (W.N.-1)	1,00,000	90,000	10,000
Direct Labour (W.N.-2)	85,000	5,000	-

Maintenance of Machine	7,200	7,200	-
Rent (full)	18,000	-	-
Other Miscellaneous Costs	31,500	25,200	6,300
Total Costs Avoided *per annum*	2,41,700	1,27,400	16,300
Total Cost Avoided in *four years*	9,66,800	5,09,600	65,200
Cash Realisation:			
Sale of Machine	50,000	50,000	-
Sale of "Protecto" Stock (W.N.-4)	1,28,000	1,15,200	12,800
Total Cash Inflow ...(A)	11,44,800	6,74,800	78,000
OUTFLOWS:			
Payment to Max Associates *per annum* (W.N.-3)	3,00,000	2,50,000	5,000
Cash Outflow *in 4 years* ...(B)	12,00,000	10,00,000	2,00,000
Profit / (Loss) in terms of Cash Flows ...(A) – (B)	(55,200)	(3,25,200)	(1,22,000)

Recommendation

The above analysis shows that net cash outflows exceed the amount of costs avoided in the three alternative courses of action. Hence, none of the alternatives is profitable. Tuscan Reel Ltd. should, therefore, continue to manufacture and maintain the crates.

Working Notes

1. The total cost of direct materials (including "Protecto") is ₹1,40,000. The cost of "Protecto" used for the last year comes to ₹40,000. Thus, cost of direct materials that can be avoided in Alternative-I comes to ₹1,00,000 (₹1,40,000 – ₹40,000). The cost of direct materials excluding "Protecto", to be avoided under Alternatives-II and III have been calculated on the basis of this amount.

2. Cost of direct labour that can be avoided under Alternative-I: ₹ 85,000 (₹1,00,000 – ₹15,000) [terminal benefits].

3. The total cash outflow per annum under Alternative-I will amount to ₹3,00,000 (₹ 2,50,000 + ₹50,000).

4. The stock of 'Protecto', in terms of quantity comes to 160 tonnes (₹1,60,000 /1,000).

The amount to be realised from the sale of "Protecto" under different alternatives has been ascertained as follows:

Alternative I: ₹1,28,000 (160 tonnes × ₹ 800)

Alternative II: ₹1,15,200 $\left(160\text{tonnes} \times \frac{9}{10} \times ₹800\right)$

Alternative III: ₹12,800 $\left(160\text{tonnes} \times \frac{1}{10} \times ₹800\right)$

5. The sale proceeds of machinery and stock could have alternatively been added to the avoided costs', in place of deducting them from cash outflow.

Problem-74

'EXE' Ltd. manufactures a product called 'HN-2'. The company is organized into two divisions, viz., Division 'KXA' and Division 'KXB'. Division 'KXA' manufactures 'HN-2' and Division 'KXB', which manufactures the containers, packs 'HN-2' in the containers and stores them by using a special protective material called 'P-6'. The details of the expenses incurred by Division 'KXB' during 2011 are as under:

	(₹)
Direct Materials including 'P-6'	*5,25,000*
Direct Labour	*3,75,000*
Supervision	*60,000*
Maintenance of Machine	*27,000*
Rent of a part of the Warehouse used	*33,750*
Depreciation of Machine	*1,12,500*
Miscellaneous Overheads	*1,18,125*
Administration Overheads apportioned to the Division	*1,80,000*

'WYE' Ltd. a company engaged in warehousing of a variety of a products, approached 'EXE' Ltd. to undertake to manufacture the containers required on contract basis for a period of four years for ₹ 9,37,500 per annum and/or store the packed product for a further sum of ₹ 1,87,500 per annum.

Division 'KXB' uses a machine for the manufacture of containers This machine was installed four years ago at a capital cost of ₹ 9,00,000 and it has a useful life of four more years. It can be currently sold at ₹ 1,87,500.

Division 'KXB' purchased 'P-6' worth ₹ 7,50,000 during the last year. Out of this, one-fifth was used during the last year and the cost thereof is included in the material cost of 2011. The original purchase price of 'P-6' was ₹ 3,750 per tonne but, if sold now, the stock of 'P-6' would fetch only ₹ 3,000 per tonne. Its current replacement cost is ₹ 4,500 per tonne.

Division 'KXB' hired a warehouse for storage of the product for ₹ 67,500 per annum. It uses *only half of the space and has taken only half the amount of rent into account. The remaining space of the warehouse is idle.*

Required

Evaluate the following three proposals on a four-year term basis and state recommendations.

(i) If the contract for manufacture of the containers and the storage of the product, 'HN-2' is given to 'WYE' ltd. Division 'KXB' will be close down. In that event the supervisory staff will be transferred to another department and there will be 100% saving in direct labour cost.

(ii) If 'EXE' Ltd. continues to store the product 'HN-2' and leaves the manufacture of the containers to 'WYE' Ltd., The machine in Division 'KXB' will not be required and the storage space requirements cannot be dispensed with. The supervisory staff will be required to be retained in Division 'KXB' and only 10% of all material will be used. The saving on account of labour retrenchment will come to ₹ 18,750 per annum. The miscellaneous overheads will be reduced by 80%.

(iii) If 'EXE' Ltd. continues to manufacture the containers and leaves the storage of 'HN-2' to 'WYE' Ltd. Division 'KXB' will retain the machine and the warehouse space for use. The supervisory staff will also be retained and 90% of all materials will be required. The labour force will continue and the miscellaneous overheads will be reduced by 20%.

Solution

Statement Showing Evaluation of Alternatives

	Alternative One	**Alternative Two**	**Alternative Three**
Manufacture of Containers	**'WYE' Ltd**	**'WYE' Ltd**	**'EXE' Ltd**
Storage of Product	**'WYE' Ltd**	**'EXE' Ltd**	**'WYE' Ltd**
Cash Inflows (including avoidable cost):			
Direct Materials *other than 'P-6'* (W.N.-1)	3,75,000	3,37,500	37,500
Direct Labour (W.N.-4)	3,75,000	18,750	-
Rent of a part of Warehouse (W.N.-6)	67,500	-	-
Maintenance of Machine (W.N.-7)	27,000	27,000	-
Miscellaneous Overhead (W.N.-8)	1,18,125	94,500	23,625
Total Cash Inflows p.a. ...(A)	9,62,625	4,77,750	61,125
Cash Outflows:			

Contract Fee to 'WYE' Ltd.			
For Manufacture	9,37,500	9,37,500	-
For Packing and Storage	1,87,500		1,87,500
Total Outflow p.a. ...(B)	11,25,000	9,37,500	1,87,500
Net Cash Outflow p.a. ...(C) = (A) - (B)	1,62,375	4,59,750	1,26,375
Cash Outflows for 4 years [(C) × 4]	6,49,500	18,39,000	5,05,500
One Time Income / Inflow:			
Sale of 'P-6' (W.N.-3)	(4,80,000)	(4,32,000)	(48,000)
Sale of Machine (W.N.-5)	(1,87,500)	(1,87,500)	-
Net Cash Outflow	(18,000)	12,19,500	4,57,500

Therefore it is in the interest of 'EXE' Ltd. to *shut down* Division 'KXB'.

Working Note

(1) Direct Material other than 'P-6'

Direct material including 'P-6'	₹5,25,000
Use of 'P-6' 1/5th of ₹7,50,000	₹1,50,000
	₹3,75,000

Alternative One:

The material will be avoidable cost if Division 'KXB' is closed down.

Alternative Two:

Savings: ₹3,37,500 (₹3,75,000 − ₹37,500) if manufacture is given to 'WYE' Ltd. and storage remains with 'EXE' Ltd.

Alternative Three:

Savings: ₹37,500 [₹3,75,000 − (90% of ₹3,75,000)] if manufacture is done by 'EXE' Ltd. and storage given to 'WYE' Ltd.

(2) 'P-6' –Stock

Stock in 2011	₹7,50,000
Used last year (1/5th)	₹1,50,000
Balance Stock	₹6,00,000

It is given that original price is ₹3,750

Therefore, 160 tonnes (₹6,00,000 / ₹3,750) 'P-6' is there.

(3) 'P-6' –Value

Alternative One:

Manufacturing and Storage is done by 'WYE' Ltd. Therefore it will be sold at ₹3,000 per tonne.

Cash inflow will be ₹4,80,000 (₹3,000 × 160)

Alternative Two:

10% of all material will be used. It means 90% of 160 tonne will be sold.

Cash inflow will be ₹4,32,000 (160 × 0.90 × ₹3,000)

Alternative Three:

In this situation storage is done by 'WYE' Ltd. Therefore only 10% of whole quantity of 160 tonnes will be sold in market at ₹3,000 per tonne.

Cash inflow will be ₹48,000 (16 × ₹3,000)

(4) Direct Labour Cost

Alternative One:

Avoidable Cost, if Deptt. KXB is closed (saving) ₹3,75,000

Alternative Two:

If manufacturing is given to 'WYE' Ltd. and 'EXE' Ltd. continues to store the product, saving on account of labour retrenchment will be only ₹18,750.

Alternative Three:

If manufacturing is done by 'EXE' Ltd. then labour force will continue. It means impact of labour cost in third alternative will be nil.

(5) Machine

Machine is used for manufacturing of containers. It is not required in alternative one and two. Therefore, it will be sold and there will be one time cash inflow of ₹1,87,500 under alternative one and two.

(6) Rent of Warehouse

The hire charge of warehouse is ₹67,500 per annum. The remaining space of the warehouse is idle. It means, when department 'KXB' is closed, cash outflow of ₹67,500 will be avoided. Therefore, cash flow for alternatives two and three will not be disturbed on this account.

(7) Maintenance of Machine

Maintenance of machine is required for manufacturing. It means ₹27,000 will be avoidable cost for alternative one and two. In third alternative this cost will continue to be there.

(8) Miscellaneous Overhead

Miscellaneous overhead of ₹1,18,125 will be avoidable cost for alternative one. For second alternative 80% of this i.e. ₹94,500 will be avoidable cost. For third alternative 20% of ₹1,18,125 i.e. ₹23,625 will be avoidable cost.

(9) Supervisory Staff

Supervisory staff will be transferred to another department in the first alternative. It means cash flow will not be affected. In the second and third alternatives, supervisory staff will be retained and it means no additional cash flow or relevant cost due to decision.

(10) Depreciation

Depreciation does not affect the cash flow. Therefore it is not relevant for these decisions.

Problem-75

SFM Ltd. wants to evaluate the potential elimination of Division 'Z'. The basic information regarding cost and revenue is given below:

	Division X and Y	*Division Z*	*Total*
Sales	*₹ 1,20,000*	*₹ 15,000*	*₹ 1,35,000*
Variable Expenses	*(60,000)*	*(8,000)*	*(68,000)*
Contribution Margin	*60,000*	*7,000*	*67,000*
Traceable Fixed Costs	*(42,000)*	*(12,000)*	*(54,000)*
Divisional Income	*18,000*	*(5,000)*	*13,000*
Unallocated Fixed Costs	---	---	*(6,000)*
Income before Taxes			*7,000*

Required

(i) What will be the increase or decrease in profit by eliminating Division 'Z' if all costs traceable to division 'Z' are avoidable? Should the company eliminate?

(ii) Assume that executives and supervisory personnel in Division 'Z' will be reassigned to other divisions, if division is eliminated. Included in ₹ 12,000 of traceable fixed costs of Division 'Z' are ₹ 6,000 of salaries for these personnel. What is the effect of eliminating division 'Z' with this assumption?

(iii) Assume that fixed assets of Division 'Z' can be sold for ₹ 1,50,000 if Division 'Z' is eliminated. Remaining life of these assets is 10 years. Company can earn interest of 12% on invested funds. By what amount will this information affect the benefit to eliminate? [PVIFA (12%, 10) = 5.650]

Solution

(i) **Comparative Profits** *assuming that* Costs Traceable to Division Z are Avoidable

Particulars	Total Company Operations, if it		Benefit / (Cost) to eliminate Z (₹)
	Keeps Z (₹)	Eliminates Z (₹)	
Sales	1,35,000	1,20,000	(15,000)
Variable Expenses	(68,000)	(60,000)	8,000
Contribution	67,000	60,000	(7,000)
Total Fixed Cost	(60,000)	(48,000)	12,000
Profit	7,000	12,000	5,000

(ii)

Advantages to Eliminate Division Z	**(₹)**
Reduction in Variable Expenses	8,000
Reduction in Fixed Expenses (₹12,000 – ₹6,000)	6,000
Total Benefit	14,000
Disadvantages to Eliminate Z	**(₹)**
Reduction in Sales	15,000
Decrease in Profit by Eliminating Division Z	1,000

(iii) ₹26,549 should be added to the annual benefits of eliminating Division Z. The equivalent annual cash flow of ₹26,549 is computed by using annuity table for an assumed annuity of ten years at 12% with present value of ₹1,50,000.

Cash Flow ₹26,549 (₹1,50,000 ÷ 5.650)

The equivalent annual cash flow of ₹26,549 is the opportunity cost of keeping division Z or alternatively it is a benefit from eliminating the division Z.

Problem-76

TQM Limited makes engines for motor cars for its parent company and for two other motor car manufacturers.

On 31st December, the company has sufficient work order for January and one further order for 21,000 engines. Due to recession in the economy, no further order are expected until May when it is hoped economic prospect for the motor car industry will have improved. Recently factory has been working at only 75% of full capacity and the order for 21,000 engines represents about one month production at this level of activity.

The board of directors are currently considering following two options:

(i) Complete the order in February and close the factory in March and April.

Or

(ii) Operate at 25 per cent of full capacity for each of three months of February, March and April.

The costs per month at different levels of activities are as follows:

	At 75% (₹)	At 25% (₹)	Idle (₹)
Direct Material	5,25,000	1,75,000	--
Direct Labour	5,23,600	1,73,250	--
Factory Overhead			
Indirect Material	8,400	4,900	4,900
Indirect Labour	1,01,500	59,500	--
Indirect Expenses			
Repairs and Maintenance	28,000	28,000	--
Others Expenses	52,500	34,300	26,600
Office Overheads			
Staff Salaries	1,48,400	98,000	67,550
Other Overheads	28,000	19,950	11,200

Other information is as follows:

- *Material cost and labour cost will not be incurred where there is no production.*
- *On the reopening of the factory, one time cost of training and engagement of new personnel would be ₹65,800 and overhauling cost of plant would be ₹14,000.*
- *Parent company can purchase engines from open market at reasonable price.*

Required

(i) To express your opinion, along with calculations, as to whether the plant should be shut down during the month of March and April or operate 25% of full capacity for three months.

(ii) To list and comment on cost / non-costs factors which might to relevant to the discussion.

Solution

(i)

	Option-I	Option-II
	At 75% in Feb and Close in March and April (₹)	**At 25% each from Feb – April (₹)**
Direct Material	5,25,000	5,25,000
Direct Labour	5,23,600	5,19,750
Factory Overheads		
Indirect Material	8,400	14,700
Two Months Idle	9,800	---
Indirect Labour	1,01,500	1,78,500
Training Cost	65,800	---
Repairs & Maintenance	28,000	84,000
Over- hauling Cost	14,000	
Others Expenses	52,500	1,02,900
Two Months Idle	53,200	
Office Overheads		
Staff Salaries	1,48,400	2,94,000
Two Months Idle	1,35,100	
Other Overheads	28,000	59,850
Two Months Idle	22,400	----
Total Cost	17,15,700	17,78,700

The more economic course of action is to operate at 75% capacity for a month only, and close the plant for March and April. This option will save ₹63,000 (₹17,78,700 – ₹17,15,700).

(ii) In regard to the decision on close down of operations or continuing with operations, the factors to be considered are:

(1) The proposal which involves the lower total costs will be selected.

(2) If the company has contracted the purchases from high quality and high price suppliers, a change in the procurement policy to 'shop around' may be considered to obtain economics in purchases.

(3) The services of unskilled labour, if any, who do not require re-training may be dispensed with. They may be recruited and put on work without incurring training cost on re-opening of the factory. This will save training and idle time cost.

(4) The possibility of wage freeze may reluctantly be considered as an extreme measure.

Miscellaneous

Problem-77

R.G. Ltd. has several product lines with a sales manager in charge of each product line and he is paid a bonus based on the net income generated by his product line.

In analysis the performance of one product line, the General Sales Manager noted that the sales declined from ₹ 8 lakhs last year to ₹ 6 lakhs for the current year. However the product line manager received a larger than last year because net income increased from ₹ 90,000 last year to ₹ 1,20,000 for the current year.

The General Sales Manager wonders how the product line manager is entitled to a bonus with a decline in sales. He also wants to know how net income increased, when sales decline.

As a Cost Accountant you are required to prepare the income statements, based which the bonus was paid. Explain with supporting figures why net income increased when sales declined. What do you think of the present method of paying the Bonus? Can you suggest some other method?

The data given in support for the bonus payment are:

	Year 2	*Year 1*
Units Sold @ ₹ 20	*30,000*	*40,000*
Standard Variable Cost of Production per unit (₹)	*8*	*8*
Fixed Factory Overhead Cost (₹)	*2,00,000*	*2,00,000*
Selling & Distribution Expenses (assumed to be fixed) (₹)	*1,40,000*	*1,40,000*
Standard Fixed Factory Overhead per unit (₹)	*5*	*5*
Units Produced	*50,000*	*30,000*
Units–Opening Finished Goods Inventory	*-*	*10,000*

All factory overhead variances are written off to cost of goods sold.

Solution

Income Statements

(Based on which bonus was paid)

(Amount in ₹)

	Year 1	**Year 2**
Units Sold	40,000	30,000
Sales @ ₹20 *per unit*	8,00,000	6,00,000

Cost of Sales:		
Variable Cost		
Year 1 : 30,000 @ ₹8	2,40,000	---
Year 2 : 50,000 @ ₹8	---	4,00,000
Fixed Factory Overhead	2,00,000	2,00,000
Cost of Production	4,40,000	6,00,000
Add: Opening Stock		
Year 1 : 10,000 @ ₹13	1,30,000	---
Year 2 : Nil	---	---
Less: Closing Stock:	5,70,000	6,00,000
Year 1 : Nil	---	---
Year 2 : 20,000 @ ₹13	---	2,60,000
Cost of Goods Sold	5,70,000	3,40,000
Add: Selling and Distribution Expenses	1,40,000	1,40,000
Cost of Sales	7,10,000	4,80,000
Income	90,000	1,20,000

In the above statements income in year 2 increased in spite of decrease in sale because fixed overheads have been carried over to next year as part of the value of closing stock in year 2.

The above method of paying bonus to sales manager cannot be considered appropriate. It may be appropriate to pay bonus to production manager. The relevant method for paying bonus to sales manager is the contribution method as shown below:

	Year 1	Year 2
	(₹)	(₹)
Sales	8,00,000	6,00,000
Less: Variable Cost	3,20,000	2,40,000
Contribution	4,80,000	3,60,000
Less: Fixed Cost	3,40,000	3,40,000
Income	1,40,000	20,000

If bonus to sales manager is paid on the contribution method, sales manager cannot get more bonus when sales decline.

SECTION - C

Quantitative Vs Qualitative Factors

Problem-1

Recently, Ministry of Health and Family Welfare along with Drug Control Department have come hard on health care centres for charging exorbitant fees from their patients. Human Health Care Ltd. (HHCL), a leading integrated healthcare delivery provider company is feeling pinch of measures taken by authorities and facing margin pressures due to this. HHCL is operating in a competitive environment so; it's difficult to increase patient numbers also. Management Consultant of the company has come out with some plan for cost control and reduction.

HHCL provides treatment under package system where fees is charged irrespective of days a patient stays in the hospital. Consultant has estimated 2.50 patient days per patient. He wants to reduce it to 2 days. By doing this, consultant has targeted the general variable cost of ₹ 500 per patient day. Annually 15,000 patients visit to the hospital for treatment.

Medical Superintendent has some concerns with that of Consultant's plan. According to him, reducing the patient stay would be detrimental to the full recovery of patient. They would come again for admission thereby increasing current readmission rate from 3% to 5%; it means readmitting 300 additional patients per year. Company has to spend ₹ 25,00,000 more to accommodate this increase in readmission. But Consultant has found bless in disguise in this. He said every readmission is treated as new admission so it would result in additional cash flow of ₹ 4,500 per patient in the form of admission fees.

Required

(i) Calculate the impact of Management Consultant's plan on profit of the company.

(ii) Also comment on result and other factors that should be kept in mind before taking any decision.

Solution

(i) Impact of Management Consultant's Plan on Profit of the HHCL

Human Health Care Ltd.

Statement Showing Cost Benefit Analysis

Particulars	₹
Cost:	
Incremental Cost *due to* Increased Readmission	25,00,000
Benefit:	

Saving in General Variable Cost *due to* Reduction in Patient Days [15,000 Patients × (2.5 Days – 2.0 Days) × ₹500)	37,50,000
Revenue from Increased Readmission (300 Patients × ₹4,500)	13,50,000
Incremental Benefit	26,00,000

(ii) Comment

Primary goal of investor-owned firms is shareholder wealth maximization, which translates to stock price maximization. Management consultant's plan is looking good for the HHCL as there is a positive impact on the profitability of the company (refer Cost Benefit Analysis).

Also HHCL operates in a competitive environment so for its survival, it has to work on plans like above.

But there is also the second side of a coin that cannot also be ignored i.e. humanity values and business ethics. Discharging patients before their full recovery will add discomfort and disruption in their lives which cannot be quantified into money. There could be other severe consequences as well because of this practice. For gaining extra benefits, HHCL cannot play with the life of patients. It would put a question mark on the business ethics of the HHCL.

May be HHCL would able to earn incremental profit due to this practice in *short run* but It will tarnish the image of the HHCL which would hurt profitability in the *long run*.

So, before taking any decision on this plan, HHCL should analyze both *quantitative as well as qualitative factors*.

Cost Classification

Problem-2

Marine Diesel Ltd. (MDL) manufactures and sells Diesel Engine. Company appoints Mr. Philips to coordinate shipments of the Diesel Engine from the factory to distribution warehouses located in various parts of the India so that goods will be available as orders are received from customers. MDL is unsure how to classify his annual salary of ₹6,00,000 in its cost records. The company's cost analyst says that Mr. Philips's salary should be classified as manufacturing cost; the finance controllers says that it should be classified as selling cost; and the managing director says that it does not matter which way Mr. Philips's salary cost is classified.

Required

Which view point is correct and why?

Solution

Selling Costs would include *all costs necessary to secure customer orders and get the finished product into the hands of customers*. The responsibility of Mr. Philips as described in the problem is coordination of shipments of Diesel Engines from the factory to distribution warehouses and same would appear to fall in this class. Accordingly, the finance controller is correct in his view point that the salary cost should be classified as selling cost.

Problem-3

Pick out from each of the following items, costs that can be classified under 'committed fixed costs' or 'discretionary fixed costs".

(i) Annual increase of salary and wages of administrative staff by 5% as per agreement

(ii) New advertisement for existing products is recommended by the Marketing Department for achieving sales quantities that were budgeted for at the beginning of the year.

(iii) Rents paid for the factory premises for the past 6 months and the rents payable for the next six months. Production is going on in the factory.

(iv) Research costs on a product that has reached 'maturity' phase in its life cycle and the research costs which may be needed on introducing a cheaper substitute into the market for facing competition.

(v) Legal consultancy fees payable for patent rights on a new product Patenting rights have been applied for.

Solution

Committed Fixed Cost	Discretionary Fixed Cost
(i) Salary and Wage increase.	(ii) New Advertisement Cost.
(iii) Rents payable for the next 6 months.	(iv) Research Cost for substitutes.
(v) Legal Fees for filing for patent rights.	

Problem-4

State the type of cost in the following cases:

(i) Cost associated with the acquisition and conversion of material into finished product.

(ii) Cost arising from a prior decision which cannot be changed in the short run.

(iii) Increase in cost resulting from selection of one alternative instead of another.

(iv) Rent paid for a factory building which is temporarily closed.

Solution

Cases		Type of Cost
(i)	Cost associated with the acquisition and conversion of material into finished product.	Product Cost
(ii)	Cost arising from a prior decision which cannot be changed in the short run.	Committed Cost
(iii)	Increase in cost resulting from selection of one alternative instead of another.	Differential/ Incremental Cost
(iv)	Rent paid for a factory building which is temporarily closed.	Shut Down Cost

Problem-5

Classify the following fixed cost as normally being either committed or discretionary.

(i) Depreciation on assets
(ii) Advertising
(iii) Research
(iv) Employees Training

Solution

Committed Cost / Discretionary Cost

S. No.	Fixed Costs	Committed / Discretionary
(i)	Depreciation on assets	Committed Cost
(ii)	Advertising	Discretionary Cost
(iii)	Research	Discretionary Cost
(iv)	Employees Training	Discretionary Cost

Problem-6

Identify the type of cost along with the reasons.

(i) An advertising program has been set and management has signed the non negotiable contract for a year with an agency. Under the terms of contract, agency will create 5 advertisements within the contract duration for the company and company will pay ₹12,00,000 for each advertisement.

(ii) A manager has to decide to run a fully automated operation that produces 100,000

widgets per year at a cost of ₹1,200,000, or of using direct labour to manually produce the same number of widgets for ₹1,400,000.

(iii) A Company had paid ₹5,00,000 a Marketing Research company to find expected demand of the newly developed product of the company.

(iv) A company has invested ₹25 lacs in a project. Company could have earned ₹2 lacs by investing the amount in Government securities.

(v) A Oil Refining Co. has paid a salary of ₹20,00,000 to the chairman for a particular year. The Company has sold 25 MT of Oil in that particular year.

(vi) Accountant of a cloth factory paid ₹25,000 for water that has been used for washing clothes before they go for final drying process.

Solution

(i) Committed Cost

Reason: Company cannot negotiate the price of advertisement in future and it has to make payment as soon as advertisement is prepared.

(ii) Differential Cost

Reason: In case of decision making among two alternatives, every manager has to compare the difference in cost involved.

(iii) Sunk Cost

Reason: Research expense has already been incurred and it will not affect any decision making in future.

(iv) Opportunity Cost

Reason: Income from government securities is the amount that company has forgone to earn income from its investment in the project.

(v) Period Cost

Reason: Salary of chairman is paid irrespective of productivity of the company.

(vi) Direct Cost

Reason: Amount paid for water can be directly attributed to the cost of finished product that is clothes.

Problem-7

Buildico, a company that builds houses presents the following facts relating to a certain housing contract that it wishes to undertake:

The CEO's and Marketing Director's food and hotel expenses of ₹ 3,750 were incurred for a meeting with a prospective client.

1,200 kgs of raw material Z will be required for the house. Inventory of Z available is 550 kg. It *was purchased at ₹ 580 per kg. It is used by Buildico in other projects. Its current market price is ₹ 650 per kg. Its resale value is ₹ 350 per kg.*

The house will require 90 hours of engineer's time. The engineers are paid a fixed monthly salary of ₹ 47,500 per engineer who can work 150 hours a month. Spare time is not available now and an engineer has to be hired for this house for one month. He cannot be used in any other project once he does this contract.

Buildico will use a special earthquake proof foundation material. This was developed by Buildico at a cost of ₹ 30,000 for some other project that had to be abandoned. If it does not use it in this project, it can use it in some other project and charge the client ₹ 50,000 for it.

A list of items is given below:

S. No.	***Item***	***Type of Cost***	***Relevant (R)/ Irrelevant (IR)***
1	*Food and hotel expenses ₹ 3,750*		
2. (i)	*Material Z : 550 kg × ₹ 580/kg*		
(ii)	*Material Z : 550 kg × ₹ 650 per kg*		
3. (i)	*Engineer's salary ₹ 47,500*		
(ii)	*Engineer's free time cost* $\frac{60}{150} \times$ *₹ 47,500*		
4. (i)	*Design cost ₹ 30,000*		
(ii)	*Design cost ₹ 50,000*		

Required

Name the type of cost and state whether it is relevant or not in calculating the cost of the given housing project.

Solution

Sl. No.	**Item**	**Type of Cost**	**Relevant / Irrelevant**
1	Food and hotel expenses ₹3,750	Sunk Cost	Irrelevant
2(i)	Material Z: 550 kg × ₹580/kg	Historical Cost / Sunk Cost	Irrelevant
(ii)	Material Z: 550 kg × ₹650 per kg	Replacement Cost	Relevant
3(i)	Engineer’s salary ₹47,500	Period Cost	Relevant
(ii)	Engineer’s free time cost 60/ 150 × ₹47,500	Committed Cost / Unavoidable Cost	Irrelevant
4(i)	Design cost ₹30,000	Sunk Cost	Irrelevant
(ii)	Design cost ₹50,000	Opportunity Cost	Relevant

3 Pricing Decision

Basic Concepts

Competitive Pricing	When a company sets its price mainly on the consideration of what its competitors are charging, its pricing policy under such a situation is called competitive pricing or competition-oriented pricing. Different type of competitive pricing in vogue are as follows: (i) Going Rate Pricing (ii) Sealed Bid Pricing
Cost Plus Pricing	In many businesses the common method of price determining is to estimate the cost of product & fix a margin of profit. The term 'cost' here means full cost at current output and wage levels since these are regarded as most relevant in price determination. In arriving at cost of production, it is necessary to determine the size of the unit whose products are to be cost and priced. In order to frame a pricing policy, one of the elements that should receive consideration is the determination of normal capacity. It has following *advantages:* (i) Fair method (ii) Assured profit (iii) Reduced risks and uncertainties (iv) Considers market factors Cost Plus Pricing has following *disadvantages:* (i) Ignores demand (ii) Ignores competition (iii) Arbitrary cost allocation (iv) Ignores opportunity cost (v) Price-Volume relationships

Distributors' Discounts	It means price deductions that systematically make the net price vary according to buyer's position in the chain of distribution. These discounts are given to various distributors in the trade channel e.g., wholesalers, dealers and retailers.
Freight-Absorption Pricing	Under freight-absorption pricing, a manufacturer will quote to the customer a delivered price equal to its factory price plus the freight costs that would be charged by a competitive seller located near that customer.
Geographic Pricing Strategies	In pricing, a seller must consider the costs of shipping goods to the buyer. These costs grow in importance as freight becomes a larger part of total variable costs. It includes Point of Production Pricing, Uniform Delivered Pricing, Zone-Delivered Pricing and Freight – Absorption Pricing.
Going Rate Pricing	It is a competitive pricing method under which a firm tries to keep its price at the average level charged by the industry.
Historical Pricing*	Basing current prices on prior period prices, perhaps uplifted by a factor such as inflation.
Incremental Pricing	Incremental pricing is used because it involves comparison of the impact of decisions on revenues and cost. If a pricing decision results in a greater increase in revenue than in costs, it is favourable.
Market-Based Pricing*	Setting a price based on the value of the product in the perception of the customer. Also known as perceived value pricing.
Market-Entry Strategies	While preparing to enter the market with a new product, management must decide whether to adopt a skimming or penetration pricing strategy.
Pareto Analysis	Pareto Analysis is a rule that recommends focus on the most important aspects of the decision making in order to simplify the process of decision making. It is based on the 80: 20 rule that was a phenomenon first observed by Vilfredo Pareto, a nineteenth century Italian economist. He noticed that 80% of the wealth of Milan was owned by 20% of its citizens. The management can use it in a number of different circumstances to direct management attention to the key control mechanism or planning aspects.
Penetration Pricing	This policy is in favour of using a low price as the principal instrument for penetrating mass markets early. It is opposite to skimming price. The low price policy is introduced for the sake of long-term survival and profitability and hence it has

	to receive careful consideration before implementation Penetrating pricing, means a pricing suitable for penetrating mass market as quickly as possible through lower price offers. This method is also used for pricing a new product.
Point-of-Production Pricing	In a widely used geographic pricing strategy, the seller quotes the selling price at the point of production and the buyer selects the mode of transportation and pays all freight costs.
Predatory Pricing*	Setting a low selling price in order to damage competitors. May involve dumping, i.e. selling a product in a foreign market at below cost, or below the domestic market price (subject to, for example, adjustments for taxation differences, transportation costs, specification differences).
Premium Pricing*	Achievement of a price above the commodity level, due to a measure of product or service differentiation.
Pricing*	Determination of a selling price for the product or service produced. A number of methodologies may be used.
Price Discrimination	Price discrimination means charging different prices and it takes various forms according to whether the basis is customer, product, place or time.
Price Discrimination on the Basis of Customer	In this case, the same product is charged at different prices to different customers. It is, however, potentially disruptive of customer relations.
Price Discrimination Based on Product Version	In this case, a slightly different product is charged at a different price regardless of its cost-price relationship.
Price Discrimination Based on Place	An example of this method is the seats in cinema theatre where the front seats are charged at lower rates than the back seats.
Price Discrimination Based on Time	An example of this method is the practice of giving off-season concession in sale of fans or refrigerators just after the summer season.
Principles of Product Pricing	Cost should not be considered as an important determinant of price. The tendency should be to lower the price in such a way so as to choose a right combination of price and output to maximise profits. The important determinants of price, therefore, are competitive situations prevailing in the market

	and elasticity. Taking the standard products into consideration, the pricing principles are much the same whether the product is a new one or the one already well established in the market. However the environmental situation and information base are different.
Pricing Strategies	Pricing strategy is defined as a broad plan of action by which an organisation intends to reach its goal. Some illustrative strategies are: (i) Expanding product lines that enjoy substantial brand equity (ii) Offer quantity discounts to achieve increase in sales volume.
Quantity Discounts	Quantity discounts are price reductions related to the quantities purchased. It may take several forms. It may be related to the size of the order which is being measured in terms of physical units of a particular commodity.
Rate of Return Pricing	Determination of return on capital employed is one of the most crucial aspects of price fixation process. In this process instead of arbitrarily adding a percentage on cost for profit, the firm determines an average mark up on cost necessary to produce a desired rate of return on its investment.
Role of Pricing Policy	The pricing policy plays an important role in a business because the long run survival of a business depends upon the firm's ability to increase its sales and device the maximum profit from the existing and new capital investment. Although cost is an important aspect of pricing, consumer demand and competitive environment are frequently far more significant in pricing decisions. Thus costs alone do not determine prices. Cost is only one of the many complex factors which determine prices. There must however, be some margin in prices over total cost if capital is to be unimpaired and production maximised by the utilisation of internal surplus.
Selective Pricing*	Setting different prices for the same product or service in different markets. Can be broken down as follows: (i) Category Pricing: Cosmetically modifying a product such that the variations allow it to sell in a number of price categories, as where a range of "brands" are based on a common product. (ii) Customer Group Pricing: Modifying the price of a product or service so that different groups of consumers pay different prices.

	(iii) Peak Pricing: Setting a price which varies according to level of demand. (iv) Service Level Pricing: Setting a price based on the particular level of service chosen from a range. (v) Time Material Pricing: A form of cost-plus pricing in which price is determined by reference to the cost of the labour and material inputs to the product/ service.
Sealed Bid-Pricing	The bid is the firms offer price, and it is a prime example of pricing based on expectations of how competitors will price rather than on a rigid relation based on the concern's own costs or demand.
Skimming Pricing	It is a policy of high prices during the early period of a product's existence. This can be synchronised with high promotional expenditure and in the later years the prices can be gradually reduced.
Uniform Delivered Pricing	Under uniform delivered pricing, the same delivered price is quoted to all buyers regardless of their locations.
Usefulness of Pareto Analysis	Pareto analysis is useful to: (i) Prioritize problems, goals, and objectives Identify root causes. (ii) Select and define key quality improvement programs Select key customer relations and service programs Select key employee relations improvement programs. (iii) Select and define key performance improvement programs Maximize research and product development time. (iv) Verify operating procedures and manufacturing processes. (v) Product or services sales and distribution. (vi) Allocate physical, financial and human resources.
Variable Cost Pricing	Variable Costs which are considered as relevant costs and are used for pricing, by adding a mark up to include fixed costs allocation also.
Zone-Delivered Pricing	Zone-delivered pricing divides a seller's market into a limited number of broad geographic zones and then sets a uniform delivered price for each zone.

(*)Source - CIMA's Official Terminology

SECTION - A

Pricing Policy/ Strategy

Question-1

Explain the concept of cost plus pricing. What are its advantages and disadvantages?

Answer

Cost *plus* Pricing: The most common method of price fixing in a business is to arrive at full cost, add a margin of profit and then set the selling price. During the world wars, the concept of cost plus pricing became very much prevalent, as most of the defence contracts were priced at full cost plus a pre-agreed quantum of profit. In cost plus pricing, the capacity utilisation of the concern has an important bearing and unless the same is considered on a realistic basis the determination of cost would get vitiated.

The advantages and disadvantages of cost plus pricing are as under:

Advantages

(i) It is a fair method and recovery of full costs is assured under it.

(ii) It leaves out scope for any uncertainty.

(iii) After arriving at full cost, the profit percentage can be flexibly adjusted to take care of market competition.

Disadvantages

(i) Covering full cost all the time may ignore the competition.

(ii) It can lead to a distorted price fixation unless the cost is determined in a scientific manner.

(iii) It ignores the concepts of Marginal Costing, Incremental Costing etc.

(iv) It is difficult to predetermine capacity utilization.

Question-2

Describe two pricing practices in which non-cost reasons are important, when setting prices.

Answer

Two pricing practices in which non-cost reasons are important when setting price are:

(i) **Price Discrimination:** This is the practice of charging to some customers a higher price than that charged to other customers e.g. Airlines tickets for business travellers and LTC travellers are priced differently.

(ii) **Peak Load Pricing:** This pricing system is based on capacity constraints. Under this pricing system a higher price for the same service or product is demanded when it approaches physical capacity limits e.g. telephones, tele-communication, hotel, car rental and electric utility industries are charged higher price at their peak load.

Question-3

Briefly explain skimming pricing and penetration pricing policies with examples.

Answer

Skimming Pricing

Policy of highly pricing a product at the entry level into the market and reducing it later.

For example: Electronic goods, mobile phone, Flat, TVs, etc.

It is used when market is price insensitive, demand inelastic or to recover high promotional costs.

Penetration Pricing

Policy of entering the market with a low price, then establishing the product and then increasing the price.

This is also used by companies with established markets, when products are in any stage of their life cycle, to avoid competition. This is also known as "stay-out pricing".

For example: Entry of a new model small segment car into the market.

Question-4

Explain Skimming pricing strategy.

Answer

Skimming Pricing

It is a policy where the prices are kept high during the early period of a product's existence. This can be synchronised with high promotional expenditure and in the latter years the prices can be gradually reduced. The reasons for following such a policy are as follows:

(i) The demand is likely to be inelastic in the earlier stages till the product is established in the market.

(ii) The gradual reduction in price in the latter years will tend to increase the sales.

(iii) This method is preferred in the beginning because in the initial periods when the demand for the product is not known the price covers the initial cost of production.

(iv) High initial capital outlays needed for manufacture, results in high cost of production. In addition to this, the producer has to incur huge promotional activities resulting in increased costs. High initial prices will be able to finance the cost of production particularly when uncertainties block the usual sources of capital.

Question-5

What is Penetration pricing? What are the circumstances in which this policy can be adopted?

Answer

Penetration Pricing: This pricing policy is in favour of using a low price as the principal instrument for penetrating mass markets early. It is opposite to skimming pricing. The low pricing policy is introduced for the sake of long-term survival and profitability and hence it has to receive careful consideration before implementation. It needs an analysis of the scope for market expansion and hence considerable amount of research and forecasting are necessary before determining the price.

Penetration pricing means a price suitable for penetrating mass market as quickly as possible through lower price offers. This method is also used for pricing a new product. In order to popularize a new product penetrating pricing policy is used initially. The company may not earn profit by resorting to this policy during the initial stage. Later on, the price may be increased as and when the demand picks up. Penetrating pricing policy can also be adopted at any stage of the product life cycle for products whose market is approached with low initial price. The use of this policy by the existing concerns will discourage the new concerns to enter the market. This pricing policy is also known as “stay-out-pricing”.

Circumstances for Adoption

The three circumstances in which penetrating pricing policy can be adopted are as under:

(i) When demand of the product is elastic to price. In other words, the demand of the product increases when price is low.

(ii) When there are substantial savings on large-scale production, here increase in demand is sustained by the adoption of low pricing policy.

(iii) When there is threat of competition. The prices fixed at a low level act as an entry barrier to the prospective competitions.

Question-6

What is Price Discrimination? Under what circumstances it is possible?

Answer

Price discrimination is charging different prices with respect to customers, products, places and time.

It is possible when-

(i) The market being capable of being segmented.

(ii) The customers are not able to resell the product at a higher price.

(iii) The competitors' underselling is not possible.

Question-7

List out the qualities required for a good pricing policy.

Answer

The pricing policy plays an important role in a business because the long run survival of a business depends upon the firm's ability to increase its sales and device the maximum profit from the existing and new capital investment. Although cost is an important aspect of pricing, consumer demand and competitive environment are frequently far more significant in pricing decisions. The pricing policy structure should:

(i) provide an incentive to producer for adopting improved technology and maximising production;

(ii) encourage optimum utilisation of resources;

(iii) work towards better balance between demand and supply;

(iv) promote exports; and

(v) avoid adverse effects on the rest of the economy.

Pareto Analysis

Question-8

What is Pareto Analysis? Name some applications.

Answer

Vilfredo Pareto, an Italian economist, observed that about 70 – 80% of value was represented by 30 – 20% of volume. This observation was found to exist in many business solutions.

Analysing and focusing on the 80% value relating to 20% volume helps business in the following areas.

(i) Pricing of a Product (in a Multi-Product Company)

(ii) Customer Profitability

(iii) Stock Control

(iv) Activity Based Costing (20% Cost Drivers are responsible for 80% of Total Cost)

(v) Quality Control

Question-9

Enumerate the uses of Pareto Analysis.

Answer

Pareto analysis is useful to:

(i) Prioritize problems, goals and objectives.

(ii) Identify the root causes.

(iii) Select and define the key quality improvement programs, key employee relations improvement programs etc.

(iv) Verify the operating procedures and manufacturing processes.

(v) Allocate physical, financial and human resources effectively.

(vi) Maximise research and product development time.

Question-10

How Pareto analysis is helpful in pricing of product in the case of firm dealing with multi-products?

Answer

In the case of firm dealing with multi products, it would not be possible for it to analyse price-volume relationship for all of them. Pareto Analysis is used for analysing the firm's estimated sales revenue from various products and it might indicate that approximately 80% of its total sales revenue is earned from about 20% of its products. Such analysis helps the top management to delegate the pricing decision for approximately 80% of its products to the lower level of management, thus freeing them to concentrate on the pricing decisions for products approximately 20% of which is essential for the company's survival. Thus, a firm can adopt more sophisticated pricing methods for small proportion of products that jointly account for 80% of total sales revenue. For the remaining 80% products, which account for 20% of the total sales value the firm may use cost based pricing method.

Question-11

What are the applications of Pareto Analysis in customer profitability analysis?

Answer

Customer Profitability Analysis identifies customer service activities and cost drivers. It also determines profitability of each customer or group of customers. Pareto Analysis i.e. the rule of 80 : 20 identified by the Vilfredo Pareto is also applied for the better analysis of the customers behavior and profitability. Pareto Analysis helps to group the customers into 20% high revenue generating customers and 80% low revenue customer group. Based on this proposition the Pareto Analysis can be applied in customer profitability analysis in the following manner:

(i) Identify most profitable customers.

(ii) Manage each customer's costs-to-serve.

(iii) Discontinue unprofitable customer segment.

(iv) Shift a customer's purchase mix towards higher- margin products and service lines.

(v) Offer discounts to attract profitable customers.

(vi) Choose types of after sale services to provide.

SECTION - B

Cost – Plus / Mark-up Pricing

Problem-1

Technocraft has just completed repair work on Car No. DL 7CL 2001 of Mr. 'M'. The parts used to repair the vehicle cost ₹250. The company's 20% mark up rate on parts covers parts–related overhead costs. Labour involved 5 hours of time from a Technocraft service engineer whose wages are ₹80 per hour. The current overhead work up rate on labour is 80%.

Required

Compute how much Mr. 'M' will be billed for his car repairs?

Solution

Computation of the Billing Amount

	(₹)
Repairs - Parts used	250
Overhead Charges (20% of ₹250)	50
Labour Charges (5 hours @ ₹80 per hour)	400
Overhead Charges (80% of ₹400)	320
Total Billing Amount	1,020

Problem-2

Computer Tec a manufacturing firm, has entered into an agreement of strategic alliance with Comp Inc. of United States of America for the manufacture of Super Computers in India. Broadly, the terms of agreement are:

(i) Comp Inc. will provide Computer Tec with kits in a dismantled condition. These will be used in the manufacture of the Super Computer in India. On a value basis, the supply, in terms of the FOB price will be 50% thereof.

(ii) Computer Tec will procure the balance of materials in India.

(iii) Comp Inc will provide to Computer Tec with designs and drawings in regard to the materials and supplies to be procured in India. For this, Computer Tec will pay Comp Inc. a technology fee of ₹ 8 crores.

(iv) *Comp Inc. will also be entitled total royalty at 10% of the selling price of the computers fixed for sales in India as reduced by the cost of standard items procured in India and also the cost of imported kits from Comp Inc.*

(v) *Computer Tec will furnish to Comp Inc. detailed quarterly returns.*

Other information available:

(a) *FOB price agreed $2,040. Exchange rate to be adopted $1 = ₹ 55.00*

(b) *Insurance and freight – ₹ 2,000 per imported kit;*

(c) *Customs duty leviable is 200% of the CIF prices; but as a concession, the actual rate leviable has been fixed at 40% of CIF.*

(d) *The technology agreement expires with the production of 8,00,000 computers;*

(e) *The quoted price on kits includes a 25% margin of profits on cost to Comp Inc.*

(f) *The estimated cost of materials and supplies to be obtained in India will be 150% of the cost of supplies made by Comp Inc.*

(g) *50% of the value in rupees of the locally procured goods represent cost of the standard items.*

(h) *Cost of assembly and other overheads in India will be ₹ 8,000 per Super Computer.*

Required

Calculate the selling price, of a personal computer in India bearing in mind that Computer Tec Ltd has targeted a profit of 20% to itself on the selling price.

Note: In making calculations, the final sum may be rounded to the next rupees.

Solution

Statement Showing "Selling Price of a Super Computer in India"

	(₹)
A. Landed Cost of a Dismantled Kit (Refer to Working Note: 4)	81,340
B. Cost of Local Procurement (Refer to Working Note: 3)	67,320
C. Cost of Assembly and Other Overheads *per computer*	8,000
D. Total Cost of Manufacture (A + B + C)	1,56,660
E. Technology Fee *per computer* (₹ 8,00,00,000 / 8,00,000 Computer)	100
F. Royalty Payment *per unit* (Refer to Working Note: 6)	9,251
G. Total Cost (D + E+ F)	166,011
H. Profit (20% on Selling Price of 25% of Total Cost)	41,503
I. Selling Price *per computer*	207,514

Working Notes

1. **FOB Price of Dismantled Kit:**

FOB Price of Dismantled Kit	\$2,040
FOB Price of dismantled Kit [\$2,040 × ₹55]	₹1,12,200

2. **Cost of a Dismantled Kit to Comp Inc.:**

It is given that Quoted Price on Kits includes a 25% Margin on Profits.

Cost of Dismantled Kit to Comp Inc. (100 / 125 × ₹1,12,200)	₹89,760

3. **Cost of Local Procurements:**

150% of the Supplies made by Comp Inc. (150% × ₹89,760 × 50%)	₹67,320

*Being 50% of Cost of a Dismantled Kit to Comp Inc.

4. **Landed Cost of a Dismantled Kit:**

	(₹)
FOB Price (50% × ₹1,12,200) (Refer to Working Note-1)	56,100
Add: Insurance & Freight	2,000
CIF Price	58,100
Add: Customs Duty (40% × ₹58,100)	23,240
Landed Cost of a Dismantled Kit	81,340

5. **Cost of the Standard Items Procured Locally:**

50% of the Cost of locally procured Goods (50% × ₹67, 320)	₹33, 660

6. **Royalty Payment *per computer*:**

Let X = Selling Price *per unit of Super Computer*

Y = Royalty Paid *per computer*

Since 20% is the Margin of Profit on Selling Price. It means Margin of 25% on Cost Price.

Therefore we have

X = 1.25 × (₹81,340 + ₹67,320 + ₹8,000 + ₹100 + Y)

Y = 10% × {X – (₹33,660 + ₹81,340)}

On solving the above equations we get:

X = ₹2,07,514 (Approx)

Y = ₹9,251(Approx)

Problem-3

RST Ltd. is specialists in the manufacture of sports goods. They manufacture croquet mallets but purchase the wooden balls, iron arches and stakes required to complete a croquet set.

Mallets consist of a head and handle. Handles use 2.5 board feet per handle at ₹ 50 per board foot. Spoilage loss is negligible for the manufacture of handles. Heads frequently split and create considerable scrap.

A head requires 0.40 board feet of high quality lumber costing ₹ 60 per board foot. Spoilage normally works out to 20% of the completed heads. 4% of the spoiled heads can be salvaged and sold as scrap at ₹ 10 per spoiled head.

In the department machining and assembling the mallets, 6 men work 8 hours per day for 25 days in a month. Each worker can machine and assemble 12 mallets per uninterrupted 40 minutes time frame. In each 8 hours working day, 15 minutes are allowed for coffee-break, 8 minutes on an average for training and 9 minutes for supervisory instructions. Besides 10% of each day is booked as idle time to cover checking in and checking out changing operations, getting materials and other miscellaneous matters. Workers are paid at a comprehensive rate of ₹ 6 per hour.

The department is geared to produce 20,000 mallets per month and the monthly expenses of the department are as under:

	(₹)
Finishing and painting of the mallets……………………	*20,000*
Lubricating oil for cutting machines…………………………..	*600*
Depreciation for cutting machine……………………………..	*1,400*
Repairs and maintenance……………………………………..	*200*
Power to run the machines……………………………………	*400*
Plant Manager's salary……………………………………..	*9,400*
Other overheads allocated to the department………......	*60,000*

Required

As the mallets are machined and assembled in lots of 250, prepare a total cost sheet for one lot and advise the management on the selling price to be fixed per mallet in order to ensure a minimum 33.33% margin on the selling price.

Solution

RST Ltd.
Cost Sheet of One Lot of 250 Croquet Mallets

Computation of Total Cost:	(₹)
Direct Material	
Handles (2.5 feet × 250 units × ₹50)	31,250
Heads (1.20 × 250 × 0.40 × ₹60) [W.N.-1]	7,200
Less: Scrap Recovery (4% × 50 × ₹10)	(20)
Direct Labour (8Hrs × ₹6 × 250 / 120) [W.N.-2]	100
Prime Cost	38,530
Factory & Other Overheads	
Variable, Finishing & Painting (20,000 × 250 / 20,000) [W.N.-3]	250
Fixed (₹72,000 × 250 / 18,000) [W.N.-4]	1,000
Total Cost	39,780
Price Quotation:	(₹)
Cost *per mallet* (₹39,780 / 250 Units)	159.12
Add: Profit (50% on Cost)	79.56
Selling Price	238.68

Working Notes

1. Since 20% of completed heads are spoiled, output of 1 unit requires input of 1.20 units (1 + 0.20); so, total heads processed, 300 (1.20 × 250), of which spoiled heads are 50.

2. Total Time *in a day* (8 × 60) 480 minutes

Less: Idle Time		48 minutes	
	Coffee Break	15 minutes	
	Instructions	9 minutes	
Training	8 minutes	80 minutes	
Productive Time *per day*:			400 minutes

Therefore, mallets to be produced per man per day, 120 units (400/40 × 12).

Since mallets are produced at the rate of 120 mallets per man day, so total monthly production will be18,000 mallets (120 units × 6 men × 25 days).

3. Finishing and painting overheads are assumed to be variable for the production of 20,000 mallets.

4. All the other expenses are fixed and are to be absorbed by 18,000 (120 units × 6 men × 25 Days) mallets of monthly production.

Problem-4

A Japanese soft drink company is planning to establish a subsidiary company in India to produce mineral water. Based on the estimated annual sales of 40,000 bottles of the mineral water, cost studies produced the following estimates for the Indian subsidiary:

	Total Annual Costs (₹)	*Percentage of Total Annual Cost which is Variable*
Material	*2,10,000*	*100%*
Labour	*1,50,000*	*80%*
Factory Overheads	*92,000*	*60%*
Administrative Overheads	*40,000*	*35%*

The Indian production will be sold by manufacturer's representatives who will receive a commission of 8% of the sale price. No portion of the Japanese office expenses is to be allocated to the Indian subsidiary.

Required

(i) Compute the sale price per bottle to enable the management to realise an estimated 10% profit on sale proceeds in India.

(ii) Calculate the break-even point in Rupee sales and also in number of bottles for the Indian subsidiary on the assumption that the sale price is ₹ 14 per bottle.

Solution

(i) Computation of Sale Price *Per Bottle*

Output: 40,000 Bottles

	(₹)
Variable Cost:	
Material	2,10,000
Labour (₹1,50,000 × 80%)	1,20,000

Factory Overheads (₹92,000 × 60%)	55,200
Administrative Overheads (₹40,000 × 35%)	14,000
Commission (8% on ₹6,00,000) (W.N.-1)	48,000
Fixed Cost:	
Labour (₹1,50,000 × 20%)	30,000
Factory Overheads (₹92,000 × 40%)	36,800
Administrative Overheads (₹40,000 × 65%)	26,000
Total Cost	5,40,000
Profit (W.N.-1)	60,000
Sales Proceeds (W.N.-1)	6,00,000
Sales Price *per bottle* $\left(\frac{₹6,00,000}{40,000 \text{ Bottles}}\right)$	15

(ii) Calculation of Break-even Point

Sales Price per Bottle = ₹14

Variable Cost per Bottle = $\frac{₹4,44,000 \text{ (W.N.-2)}}{40,000 \text{ Bottles}}$

= ₹11.10

Contribution per Bottle = ₹14 − ₹11.10

= ₹2.90

Break -even Point (in number of Bottles) = $\frac{\text{Fixed Costs}}{\text{Contribution per Bottle}}$

= $\frac{₹92,800}{₹2.90}$ = 32,000 Bottles

Break- even Point (in Sales Value) = 32,000 Bottles × ₹14

= ₹4,48,000

Working Note

W.N.-1

Let the Sales Price be ‘x’

Commission = $\frac{8x}{100}$

Profit = $\frac{10x}{100}$

$$x = 4{,}92{,}000 + \frac{8x}{100} + \frac{10x}{100}$$

$$100x - 8x - 10x = 4{,}92{,}00{,}000$$

$$82x = 4{,}92{,}00{,}000$$

$$x = 4{,}92{,}00{,}000 / 82$$

$$= ₹6{,}00{,}000$$

W.N.-2

Total Variable Cost

	(₹)
Material	2,10,000
Labour	1,20,000
Factory Overheads	55,200
Administrative Overheads	14,000
Commission [(40,000 Bottles × ₹14) × 8%]	44,800
Total	4,44,000

Problem-5

A manufacturing company has an installed capacity of 1,20,000 units per annum. The cost structure of the product manufactured is as under:

(i) *Variable cost per unit-*

Materials…………………………………………………………..₹ 8

Labour (subject to a minimum of ₹ 56,000 per month)….………₹ 8

Overheads……………………………………………………..…₹ 3

(ii) *Fixed overheads………………………… ₹ 1,68,750 per annum*

(iii) *Semi-variable overheads ₹ 48,000 per annum at 60% capacity, which increase by ₹ 6,000 per annum for increase of every 10% of the capacity utilisation or any part thereof for the year as a whole.*

The capacity utilisation for the next year is estimated at 60% for two months, 75% for six months and 80% for remaining part of the year.

Required

If the company is planning to have a profit of 25% on the selling price, calculate the selling price per unit. Assume that there are no opening and closing stocks.

Solution

Statement Showing "Selling Price and Profit"

	(₹)
Material (89,000 units × ₹8) (W.N.-1)	7,12,000
Labour Cost (W.N.-2)	7,28,000
Variable Overhead (89,000 units × ₹3)	2,67,000
Semi Variable Overhead (W.N.-3)	60,000
Fixed Overheads	1,68,750
Total Cost	19,35,750
Add: Profit (25% of Selling Price or 33⅓ on Cost)	6,45,250
Total Sales Value	25,81,000
Selling Price *per unit* (₹25,81,000 / 89,000 units)	29

Working Notes

W.N.-1

Computation of Capacity Utilisation (for the next year):	(units)
60% of Capacity for first two months (2 months × 6,000 units)	12,000
75% of Capacity for next six months (6 months × 7,500 units)	45,000
80% of Capacity for the remaining four months (4 months × 8,000 units)	32,000
Total Capacity Utilization	89,000

W.N.-2

Computation of Labour Cost (Subject to a minimum of ₹ 56,000 p.m.):

	(₹)
Labour Cost of first two months (12,000 units × ₹8)	96,000
However Minimum is (₹56,000 × 2)	1,12,000
Labour Cost of next six months (45,000 units × ₹8)	3,60,000
Labour Cost of last four months (32,000 units × ₹ 8)	2,56,000
Total Labour Cost	7,28,000

W.N.-3

Computation of Semi-Variable Overheads *per annum*:

	(₹)
Semi-Variable Overheads (at 60% Capacity)	48,000
Semi-Variable Overheads for Additional 14.16% (74.16% − 60.00%) Capacity are the same as that for 20% of the Capacity Utilisation for the entire year	12,000
	60,000

Return on Investment Pricing

Problem-6

The cost of production and sales of 80,000 units per annum of product Q are:

Material	*₹ 4,80,000*	*Labour*	*₹ 1,60,000*
Variable Overhead	*₹ 3,20,000*	*Fixed overhead*	*₹ 5,00,000*

The fixed portion of capital employed is ₹12 lacs and the varying portion is 50% of sales turnover.

Required:

Determine the selling price per unit to earn a return of 12% net on capital employed (net of Tax @ 40%).

Solution

Return of 12% Net (after tax of 40%) on Capital Employed is equivalent to 20% (Gross) [12% ÷ (1 – 0.4)] on Capital Employed.

Let Selling Price *per unit* to be 'K'

	Since Total Sales	=	Total Cost + Profit
	80,000 K	=	14,60,000 + 20% (12,00,000 + 0.5 × 80,000K)
Or,	80,000 K	=	14,60,000 + 2,40,000 + 8,000K
Or,	72,000 K	=	17,00,000
Or,	'K'	=	$\frac{17,00,000}{72,000}$
		=	₹23.61

Hence Selling Price *per unit* will be ₹23.61.

Problem-7

A company produces a single product 'Impex'.

For an annual sales of 40,000 units of Irnpex, fixed overhead is ₹ 5,50,000. The variable cost per unit is ₹ 60. Capital employed in fixed assets is ₹ 8,00,000 and in current assets is 50% of net sales (i.e. sales less discount). The company sells goods at 20% discount on the maximum retail price (M.R.P.), which is ₹ X per unit. The company wants to earn a return of 25% before tax on capital employed in fixed and current assets.

Required

Calculate the value of X.

Solution

Maximum Retail Price is ₹ X *per unit*.

Selling Price Net of Discount (i.e. 20%) = ₹ 0.80X

Statement Showing "Total Cost, Return on Capital Employed and Sales"

	Amount (₹)
Variable Cost (₹60 × 40,000 units)	24,00,000
Add: Fixed Overhead	5,50,000
Total Cost ...(i)	29,50,000
Fixed Assets (25% of ₹8,00,000)	2,00,000
Current Assets {25% of (0.5 × 40,000 units × 0.80X)}	4,000 X
Return on Capital Employed ...(ii)	2,00,000 + 4,000 X
Total Sales Net of Discount (₹0.8X × 40,000 units) ...(iii)	32,000 X

Hence, Total Sales = Total Cost + Return on Capital Employed

$\Rightarrow$ 32,000 X = 29,50,000 + 2,00,000 + 4,000 X [From (i), (ii) and (iii)]

$\Rightarrow$ 32,000 X – 4,000 X = 31,50,000

$\Rightarrow$ 28,000 X = 31,50,000

$$\Rightarrow X = \frac{₹\ 31,50,000}{28,000}$$

$\Rightarrow$ = ₹112.50

Problem-8

Excel Ltd. specialises in the manufacture of Printers. They have recently developed a technology to design a new Printer. They are quite confident of selling all of the 4,000 units *that they would be making in a year. The capital equipment that would be required will cost ₹ 12.5 lakhs. It will have an economic life of 4 years and no significant terminal salvage value.*

During each of the first four years promotional expenses are planned as under:

	Year 1	***Year 2***	***Year 3***	***Year 4***
Advertisement (₹)	*50,000*	*50,000*	*30,000*	*15,000*
Other expenses (₹)	*25,000*	*25,000*	*45,000*	*60,000*

Variable costs of producing and selling the unit would be ₹ 125 per unit.

Additional fixed operating costs incurred because of this new product are budgeted at ₹ 37,500 per year.

The company's profit goals call for a discounted rate of return of 15% after taxes on investments on new products. The income tax rate on an average works out to 30%. You can assume that the straight line method of depreciation will be used for tax and reporting.

Present value of annuity of ₹ 1 received or paid in a steady stream throughout 4 years in the future at 15% is 2.854.

Required

Work out an initial selling price per unit of the product that may be fixed for obtaining the desired rate of return on investment.

Solution

Determination of Initial Selling Price

Let the Selling Price be ₹K

Sales Value: ₹4,000K

Annual Cash Cost	**(₹)**
Variable Cost (4,000 units × ₹125)	5,00,000
Advertisement and Other Expenses	75,000
Additional Fixed Costs	37,500
Total Cash Cost	6,12,500

Depreciation *per annum* (₹12,50,000 / 4) = ₹3,12,500

Profit for Taxation = 4,000 × ₹K − (₹6,12,500 + ₹3,12,500)

= ₹4,000K − ₹9,25,000

Tax at 30% on Profit = 30% of {₹4,000K − ₹9,25,000}

= ₹1,200K − ₹2,77,500

Total Annual Cash Outflow	=	₹6,12,500 + (₹1,200K – ₹2,77,500)
	=	₹1,200K + ₹3,35,000
Net Annual Cash Inflow	=	₹4,000K – (₹1,200K + ₹3,35,000)
	=	₹2,800K – ₹3,35,000
Now, Present Value of Initial Cash Outflow	=	Present Value of Cash Inflow
Or, ₹12,50,000	=	(₹2,800K – ₹3,35,000) × 2.854
Or, K	=	₹276.06

Hence Selling Price should be ₹276.06 *per unit.*

Pricing of New Product / Services

Problem-9

Hind Metals Manufactures an alloy product 'Incop' by using Iron and Copper. The metals pass through two plants, X and Y. The company gives you the following details for the manufacture of one unit of Incop:

Materials……………………………….	*Iron: 10 kgs @ ₹ 5 per kg.*
	Copper: 5 kg @ ₹ 8 per kg.
Wages……………………………………	*3 hours @ ₹ 15 per hour in Plant X*
	5 hours @ ₹ 12 per hour in Plant Y
Overhead recovery……………………..	*On the basis of direct labour hours*
Fixed overhead…………………………	*₹ 8 per hour in Plant X*
	₹ 5 per hour in Plant Y
Variable overhead……………………....	*₹ 8 per hour in Plant X*
	₹ 5 per hour in Plant Y
Selling overhead (fully variable)………	*₹ 20 per unit*

Required

(i) *Find out the minimum selling price to be fixed for the alloy, when the alloy is new to the market. Briefly explain this pricing strategy.*

(ii) *After the alloy is well established in the market. What should be the minimum selling price? Why?*

Solution

Workings

Statement Showing "Total Cost"

(₹ per unit of alloy)

Materials		
Iron (10kg @ ₹5/-)	50	
Copper (5kg @ ₹8/-)	40	90
Wages		
X (3 hrs @ 15 ₹/hr.)	45	
Y (5 hrs @ 12 ₹/hr.)	60	105
Variable Overheads (Production)		
X (₹8 × 3 hrs)	24	
Y (₹5 × 5 hrs)	25	49
Variable Overhead – Selling		20
Total Variable Cost		264
Fixed Overhead		
X (₹8 × 3 hrs)	24	
Y (₹5 × 5 hrs)	25	49
Total Cost		313

(i) If pricing strategy is to penetrate the market, the *minimum price* for a new product should be the variable cost i.e. ₹264/-. In some circumstances, it can also be sold below the variable cost, if it is expected to quickly penetrate the market and later absorb a price increase. Total variable cost is the penetration price.

(ii) When the alloy is well established, the minimum selling price will be the total cost – including the fixed cost i.e. ₹ 313 per unit. Long run costs should cover at least the total cost.

Problem-10

R.T. Ltd, want to fix proper selling prices for their products 'A' and 'B' which they are newly introducing in the market. Both these products will be manufactured in Department D which is considered as a Profit Centre.

The estimated data are as under:

	A	*B*
Annual Production (Units)	*1,00,000*	*2,00,000*
Direct Materials per unit	*₹ 15.00*	*₹ 14.00*
Direct Labour per unit (Direct Labour Hour Rate ₹ 3)	*₹ 9.00*	*₹ 6.00*

The proportion of Overheads other than interest, chargeable to the two products are as under:

Factory Overheads (50% Fixed) 100% of Direct Wages, Administration Overheads (100% Fixed) 10% of Factory Cost, Selling and Distribution Overheads (50% Variable) ₹ 3 and ₹ 4 respectively per unit of products A and B.

The fixed capital investment in the Department is ₹ 50 Lakhs. The working capital requirement is equivalent to 6 months stocks of cost of sales of both the products. For this project a term loan amounting to ₹ 40 lakhs has been obtained from Financial Institutions at an interest rate of 14% per annum. 50% of the working capital needs are met by Bank Borrowing carrying interest at 18% per annum. The Department is expected to give a return of 20% on its capital employed.

Required

(a) Fix the selling prices of products A and B such that the contribution per direct labour hour is the same for both the products;

(b) Prepare a statement showing in detail the over-all profit that would be made by the Department.

Solution

(a) Statement Showing "Fixation of the Selling Price of Products A and B"

	Products		
	A	**B**	**Total**
Sales (units) ...(A)	1,00,000	2,00,000	
	(₹)	(₹)	(₹)
Contribution (W.N.-5) ...(B)	19,26,429	25,68,571	44,95,000
Variable Cost (W.N.-2) ...(C)	30,00,000	50,00,000	80,00,000
Sales Value ...(D) = (B) + (C)	49,26,429	75,68,571	1,24,95,000
Selling Price per unit ...(D) /(A)	49.26	37.84	
Direct Labour Hours (W.N.-6) ...(E)	3,00,000 hrs.	4,00,000 hrs.	
Contribution per Labour Hr. …(B) / (E)	6.42	6.42	

(b) **Statement Showing "Overall Profit"**

	Products		
	A	B	Total
Contribution (W.N.-5)	19,26,429	25,68,571	44,95,000
Less: Fixed Costs			
Factory Overheads	4,50,000	6,00,000	10,50,000
Administration Overheads	3,30,000	5,20,000	8,50,000
Selling & Dist. Overheads	1,50,000	4,00,000	5,50,000
Interest on Term Loan (₹40,00,000 × 14%)			5,60,000
Interest on Working Capital (₹52,25,000 × 0.5 × 18%)			4,70,250
Profit			10,14,750

Working Notes

1. Statement of Variable Cost and Total Cost *per unit* for each Product

Particulars	A		B	
	Total Cost	Variable Cost	Total Cost	Variable Cost
Direct Materials	15.00	15.00	14.00	14.00
Direct Labour	9.00	9.00	6.00	6.00
Factory Overheads	9.00	4.50	6.00	3.00
Total Factory Cost	33.00	28.50	26.00	23.00
Adm. Overheads	3.30	---	2.60	---
Selling & Distribution Overheads	3.00	1.50	4.00	2.00
Total	39.30	30.00	32.60	25.00

2. Statement of Total Variable Costs and Total Costs

	Variable Costs (₹)	Total Cost (₹)
Product A - 1,00,000 units	30,00,000	39,30,000
Product B - 2,00,000 units	50,00,000	65,20,000
Total	80,00,000	1,04,50,000

3. Computation of Capital Employed

	(₹)
Fixed Capital	50,00,000
Working Capital (6 months Cost of Sales, i.e. ½ of ₹1,04,50,000 as per W.N.-2 above)	52,25,000
Total Capital Employed	1,02,25,000

4. Expected Return on Capital Employed at 20%

$$\frac{₹1,02,25,000 \times 20}{100} = ₹20,45,000$$

5. Computation of Sales Value and Contribution

	(₹)
Total Cost (W.N.-2)	1,04,50,000
Add: Expected Returned	20,45,000
Sales Value	1,24,95,000
Less: Variable Costs (W.N.-2)	80,00,000
Contribution	44,95,000

Contribution for Product A $= \text{Total Contribution} \times \frac{\text{Direct Labour Hrs. for Product A}}{\text{Total Direct Labour Hrs.}}$

$= ₹44,95,000 \times \frac{3,00,000\text{ hrs}}{7,00,000\text{ hrs}}$

$= ₹19,26,429$

Contribution for Product B $= \text{Total Contribution} \times \frac{\text{Direct Labour Hrs. for Product B}}{\text{Total Direct Labour Hrs.}}$

$= ₹44,95,000 \times \frac{4,00,000\text{ hrs}}{7,00,000\text{ hrs}}$

$= ₹25,68,571$

6. Total Labour Hours

Product A (1,00,000 units × 3 hrs)	3,00,000
Product B (2,00,000 units × 2 hrs)	4,00,000
Total Direct Labour Hours	7,00,000

Problem-11

Sunny Ltd. has developed a new product which is about to be launched into the market. The variable cost of selling the product is ₹ 17 per unit. The marketing department has estimated that at a sale price of ₹ 25, annual demand would be 10,000 units. However, if the sale price is set above ₹ 25, sales demand would fall by 500 units for each ₹ 0.50 increase above ₹ 25. Similarly, if the price is below ₹ 25, demand would increase by 500 units for each ₹ 0.50 stepped reduction in price below ₹ 25.

Required

Determine the price which would maximise Sunny Ltd.'s profit in the next year.

Solution

Statement of Total Contribution

Sales Price p.u. (₹)	Variable Cost p.u. (₹)	Contribution p.u. (₹)	Sales Volume (units) (₹)	Total Contribution (₹)
(1)	(2)	(3) = (1) − (2)	(4)	(5) = (3) × (4)
25.00	17.00	8.00	10,000	80,000
24.50	17.00	7.50	10,500	78,750
24.00	17.00	7.00	11,000	77,000
25.50	17.00	8.50	9,500	80,750
26.00	17.00	9.00	9,000	81,000
27.00	17.00	10.00	8,000	80,000
27.50	17.00	10.50	7,500	78,750

From the above statement it is quite apparent that the contribution would be maximum at a sale price of ₹26 per unit and sales demand of 9,000 units.

Problem-12

Genie Carpets Associates have just developed a new carpet design with the brand name 'Arabian Nights'. Sales demand is very difficult to predict but it very must depends upon the selling price. At a price of ₹ 30 per square metre it is estimated that the annual sales demand would be between 50,000 and 90,000 sq. Metres per annum. At a price of ₹ 40 per sq. metre, sales demand would be between 34,000 and 44,000 sq. metres per annum. As regards cost, at production volumes of 45,000 sq. metres or less per annum, attributable fixed costs would be ₹ 2,12,000 per annum and variable costs would be ₹ 32 per sq. metre. At higher *production volumes, attributable fixed costs would increase to ₹ 3,08,000 but variable costs per sq. metre would be only ₹ 24.*

'Arabian Nights' has been developed at a cost of ₹ 80,000.

When the product is marketed, an amount of ₹ 70,000 per annum will be charged to the operation towards Head Office Expenses.

The production of the new carpet will have to be supervised by a foreman. In order to find time for supervision he has to give up work in another department, for which he is paid a salary of ₹ 1,000 per month.

The production of 'Arabian Nights' would be undertaken, of course, in a division of the factory which is at present rented out to M/s S&R Ltd., Umbrella – makers for an amount of ₹ 10,000 per quarter.

Required

Calculate the margin of safety, as a percentage of expected sales volume at both the maximum and minimum sales volume for the two price levels and decide on the selling price per sq. metre.

Solution

Working Notes

(i) Relevant Total Fixed Costs

	At a Price of ₹ 30 *per sq. mt.* (₹)	**At a Price of ₹ 40 *per sq. mt.* (₹)**
Attributed Fixed Costs	3,08,000	2,12,000
Foreman's Salary	12,000	12,000
Rent Foregone (Opportunity Cost)	40,000	40,000
Total Fixed Cost	3,60,000	2,64,000

(ii) Contribution *per sq. metre* ₹6 ₹8

(iii) Profit or Loss at Minimum Sales Volume

Minimum Sales Volume (Sq. Metres)	50,000	34,000
Total Contribution at above volume (₹)	3,00,000	2,72,000
Less: Total Fixed Costs (₹)	3,60,000	2,64,000
Profit / (Loss)	(60,000)	8,000

(iv) Profit or Loss at Maximum Sales Volume

Maximum Sales Volume (Sq. Metres)	90,000	44,000
Total Contribution (₹)	5,40,000	3,52,000
Less: Total Fixed Costs (₹)	3,60,000	2,64,000
Profit	1,80,000	88,000

(v) Break-even Sq. Metres $\frac{₹3,60,000}{₹6}$ $\frac{₹2,64,000}{₹8}$

60,000 Sq. mts. 33,000 Sq. mts.

Margin of Safety

At Minimum Sales Volume	Nil (Loss)	2.94% $\left(\frac{34,000\text{ Sq.Mtr.} - 33,000\text{ Sq.Mtr.}}{34,000\text{ Sq.Mtr.}} \times 100\right)$
At Maximum Sales Volume	33.33% $\left(\frac{90,000\text{ Sq.Mtr.} - 60,000\text{ Sq.Mtr.}}{90,000\text{ Sq.Mtr.}} \times 100\right)$	25.00% $\left(\frac{44,000\text{ Sq.Mtr.} - 33,000\text{ Sq.Mtr.}}{44,000\text{ Sq.Mtr.}} \times 100\right)$

Selling Price

At a price of ₹40 per sq. metre, there is possibility of earnings profit at both the minimum and maximum level of sales. Hence, this price should be adopted. However at the maximum and intermediate volumes (beyond 74,667 sq. mts.) profits will be higher at a price of ₹30 per sq. mt. Therefore, the price of ₹30 per sq. mt. should be preferred, assuming that at this price sales would be above 74,667 sq. mts. when the profit at ₹30 will be equal to the profit from maximum sales volume at ₹40 per sq. mt.

Pricing – Different Scenario

Problem-13

6,000 pen drives of 2 GB to be sold in a perfectly competitive market to earn ₹ 1,06,000 profit, whereas in a monopoly market only 1,200 units are required to be sold to earn the same profit. The fixed costs for the period are ₹ 74,000. The contribution per unit in the monopoly market is as high as three fourths its variable cost.

Required

Determine the targets selling price per unit under each market condition.

Solution

	Perfect Competition	Monopoly
Units	6,000	1,200
Contribution (₹1,06,000 + ₹74,000)	1,80,000	1,80,000
Contribution *per unit*	30	150
Variable Cost *per unit* $\left(₹150 \times \frac{4}{3}\right)$	---	200
Variable Cost *per unit*	200	---
Selling Price *per unit*	230	350

Problem-14

An organisation manufactures a product, particulars of which are detailed below:

Annual Production (Units)	*20,000*
Cost per annum (₹)	
Material	*50,000*
Other variable cost	*60,000*
Fixed cost	*40,000*
Apportioned Investment (₹)	*1,50,000*

Required

Determine the unit selling price under two strategies mentioned below. Assume that the organisation's Tax rate is 40%—

(a) 20% return on investment.

(b) 6% profit on list sales, when trade discount is 40%.

Solution

(a) Selling Price to Yield 20% Return on Investment

Investment (₹)	1,50,000
After Tax Required ROI 20% (₹)	30,000
Tax Rate	40%
After Tax Profit	60%

Pre Tax Profit - Return [(30,000 ÷ 60) × 100] (₹)	50,000
Sales (₹1,50,000 + ₹50,000) (₹)	2,00,000
Number of units Produced	20,000
Selling Price *per unit* (₹2,00,000 ÷ 20,000 units)	₹10

(b) Selling Price to Yield 6% Profit on List Price

Let 'K' be the List Sales

$$\{\text{List Sales } (1 - \text{Trade Discount}) - \text{Cost}\}\ (1 - \text{Tax Rate}) = 0.06K$$

$$\{K\ (1 - 0.40) - 1{,}50{,}000\}\ (1 - 0.40) = 0.06K$$

$$\{0.60\ K - 1{,}50{,}000\}\ 0.6 = 0.06K$$

$$0.30\ K = 90{,}000$$

$$K = ₹3{,}00{,}000$$

List Sales Price *per unit* is ₹15 $\left(\frac{₹3{,}00{,}000}{20{,}000\ \text{units}}\right)$.

Net Selling Price *per unit* is ₹9 (₹15 – 40% of 15).

Problem-15

LMV Limited manufactures product Z in departments A and B which also manufacture other products using same plant and machinery. The information of product Z is as follows:

Items	***Department A (₹)***	***Department B (₹)***
Direct Material per unit	*30*	*25*
Direct Labour per unit (₹ 10 per hour)	*30*	*40*
Overhead Rates:		
Fixed	*8 per hour*	*4 per hour*
Variable	*6 per hour*	*3 per hour*
Value of Plant and Machinery	*25 lakhs*	*15 lakhs*

Overheads are recovered on the basis of direct labour hours. Variable selling and distribution overheads relating to product Z are amounting to ₹ 30, 000 per month. The product requires a working capital of ₹ 4, 00,000 at the target volume of 1,500 units per month occupying 30 per cent of practical capacity.

Required

(i) To calculate the price of product Z to yield a contribution to cover 21 percent rate of return on investment.

(ii) Set the minimum selling price of the product if (1) the product is well established in the market; (2) the product is first time launched in the market.

Solution

(i) **Statement Showing "Computation of Variable Cost"**

		(₹)	(₹)
Direct Material	Deptt. A---	30	
	Deptt. B---	25	55
Direct Labour	Deptt. A---	30	
	Deptt. B---	40	70
Variable Overhead	Deptt. A (3 hrs × ₹6)---	18	
	Deptt B (4 hrs × ₹3)---	12	30
Variable Selling and Distribution Overhead	(₹30,000 / 1,500 units)		20
Total Variable Cost *per unit*			175

Total Hours Required for a Target of 1,500 units of Product Z:

Deptt. A (1,500 units × 3hrs)		4,500 hrs
Deptt. B (1,500 units × 4hrs)		6,000 hrs
		10,500 hrs
10,500 hrs represent 30% Capacity		
So Total Capacity *per month* (10,500 hrs. / 0.30)	=	35,000 hrs
Yearly Capacity (35,000 hrs. × 12 months)	=	4,20,000 hrs
Fixed Capital Employed *in both departments* (25 Lakhs + 15 Lakhs)	=	₹40.00 Lakhs
Expected Return (0.21 × ₹40,00,000)	=	₹8,40,000
Contribution *per hour* (₹8,40,000 / 4,20,000 hrs)	=	₹2.00 *per hour*
Return on Working Capital (0.21 × ₹4,00,000)	=	₹84,000
Contribution *per unit* (₹84,000 / 18,000 units)	=	₹4.67 *per unit*
Total Contribution Required		
To Cover Fixed Cost (3 hrs of A and 4 hrs of B @ 2 per hr)	=	₹14.00
To Working Capital	=	₹ 4.67
		₹18.67

Fixed Charges Recovery is based on usage. Full Capacity is not being used by Product Z and Departments are also producing other Products using same Plant and Machinery.

Price of Product is ₹193.67 per unit [Variable Cost (₹175) + Contribution Required (₹18.67)].

(ii) Price of Product when product is *well established in market*:

Variable Cost	₹175
Fixed Cost (₹24 + ₹16)	₹40
Total price	₹215

The Product is *first time launched in the market*, and then Variable Cost ₹175 should form the basis for Price Fixation.

Problem-16

A shoe manufacturer has a net profit of ₹ 25 per pair on a selling price of ₹143. He is producing 6,000 pairs per annum which is 60% of the potential capacity. The cost per pair is as under:

	₹
Direct Materials	*35.00*
Direct Wages	*12.50*
Works Overheads (50% fixed)	*62.50*
Administrative Overheads (75% fixed)	*6.00*

During the current year the manufacturer also estimates demand of 6,000 pairs but anticipates that the fixed charges to go up by 10% while the rate of direct labour and direct materials will increase by 8% and 6% respectively. But he has no option of increasing the selling price. Under this situation he obtains an offer to utilise further 20% of capacity. What minimum price will you recommend to ensure an overall profit of ₹1,67,300?

Solution

Computation of Profitability at 6,000 Pairs Activity

	Existing Price Level Amount (₹)	**Revised Price Level Amount (₹)**
Selling Price *per pair*	143.00	143.00
Variable Costs:		
Direct Materials	35.00	37.10

		(₹35 × 1.06)
Direct Wages	12.50	13.50 (₹12.5 × 1.08)
Works Overhead (50% of ₹62.50)	31.25	31.25
Administration Overhead (25% of ₹6)	1.50	1.50
Total Variable Cost *per pair*	80.25	83.35
Contribution *per pair*	62.75	59.65
Total Contribution ...(A)	3,76,500	3,57,900
Fixed Costs		
Works Overhead (6,000 pairs × ₹31.25)	1,87,500	2,06,250 (₹1,87,500 × 1.1)
Administration Overhead (6,000 pairs × ₹4.50)	27,000	29,700 (₹27,000 × 1.1)
Other Fixed Overheads *	12,000	13,200 (₹12,000 × 1.1)
Total Fixed Costs ...(B)	2,26,500	2,49,150
Profit ...(A) – (B)	1,50,000	1,08,750
Desired Profit	---	1,67,300
Additional Profit(₹1,67,300-₹1,08,750)	---	58,550
Additional Offer $\left(\frac{6,000}{60\%}\times 20\%\right)$		2,000 Pairs
Profit *per pair*		29.275

(*)

Other Fixed Overhead = Contribution – Profit – (Fixed Works Overheads + Fixed Administrative Overheads)

Selling Price *per pair* = Variable Cost *per pair* + Profit *per pair*

= ₹83.35 + ₹29.275

= ₹112.625 or ₹112.63

Therefore, minimum selling price per pair for the additional offer shall be ₹112.63

☞

Selling price is ₹143 per pair and net profit is ₹25 per pair, hence, total cost per pair at the existing level should be ₹118 (₹143 – ₹25). However, the total cost per pair given is ₹116. It is assumed that balance ₹2 per pair (₹118 – ₹116) is **Other Fixed Overheads**. This problem can also be solved by assuming difference of ₹2 as **Other Variable Costs** with an anticipation that it will not change in the revised situation.

Problem-17

The Board of Directors XY Company Limited are considering a new type of handy sewing machine which their R & D Department has developed. The expenditure so far on research has been ₹ 95,000 and a consultant's report has been prepared at a cost of ₹ 22,500. The report provides the following information:

Cost of production per unit:

	₹
Material……………………………………………………………………………	*45.00*
Labour…………………………………………………………………………..	*75.00*
Fixed overheads (Based on Company's normal allocation rates)………...	*20.00*

Anticipated additional fixed costs:

	₹
Rent for additional space ……………………………………	*₹ 1,25,000 per annum*
Other additional fixed costs ………………………………..	*₹ 70,000 per annum*

A new machine will be built with the available facilities with a cost of ₹ 1,10,000 (material ₹90,000 and labour ₹ 20,000). The materials are readily available in stores which are regularly used. However, these are to be replenished immediately. The price of these materials have since been increased by 50%. Scrap value of the machine at the end of the 10th year is estimated at ₹ 20,000. The product scraps generated can be disposed off at the end of year 10 for a price of ₹ 1,43,000.

Years 1-5		***Years 6-10***	
Demand (Unit)	***Probability***	***Demand***	***Probability***
40,000	*0.15*	*24,000*	*0.30*
20,000	*0.60*	*16,000*	*0.50*
12,000	*0.25*	*4,000*	*0.20*

It is estimated that the commercial life of the machine will be no longer than 10 years and the after tax cost of capital is 10%. The full cost of the machine will be depreciated on straight line basis, which is allowed for computing the taxable income, over a period of 10 years. Tax rate is 30%.

DCF factors at 10%:	
1 - 5 years (cumulative)	*3.79*
6 - 10 years (cumulative)	*2.355*
10th year	*0.386*

Required

Compute minimum selling price for the handy sewing machine.

Solution

(i) Expected Sales Volume

Years 1-5: (40,000 x 0.15 + 20,000 x 0.60 + 12,000 x 0.25) = 21,000 units

Years 6-10: (24,000 x 0.30 + 16,000 x 0.50 + 4,000 x 0.20) = 16,000 units

(ii) Capital Cost

	₹
Materials (₹ 90,000 x 1.50)	1,35,000
Labour (Replacement cost)	20,000
Overheads (Not Relevant)	---
	1,55,000

(iii) Production Variable Cost

	₹
Materials	45
Labour	75
Overheads (Not relevant)	---
Total	120

(iv) Profitability

Details	**Years 1-5**	**Years 6-10**
Sales Units	21,000	16,000
Selling Price(₹)	X	X
Sales Value (₹) …[A]	21,000X	16,000X
Material and Labour Cost @ ₹120	25,20,000	19,20,000
Incremental Fixed Cost (₹)	1,95,000	1,95,000
Depreciation (1,55,000/10)	15,500	15,500
Total Cost (₹) …[B]	27,30,500	21,30,500
Profit (₹) …[A-B]	21,000X – 27,30,500	16,000X– 21,30,500
Less: Tax @ 30%	6,300X – 8,19,150	4,800X – 6,39,150

Profit After Tax	14,700X – 19,11,350	11,200X – 14,91,350
Add: Depreciation	15,500	15,500
Cash Inflow	14,700X – 18,95,850	11,200X – 14,75,850

(v) Cash Inflow in the Terminal Year (year 10)

	₹
Sale Value of the Machine	20,000
Scrap Realization	143,000
Total	163,000
Tax @ 30%	(48,900)
After Tax Cash Inflow	114,100

(vi) Present Value of Cash Flows

Details	Year 0	Year 1-5	Year 6-10	Year 10
Capital Cost	1,55,000	–	–	–
Cash Flow from Operation	–	14,700X – 18,95,850	11,200X – 14,75,850	–
Cash Flow Terminal Year	–	–	–	1,14,100
Discount Factor	1	3.79	2.355	0.386
Present Value of Cash Flows	-1,55,000	55,713X – 71,85,271.50	26,376X – 34,75,626.70	44,042.6

(vii) Net Cash Inflows

= (-1,55,000) + (55,713X – 71,85,271.50) + (26,376X – 34,75,626.70) + (44,042.60)

= 82,089X – 1,07,71,855.60

(viii) Computation of Minimum Selling Price

For determining Minimum Selling Price, Net Cash Inflows should be equal to zero:

82,089X – 1,07,71,855.60 = 0

Or X = 131.22

Minimum selling price is ₹131.22

Note

(a) R&D expenses of ₹ 95,000 is not relevant.

(b) Fee for consultant's report of ₹ 22,500 is not relevant.

(c) Tax element on irrelevant costs not considered, since the benefit will arise even without this product.

Pareto Analysis

Problem-18

Generation 2050 Technologies Ltd. develops cutting-edge innovations that are powering the next revolution in mobility and has nine tablet smart phone models currently in the market whose previous year financial data is given below:

Model	*Sales (₹'000)*	*Profit-Volume (PV) Ratio*
Tab - A001	*5,100*	*3.53%*
Tab - B002	*3,000*	*23.00%*
Tab - C003	*2,100*	*14.29%*
Tab - D004	*1,800*	*14.17%*
Tab - E005	*1,050*	*41.43%*
Tab - F006	*750*	*26.00%*
Tab - G007	*450*	*26.67%*
Tab - H008	*225*	*6.67%*
Tab - I009	*75*	*60.00%*

Required

(i) *Using the financial data, carry out a Pareto analysis (80/20 rule) of Sales and Contribution.*

(ii) *Discuss your findings with appropriate recommendations.*

Solution

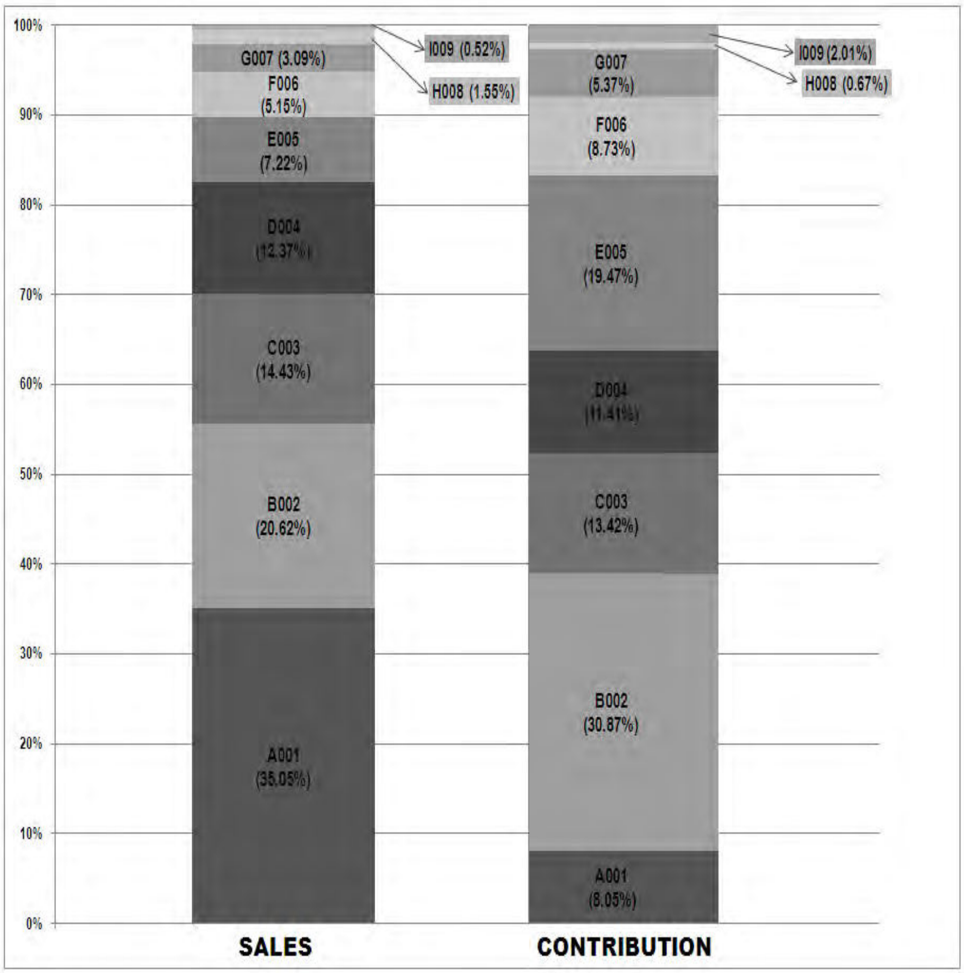
Statement Showing "Pareto Analysis"

Model	Sales (₹'000)	% of Total Sales	Cumulative Total	Model	Cont. (₹'000)	% of Total Cont.	Cumulative Total %
Pareto Analysis Sales				**Pareto Analysis Contribution**			
A001	5,100	35.05%	35.05%	B002	690	30.87%	30.87%
B002	3,000	20.62%	55.67%	E005	435	19.47%*	50.34%
C003	2,100	14.43%	70.10%	C003	300	13.42%	63.76%
D004	1,800	12.37%	82.47%	D004	255	11.41%	75.17%
E005	1,050	7.22%	89.69%	F006	195	8.73%*	83.90%
F006	750	5.15%	94.84%	A001	180	8.05%	91.95%
G007	450	3.09%	97.93%	G007	120	5.37%	97.32%

H008	225	1.55%	99.48%	I009	45	2.01%	99.33%
I009	75	0.52%	100.00%	H008	15	0.67%	100.00%
	14,550	100.00%			2,235	100.00%	

(*) *Rounding - off difference adjusted.*

Diagram Showing "Sales and Contribution"



☞

This Diagram is shown for **better understanding** of the concept.

Recommendations

Pareto Analysis is a rule that recommends focus on most important aspects of the decision making in order to simplify the process of decision making. The very purpose of this analysis is to direct attention and efforts of management to the product or area where best returns can be achieved by taking appropriate actions.

Pareto Analysis is based on the 80/20 rule which implies that 20% of the products account for 80% of the revenue. But this is not the fixed percentage rule; in general business sense it means that a few of the products, goods or customers may make up most of the value for the firm.

In present case, five models namely A001, B002, C003, D004 account for 80% of total sales where as 80% of the company's contribution is derived from models B002, E005, C003, D004 and F006.

Models B002 and E005 together account for 50.34% of total contribution but having only 27.84% share in total sales. So, these two models are the key models and should be the top priority of management. Boths C003 and D004 are among the models giving 80% of total contribution as well as 80% of total sales so; they can also be clubbed with B002 and E005 as key models. Management of the company should allocate maximum resources to these four models.

Model F006 features among the models giving 80%of total contribution with relatively lower share in total sales. Management should focus on its promotional activities.

Model A001 accounts for 35.05% of total sales with only 8.05% share in total contribution. Company should review its pricing structure to enhance its contribution.

Models G007, H008 and I009 have lower share in both total sales as well as contribution. Company can delegate the pricing decision of these models to the lower levels of management, thus freeing themselves to focus on the pricing decisions for key models.

SECTION - C

Pricing Policy/ Strategy

Problem-1

Rapid Heal Tech Ltd. (RHTL) is a leading IT security solutions and ISO 9001 certified company. The solutions are well integrated systems that simplify IT security management across the length and depth of devices and on multiple platforms. RHTL has recently developed an Antivirus Software and company expects to have life cycle of less than one year. It was decided that it would be appropriate to adopt a market skimming pricing policy for the launch of the product. This Software is currently in the Introduction stage of its life cycle and is generating significant unit profits.

Required

(i) Explain, with reasons, the changes, if any, to the unit selling price that could occur when the Software moves from the Introduction stageto Growth stage of its life cycle.

(ii) Also suggest necessary strategies at this stage.

Solution

Following acceptance by early innovators, conventional consumers start following their lead. New competitors are likely to now enter the market attracted by the opportunities for large scale production and profit. RHTL may wish to discourage competitors from entering the market by lowering the price and thereby lowering the unit profitability. The price needs to be lowered so that the product becomes attractive to different market segments thus increasing demand to achieve the growth in sales volume.

Strategies at this stage may include the following

(i) Improving quality and adding new features such as Data Theft Protection, Parental Control, Web Protection, Improved Scan Engine, Anti Spyware, Anti Malware etc.

(ii) Sourcing new market segments/ distribution channels.

(iii) Changing marketing strategy to increase demand.

(iv) Lowering price to attract price-sensitive buyers.

Problem-2

State the appropriate pricing policy in each of the following independent situations:

(i) 'A' is a new product for the company and the market and meant for large scale production and long term survival in the market. Demand is expected to be elastic.

(ii) 'B' is a new product for the company, but not for the market. B's success is crucial for the company's survival in the long term.

(iii) 'C' is a new product to the company and the market. It has an inelastic market. There needs to be an assured profit to cover high initial costs and the usual sources of capital have uncertainties blocking them.

(iv) 'D' is a perishable item, with more than 80% of its shelf life over.

Solution

Situation		Appropriate Pricing Policy
(i)	'A' is a new product for the company and the market and meant for large scale production and long term survival in the market. Demand is expected to be elastic.	Penetration Pricing
(ii)	'B' is a new product for the company, but not for the market. B's success is crucial for the company's survival in the long term.	Market Price or Price Just Below Market Price
(iii)	'C' is a new product to the company and the market. It has an inelastic market. There needs to be an assured profit to cover high initial costs and the unusual sources of capital have uncertainties blocking them.	Skimming Pricing
(iv)	'D' is a perishable item, with more than 80% of its shelf life over.	Any Cash Realizable Value*

(*) this amount decreases every passing day.

Problem-3

State the most appropriate pricing policy to be adopted in the following independent situations:

(i) Modern patented drug entering the market.

(ii) The latest version of a mobile phone is being launched by an established, financially strong company.

(iii) An established company has recently entered the stationery market segment and launched good quality paper for printing at home and office.

(iv) A car manufacturer is launching an innovative, technologically advanced car in the highly priced segment.

Solution

Situation		Appropriate Pricing Policy
(i)	Modern patented drug entering the market.	Skimming Pricing
(ii)	The latest version of a mobile phone is being launched by an established, financially strong company.	Penetration Pricing
(iii)	An established company has recently entered the stationery market segment and launched good quality paper for printing at home and office.	Market Price
(iv)	A car manufacturer is launching an innovative, technologically advanced car in the highly priced segment.	Skimming Pricing

4 Budget & Budgetary Control

Basic Concepts

Budget*	Quantitative expression of a plan for a defined period of time. It may include planned sales volumes and revenues; resource quantities, costs and expenses; assets, liabilities and cash flows.
Budget Centre*	Section of an entity for which control may be exercised through prepared budgets. It is often a responsibility centre where the manager has authority over, and responsibility for, defined costs and (possibly) revenues.
Budgetary Control*	Master budget, devolved to responsibility centres, allows continuous monitoring of actual results versus budget, either to secure by individual action the budget objectives or to provide a basis for budget revision.
Budget Manual*	Detailed set of guidelines and information about the budget process typically including a calendar of budgetary events, specimen budget forms, a statement of budgetary objectives and desired results, listing of budgetary activities and budget assumptions regarding, for example, inflation and interest rates.
Budget Period*	Period for which a budget is prepared and used, which may then be subdivided into control periods.
Budgetary Planning	Budgetary planning is mainly concerned with preparing the short to medium term plan of the organisation. An organization's annual budget is considered as an intermediary step towards achieving the strategic plan.
Budget Purposes*	Budgets may help in authorising expenditure, communicating objectives and plans, controlling operations, co-ordinating activities, evaluating performance, planning and rewarding performance. Often, reward systems involve comparison of actual with budgeted performance.

Budget Cost Allowance*	Calculated after an accounting period, the cost allowance reflects the actual level of output achieved. Variable costs are flexed in proportion to volume achieved and fixed costs are based on the annual budget.
Bottom-Up Budgeting / Participative Budgeting*	Budgeting process where all budget holders have the opportunity to participate in setting their own budgets.
Cash Budget*	Detailed budget of estimated cash inflows and outflows incorporating both revenue and capital items.
Continuous Budget*	Budget continuously updated by adding a further accounting period (month or quarter) when the earliest accounting period has expired. Its use is particularly beneficial where future costs and / or activities cannot be forecast accurately.
Departmental / Functional Budget*	Budget of income and / or expenditure applicable to a particular function frequently including sales budget, production cost budget (based on budget production, efficiency and utilisation), purchasing budget, human resources budget, marketing budget, and research and development budget.
Fixed Budget*	Budget set prior to the control period and not subsequently changed in response to changes in activity, costs or revenues. It may serve as a benchmark in performance evaluation.
Flexible Budget*	Flexing variable costs from original budgeted levels to the allowances permitted for actual volume achieved while maintaining fixed costs at original budget levels. (Variable cost allowance = Ratio of actual volume achieved to budget volume × original budget variable cost)
Full Capacity*	Output achievable if sales orders, supplies, workforce, for example, were all available.
Line Item, Budget*	Traditional form of budget layout showing, line by line, the costs of a cost centre analysed by their nature (for example salaries, occupancy, maintenance).
Master Budget*	Consolidates all subsidiary budgets and is normally comprised of the budgeted profit and loss account, balance sheet and cash flow statement.
Negotiated Budget*	Budget in which budget allowances are set largely on the basis of negotiations between budget holders and those to whom they report.

Normal Capacity*	Measure of the long-run average level of capacity that may be expected. This is often used in setting the budgeted fixed overhead absorption rate (giving it stability over time, although budgeted fixed overhead volume variances may be produced as a consequence).
Operating Budget*	Budget of the revenues and expenses expected in a forthcoming accounting period.
Operational Planning	It concerns with the short-term or day-to-day planning process. It plans the utilisation of resources and will be carried out within the framework of the budget.
Performance Budgeting	A performance budget is one which presents the purposes and objectives for which funds are required, the costs of the programmes proposed for achieving those objectives, and quantities data measuring the accomplishments and work performed under each programme. Thus it is a technique of presenting budgets for costs and revenues in terms of functions.
Practical Capacity*	Full capacity less an allowance for known, unavoidable volume losses.
Principal Budget Factor*	Principal budget factor limits the activities of an undertaking. Identification of the principal budget factor is often the starting point in the budget setting process. Often the principal budget factor will be sales demand but it could be production capacity or material supply.
Strategic Planning	Strategic planning is concerned with preparing long-term action plans to attain the organization's objectives by considering the changes at horizon.
Top-Down Budgeting*	Budgeting process where budget allowances are set without permitting ultimate budget holders the opportunity to participate in the process.
Zero-Based Budgeting*	Method of budgeting that requires all costs to be specifically justified by the benefits expected.

(*) Source- CIMA's Official Terminology

Formulae

Efficiency Ratio	= (Standard Hours ÷ Actual Hours) × 100
Activity Ratio	= (Standard Hours ÷ Budgeted Hours) × 100
Calendar Ratio	= (Available Working Days ÷ Budgeted Working Days) × 100
Standard Capacity Usage Ratio	= (Budgeted Hours ÷ Max. Possible Hours in the Budgeted Period) × 100
Actual Capacity Usage Ratio	= (Actual Hours Worked ÷ Maximum Possible Working Hours in a Period) × 100
Actual Usage of Budgeted Capacity Ratio	= (Actual Working Hours ÷ Budgeted Hours) × 100
Maximum Capacity	= Maximum No. of Days in a Period x No. of Workers *Or* Maximum No. of Hours x No. of Workers *Or* [The maximum no. of units that can be produced by a manufacturing facility in a certain period]
Practical Capacity	= Maximum Capacity – Sundays, Holidays, Normal Maintenance & Idle Time
Normal Capacity	= Average of Past 3 Year's Normal Performance *excluding* Abnormal Data
Principal Budget Factor	= Factor that Limits the Activities of the Functional Budgets of the Organization.

SECTION - A

Zero Based Budgeting (ZBB)

Question-1

What are the advantages and limitations of Zero Based Budgeting (ZBB)?

Answer

Advantage of ZBB

(i) It provides a systematic approach for evaluation of different activities and ranks them in order of preference for allocation of scare resource.

(ii) It ensures that the various functions undertaken by the organisation are critical for the achievement of its objectives and are being performed in the best way.

(iii) It provides an opportunity to the management to allocate resources for various activities only after having a thorough cost-benefit analysis.

(iv) The area of wasteful expenditure can be easily identified and eliminated.

(v) Departmental budgets are closely linked with corporate objectives.

(vi) The technique can also be used for the introduction and implementation of the system of 'management by objective'.

Limitations of ZBB

(i) Various operational problems are likely to be faced in implementing the technique.

(ii) The full support of top management is required.

(iii) It is time consuming as well as costly.

(iv) It requires proper trained managerial staff.

Question-2

What are the steps involved in Zero Based Budgeting?

Answer

Steps involved in the process of Zero Based Budgeting

(i) Determination of a set of objects is the pre-requisite and essential step in the direction of ZBB technique.

(ii) Deciding about the extent to which the technique of ZBB is to be applied whether in all areas of organization activities or only in few selected areas on trial basis.

(iii) Identify the areas where decisions are required to be taken.

(iv) Developing decision packages and ranking them in order of performance.

(v) Preparation of budget that is translating decision packages into practicable units/items and allocating financial resources.

ZBB is simply an extension of the cost, benefit analysis method to the area of corporate planning and budgeting.

Miscellaneous

Question-3

What do you mean by a flexible budget? Give an example of an industry where this type of budget is typically needed?

Answer

A flexible budget is a budget which, by recognizing the difference between fixed, semi-variable and variable costs, is designed to change in relation to the level of activity attained.
Examples- Seasonal products – e.g. soft drink industry, Industries in make to order business like ship building, Industries influenced by change in fashion, Industries which keep on introducing new products / new designs.

Question-4

Define the following:

(i) Maximum Capacity (theoretical capacity)

(ii) Practical Capacity

(iii) Normal Capacity

(iv) Principal Budget Factor

(The first three relate to a manufacturing plant)

Answer

(i) Maximum Capacity = Maximum No. of Days in a Period × No. of Workers or

Maximum No. of Hours × No. of Workers or

[The maximum no. of units that can be produced by a manufacturing facility in a certain period]

(ii)	Practical Capacity	=	Maximum Capacity – Sundays, Holidays, Normal Maintenance & Idle Time
(iii)	Normal Capacity	=	Average of Past 3 Year's Normal Performance *excluding* Abnormal Data
(iv)	Principal Budget Factor	=	Factor that Limits the Activities of the Functional Budgets of the Organization.

SECTION - B

Fixed and Flexible Budgets

Problem-1

The PLN Co. presents the following static budgets for 4,000 units and 6,000 units activity levels for October 2013:

	Activity Level	
	4,000 units	***6,000 units***
Overhead A ₹12/hr. x 2 hr. / unit	*96,000*	*1,44,000*
Overhead B	*1,40,000*	*1,90,000*

Overhead C was omitted to be listed out. It is a fixed plant overhead, estimated at ₹12.5/hr. at 4,000 units activity level. This has to also feature in the flexible budget. The actual production was 5,000 units and 9,600 hours were needed for production.

Required

Present the flexible budget amount of each overhead to enable appropriate comparison with the actual figures.

Solution

Statement Showing "Flexible Budget for 5,000 units Activity Level"

Particulars	**Amount (₹)**
Overhead A (₹12.00 *per hour* × 2 hrs. *per unit* × 5,000 units)	1,20,000
Overhead B* (₹ 40,000 + ₹ 25 × 5,000 units)	1,65,000
Overhead C (₹ 12.50 *per hour* × 2 hrs. *per unit* × 4,000 units)	1,00,000
Total	3,85,000

Working Note (*):

Overhead B

Variable Cost (per unit) = $\frac{\text{Change in Overhead Cost}}{\text{Change in Production Units}}$

$$= \frac{₹\,1,90,000 - ₹\,1,40,000}{6,000\text{ units} - 4,000\text{ units}}$$

$$= \frac{₹50,000}{2,000\text{units}}$$

= ₹ 25

Fixed Cost = ₹1,40,000 – 4,000 units × ₹ 25

= ₹ 40,000

Problem-2

Tricon Co. has prepared the following statement for the month of April 2015.

Particulars	*Budget Details*	*Static Budget*	*Actual*
Units produced & Sold		*4,000*	*3,200*
		₹	*₹*
Direct Materials	*3 kg p.u. @ ₹ 15 per kg.*	*1,80,000*	*1,55,000*
Direct Labour	*1 hr. p.u. @ ₹ 36 per hour*	*1,44,000*	*1,12,800*
Variable Overhead	*1 hr. p.u. @ ₹ 22 per hour*	*88,000*	*73,600*
Fixed Overhead		*90,000*	*84,000*
Total Cost		*5,02,000*	*4,25,400*
Sales		*6,00,000*	*4,48,000*
Profit		*98,000*	*22,600*

During the month 10,000 kg. of materials and 3,100 direct labour hours were utilized.

Required

(i) Prepare a flexible budget for the month.

(ii) Determine the material usage variance and the direct labour rate variance for the actual Vs the flexible budget.

Solution

(i) Statement Showing "Flexible Budget for 3,200 units Activity Level"

Particulars	Amount (₹)
Sales $\left(\frac{₹\,6,00,000}{4,000\text{ units}} \times 3,200\text{ units}\right)$	4,80,000
Less: Variable Cost	

Direct Material (3,200 units × 3 kg. per unit × ₹15 per kg.)	1,44,000
Direct Labour (3,200 units × 1 hr. per unit × ₹36 per hr.)	1,15,200
Variable Overhead (3,200 units × 1 hr. per unit × ₹22 per hr.)	70,400
Contribution	1,50,400
Less: Fixed Overhead	90,000
Profit	60,400

(ii) Computation of Variances

Material Usage Variance = Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity

= (SQ × SP) – (AQ × SP)

Or

= (SQ – AQ) × SP

= [(3,200 units × 3 kg.) – 10,000 kg.] × ₹15.00

= ₹6,000(A)

Labour Rate Variance = Standard Cost of Actual Time – Actual Cost

= (SR × AH) – (AR × AH)

Or

= (SR – AR) × AH

$$= \left[\left(₹\,36 - \frac{₹\,1,12,800}{3,100\,\text{hrs.}}\right) \times 3,100\,\text{hrs.}\right]$$

= ₹1,200 (A)

Problem-3

Satjuj Motors Ltd. had prepared fixed and flexible budget for the financial year 2013-14 as under:

	Fixed Budget for full capacity ***(₹)***	***Flexible Budget for 75% level*** ***(₹)***
Sales	*13,50,000*	*10,12,500*
Direct Material	*4,25,000*	*3,18,750*
Direct Labour	*1,85,000*	*1,38,750*
Variable Overheads	*2,15,000*	*1,61,250*
Semi-Variable Overheads	*3,65,000*	*3,23,750*
Profit	*1,60,000*	*70,000*

After the closing of the financial year 2013-14, total actual sales stood at ₹ 11,07,000 and there was a favourable sales price variance of ₹ 17,000 (F).

Required

Prepare a flexible budget for the actual level of sales.

Solution

Flexible Budget at 80.74..% Activity Level

	(Amount in ₹)
Sales	10,90,000
Less: Direct Material (₹4,25,000 × 80.74..%)	3,43,148
Direct Labour (₹1,85,000 × 80.74..%)	1,49,370
Variable Overheads (₹ 2,15,000 × 80.74..%)	1,73,593
Semi-Variable Overheads	
Variable Cost (₹1,650 × 80.74..) [W.N.-2]	1,33,222
Fixed Cost [W.N.-2]	2,00,000
Profit	90,667

Working Notes

(1) Calculation of Actual Sales at Budgeted Prices

	(₹)
Actual Sales at Actual Price	11,07,000
Less: Sales Price Variance (F)	17,000
Actual Sales at Budgeted Prices	10,90,000

$$\text{Activity Level} = \frac{\text{Actual Sales at Budgeted Prices}}{\text{Budgeted Sales at Full Capacity}} \times 100$$

$$= \frac{₹10,90,000}{₹13,50,000} \times 100$$

$$= 80.74...\%$$

(2) Segregation of Fixed & Variable Cost Element from Semi-Variable Overheads

$$\text{Variable Overhead} = \frac{\text{Overhead at Full Capacity - Overhead at 75\% Capacity}}{\text{Difference in Activity Level}}$$

$$= \frac{₹3,65,000 - ₹3,23,750}{25}$$

= ₹1,650

Fixed Overhead = Total Other Overheads at 100% Level – Variable Overheads at 100% level

= ₹3,65,000 – (₹1,650 × 100)

= ₹2,00,000

Problem-4

The budgets for activity and cost of PQR Ltd. for the first three quarters of operation are shown below:

	Budgets Quarters I – III		
Period Covered	***Q – I***	***Q – II***	***Q – III***
Months	***1 – 3***	***4 – 6***	***7 – 9***
	('000)	***('000)***	***('000)***
Activity :			
Sales (Units)	*9*	*17*	*15*
Production (Units)	*10*	*20*	*15*
Costs (₹) :			
Direct Material			
A	*60*	*120*	*90*
B	*50*	*100*	*75*
Production Labour	*180*	*285*	*230*
Manufacturing Overheads Excluding Depreciation	*90*	*120*	*105*
Depreciation of Production Machinery	*20*	*20*	*20*
Administration Expenses	*25*	*25*	*25*
Selling & Distribution Expenses	*38*	*54*	*50*

The figures shown above represent the costs structure of PQR Ltd., which have the following major features:

(i) Fixed element of any cost is completely independent of activity levels.

(ii) Any variable element of each cost displays a linear relationship with activity level, except that the variable labour cost become 50% higher for activity in excess of 19,000 units per quarter due to the necessity for overtime working.

(iii) The variable element of selling and distribution expenses is a function of sales. All other costs with a variable element are a function of production volume.

Activity for each quarter is spread evenly throughout that quarter.

In Quarter IV Production level will be set equal to sales level. Production and sales in this quarter is expected to range between 15,000 units and 21,000 units. The most likely volume is 18,000 units. In month 9 it will be possible to accurately estimate the sales for Quarter IV.

Cost structure will remain the same as in Quarters I to III except the following:

(i) Labour wage rate will rise by 12½%.

(ii) Variable labour input per unit of output will decrease, due to learning curve effect, such that 80% of the previous labour input per unit of output will be required in Quarter IV. The threshold for overtime working remains at 19,000 units per quarter.

(iii) Fixed factory overheads and the fixed element of selling and distribution costs will each rise by 20% (The variable element of selling and distribution costs will be unaltered.)

Required

(i) Prepare a Statement to show, under each cost classification given in the budgets, the variable cost per unit and fixed costs which will be effective in Quarter IV.

(ii) Prepare a flexible budget of production costs for the Quarter IV.

Solution

(i) Statement of Variable Cost *per unit* and Fixed Costs under Given Cost Classification Effective for Quarter IV

Particulars	Total Fixed Cost (₹)	Variable Cost p.u. (₹)
Direct Materials (W.N.1)		
A	-----	6
B	-----	5
Production Labour (W.N.2)	90,000	9
Manufacturing Overhead Ex. Depreciation (W.N.3)	72,000	3
Depreciation of Production Machinery	20,000	-----
Administration Expenses	25,000	-----
Selling & Distribution Expenses (W.N.4)	24,000	2

(ii) Flexible Budget of Production Costs for the Quarter IV

Particulars	**15,000 units (₹)**	**18,000 units (₹)**	**21,000 units (₹)**
Direct Material			
A	90,000 (15,000 units × ₹ 6)	1,08,000 (18,000 units × ₹ 6)	1,26,000 (21,000 × ₹ 6)
B	75,000 (15,000 units × ₹ 5)	90,000 (18,000 × ₹ 5)	1,05,000 (21,000 units × ₹5)
Production Labour	2,25,000 (15,000 units × ₹ 9 + ₹ 90,000)	2,52,000 (18,000 units × ₹ 9 + ₹ 90,000	2,88,000*
Manufacturing Overhead	1,17,000 (15,000 units × ₹ 3 + ₹ 72,000)	1,26,000 (18,000 units × ₹ 3 ₹ 72,000)	1,35,000 (21,000 units × ₹ 3 + ₹ 72,000)
Depreciation	20,000	20,000	20,000
Total Production Cost	5,27,000	5,96,000	6,74,000

* Production Labour (21,000 units level)

	₹
Variable Cost (21,000 units × ₹ 9)	1,89,000
Fixed Cost	90,000
Overtime (2,000 units × ₹ 9 × 0.50)	9,000
	2,88,000

Working Notes

1. Direct Material Cost:

$$A: \frac{₹\ 60,000}{10,000 \text{ units}} = ₹\ 6$$

$$B: \frac{₹\ 50,000}{10,000 \text{ units}} = ₹\ 5$$

Direct material cost (variable cost) for material A and B for all the quarters on computation comes to ₹ 6 /- and ₹ 5 /- for materials A and B respectively.

2. Fixed and Variable Cost Component of *production labour cost:*

Particulars	**Quarter I**	**Quarter III**	**Change**
Production (units)	10,000	15,000	5,000
Production labour (₹)	1,80,000	2,30,000	50,000

Variable Cost (per unit) $= \dfrac{\text{Change in Production Labour Cost}}{\text{Change in Production Units}}$

$= \dfrac{₹\ 50,000}{5,000}$

= ₹ 10

Fixed Cost = ₹ 1,80,000 – ₹ 1,00,000

= ₹ 80,000

For Quarter II (20,000 units):

	₹
Variable Cost of 20,000 units @ ₹ 10 p.u.	2,00,000
Fixed Cost	80,000
Overtime Premium on 1,000 @ ₹ 5 p.u.	5,000
Total Production Labour Cost	2,85,000

For Quarter IV (18,000 units):

	₹
Variable Cost of 18,000 units @ ₹ 9 p.u.	1,62,000
(₹ 10 × 1.125 × 0.80 = ₹ 9)	
Fixed Cost (₹ 80,000 × 1.125)	90,000
Total Production Labour Cost	2,52,000

3. Fixed and Variable Cost Component of *manufacturing overhead:*

	Quarter I	Quarter II	Change
Production (units)	10,000	20,000	10,000
Manufacturing Overhead (₹) (Excluding Depreciation)	90,000	1,20,000	30,000

Variable Cost Component of *manufacturing overhead:*

$$= \frac{\text{Change in Manufacturing Overhead Costs}}{\text{Change in Production Units}}$$

$$= \frac{₹\ 30{,}000}{10{,}000 \text{ units}}$$

= ₹ 3 p.u

Fixed Cost Component of *manufacturing overhead:*

= ₹ 1,20,000 – 20,000 units × ₹ 3

= ₹ 60,000

For Quarter IV:

		₹
Fixed Cost	=	60,000
Add: 20% Increase	=	12,000
Total Fixed Cost	=	72,000

4. Fixed and Variable Cost Component of *selling and distribution expenses*

	Quarter I	Quarter II	Change
Sales (units)	9,000	17,000	8,000
Selling & Distribution Expenses	38,000	54,000	16,000

Variable Cost Component of *selling & distribution expenses:*

$$= \frac{\text{Change in selling \& Distribution expenses}}{\text{Change in sales units}}$$

$$= \frac{₹\ 16{,}000}{8{,}000}$$

= ₹ 2 per unit

Fixed Cost Component of *selling & distribution expenses:*

= ₹ 54,000 – 17,000 units × ₹ 2

= ₹ 20,000

Fixed Cost Component for IV Quarter:

= ₹ 20,000 × ₹ 1.20

= ₹ 24,000

Cash Budget

Problem-5

From the information given below:

a) Sales are both on credit and for cash, the latter being one third of the former;

b) Realisations from debtors are 25% in the month of sale; 60%, in month following that and the balance in the month after that;

c) The company adopts a uniform pricing policy of the selling price being 25% over cost;

d) Budgeted sales of each month are purchased and paid for in the preceding month;

e) The company has outstanding debentures of ₹ 2 lakhs on 1st January, which carry interest at 15% per annum payable on the last date of each quarter on calendar year basis. 20% of the debentures are due for redemption, on 30th June 2014;

f) The company has to pay the last instalment of advance tax, for assessment year 2014-15, amounting to ₹ 54,000;

g) Anticipated office costs for the six-month period are; January ₹ 25,000; February ₹ 20,000; March ₹ 40,000; April ₹ 35,000; May ₹ 30,000 and June ₹ 45,000;

h) The opening cash balance of ₹10,000 is the minimum cash balance to be maintained. Deficits have to be met by borrowings in multiples of ₹10,000 on which interest, on monthly basis, has to be paid on the first date of the subsequent month at 12% p.a. Interest is payable for a minimum period of one month.

i) Rent payable is ₹ 2,000 per month.

j) Sales forecast for the different months are:

Oct'13 - ₹160,000; Nov'13 - ₹1,80,000; Dec'13 - ₹2,00,000; Jan'14 - ₹2,20,000; Feb'14 - ₹1,40,000; Mar'14 - ₹1,60,000; Apr'14 - ₹1,50,000; May'14 - ₹2,00,000; Jun'14 - ₹1,80,000 and Jul'14 - ₹1,20,000.

Required

Prepare a Cash Budget of Excel Limited for the first half year of 2014, year of assuming that costs would remain unchanged.

Solution

Excel Limited

Cash Budget for Jan to Jun, 2014

Particulars	Jan (₹)	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)	Jun (₹)
Opening Balance:	10,000	77,500	1,10,250	44,500	10,875	17,775

Receipts:						
Cash Sales (1/4 of total sales)	55,000	35,000	40,000	37,500	50,000	45,000
From Debtors (W.N.1)	1,51,500	1,47,750	1,17,750	1,15,875	1,23,000	1,40,625
Borrowings (W.N. 2)	-----	-----	-----	10,000	10,000	-----
Total Cash Available (A)	2,16,500	2,60,250	2,68,000	2,07,875	1,93,875	2,03,400
Payments:						
Purchase	1,12,000	1,28,000	1,20,000	1,60,000	1,44,000	96,000
Office Expenses	25,000	20,000	40,000	35,000	30,000	45,000
Rent	2,000	2,000	2,000	2,000	2,000	2,000
Debenture Interest	-----	-----	7,500	-----	-----	7,500
Interest on Borrowings	-----	-----	-----	-----	100	200
Advance Tax	-----	-----	54,000	-----	-----	-----
Redemption of Debentures	-----	-----	-----	-----	-----	40,000
Total Payments(B)	1,39,000	1,50,000	2,23,500	1,97,000	1,76,100	1,90,700
Closing Balance (A-B)	77,500	1,10,250	44,500	10,875	17,775	12,700

Working Notes

1. Receipts from Sundry Debtors

Particulars	Nov (₹)	Dec (₹)	Jan (₹)	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)	Jun (₹)
Credit Sales (3/4 of total sales)	1,35,000	1,50,000	1,65,000	1,05,000	1,20,000	1,12,500	1,50,000	1,35,000
Cash Collection from Debtors:								
25% in the same month			41,250	26,250	30,000	28,125	37,500	33,750
60% in the next month			90,000	99,000	63,000	72,000	67,500	90,000
15% in the third month			20,250	22,500	24,750	15,750	18,000	16,875
Total			1,51,500	1,47,750	1,17,750	1,15,875	1,23,000	1,40,625

2. Computation of Deficits to be met by *borrowings*

Opening Balance	10,000	77,500	1,10,250	44,500	10,875	17,775
Receipts *excluding borrowings*	2,06,500	1,82,750	1,57,750	1,53,375	1,73,000	1,85,625
Total Cash Available *before current financing*	2,16,500	2,60,250	2,68,000	1,97,875	1,83,875	2,03,400
Payments	1,39,000	1,50,000	2,23,500	1,97,000	1,76,100	1,90,700
Balance	77,500	1,10,250	44,500	875	7,775	12,700
Add: Borrowings to maintain *minimum cash balance*	-----	-----	-----	10,000	10,000	-----
Closing Balance	77,500	1,10,250	44,500	10,875	17,775	12,700

Problem-6

Sri Ganesh has given the sales forecast for Jan to Jul 2014 and actual sales for Nov, Dec. with the other particulars:

Sales (₹):

Nov'13............................. 80,000 Apr'14.......................... 1,00,000

Dec'13............................. 70,000 May'14.......................... 90,000

Jan'14............................. 80,000 Jun'14.......................... 1,20,000

Feb'14.............................1,00,000 Jul'14.......................... .1,00,000

Mar'14 80,000

Sales 20% cash 80% credit payable in the third month (Jan sales in Mar)

Variable expenses 5% on turnover, time lag half month.

Commission 5% on credit sales payable in the third month.

Purchases 60% of the sales of the third month.

Payment 3rd month of purchases.

Rent and .other expenses ₹3,000 paid every month.

Other payments: Fixed Assets Purchase March ₹50,000.

Taxes paid in Apr ₹20,000.

Opening cash balance ₹25,000.

Required

Prepare cash budget for five months Jan to May 2014.

Solution

Cash Budget from Jan'14 to May'14

Particulars	Jan (₹)	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)
Opening Balance	25,000	47,050	52,750	24,050	32,550
Cash Sales	16,000	20,000	16,000	20,000	18,000
Collection from Debtors	64,000	56,000	64,000	80,000	64,000
Total Cash Inflow (i)	1,05,000	1,23,050	1,32,750	1,24,050	1,14,550
Payment to Creditors	48,000	60,000	48,000	60,000	54,000
Variable Expenses	3,750	4,500	4,500	4,500	4,750
Commission	3,200	2,800	3,200	4,000	3,200
Rent	3,000	3,000	3,000	3,000	3,000
Fixed Assets	-----	-----	50,000	-----	-----
Taxes	-----	------	-----	20,000	-----
Total Cash Out Flow(ii)	57,950	70,300	1,08,700	91,500	64,950
Balance (i) –(ii)	47,050	52,750	24,050	32,550	49,600

Working Notes

(i) Cash Sales and Realization from Debtors:

Particulars	Nov (₹)	Dec (₹)	Jan (₹)	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)
Total Sales	80,000	70,000	80,000	1,00,000	80,000	1,00,000	90,000
Cash Sales 20%	16,000	14,000	16,000	20,000	16,000	20,000	18,000
Credit Sales 80%	64,000	56,000	64,000	80,000	64,000	80,000	72,000
Realisation from Debtors			64,000	56,000	64,000	80,000	64,000

(ii) Payment for Purchases made for the third month requirements, i.e. Nov purchases will be for Jan sales. In addition, payment is made in third month from the purchase i.e. the payment for Nov purchases will be made in Jan. It means payment for purchases will be 60% of each month's sales.

Particulars	Jan (₹)	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)
Payment for Purchases: (equal to 60% of sales of current month)	48,000	60,000	48,000	60,000	54,000

(iii) Commission @5% on Credit Sales paid in the third month i.e. for Nov month Sales paid in Jan:

Particulars	Nov (₹)	Dec (₹)	Jan (₹)	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)
Credit Sales	64,000	56,000	64,000	80,000	64,000	80,000	72,000
Commission @5%	3,200	2,800	3,200	4,000	3,200	4,000	3,600
Payment for Commission			3,200	2,800	3,200	4,000	3,200

(iv) Variable Expenses:

Particulars	Nov (₹)	Dec (₹)	Jan (₹)	Feb (₹)	Mar (₹)	April (₹)	May (₹)
Variable Expenses (5% of Sales)	4,000	3,500	4,000	5,000	4,000	5,000	4,500
Payment: ½ of previous month			1,750	2,000	2,500	2,000	2,500
Payment: ½ of current month			2,000	2,500	2,000	2,500	2,250
Total Payment			3,750	4,500	4,500	4,500	4,750

Problem-7

You are given the following information:

(a) *Estimated monthly Sales are as follows:*

	₹		₹
Jan	*1,00,000*	*Jun*	*80,000*
Feb	*1,20,000*	*Jul*	*1,00,000*
Mar	*1,40,000*	*Aug*	*80,000*
Apr	*80,000*	*Sep*	*60,000*
May	*60,000*	*Oct*	*1,00,000*

(b) *Wages and Salaries are estimated to be payable as follows:*

	₹		₹
Apr	*9,000*	*Jul*	*10,000*
May	*8,000*	*Aug*	*9,000*
Jun	*10,000*	*Sep*	*9,000*

(c) *Of the sales, 80% is on credit and 20% for cash. 75% of the credit sales are collected within one month and the balance in two months. There are no bad debt losses.*

(d) *Purchases amount to 80% of sales and are made and paid for in the month preceding the sales.*

(e) *The firm has taken a loan of ₹1,20,000. Interest @ 10% p.a. has to be paid quarterly in January, April and so on.*

(f) *The firm is to make payment of tax of ₹ 5,000 in July, 2014.*

(g) *The firm had a cash balance of ₹ 20,000 on 1St April, 2014 which is the minimum desired level of cash balance. Any cash surplus/deficit above/below this level is made up by temporary investments/liquidation of temporary investments or temporary borrowings at the end of each month (interest on these to be ignored).*

Required

Prepare monthly cash budgets for six months beginning from April, 2014 on the basis of the above information.

Solution

Computation – Collections from Debtors

Particulars	Feb (₹)	Mar (₹)	Apr (₹)	May (₹)	Jun (₹)	Jul (₹)	Aug (₹)	Sep (₹)
Total Sales	1,20,000	1,40,000	80,000	60,000	80,000	1,00,000	80,000	60,000
Credit Sales (80% of total Sales)	96,000	1,12,000	64,000	48,000	64,000	80,000	64,000	48,000
Collection (within one month)		72,000	84,000	48,000	36,000	48,000	60,000	48,000
Collection (within two months)			24,000	28,000	16,000	12,000	16,000	20,000
Total Collections			1,08,000	76,000	52,000	60,000	76,000	68,000

Monthly Cash Budget for Six Months: April to September, 2014

Particulars	April (₹)	May (₹)	June (₹)	July (₹)	August (₹)	Sept. (₹)
Receipts:						
Opening Balance	20,000	20,000	20,000	20,000	20,000	20,000
Cash Sales	16,000	12,000	16,000	20,000	16,000	12,000
Collections from Debtors	1,08,000	76,000	52,000	60,000	76,000	68,000
Total Receipts (A)	1,44,000	1,08,000	88,000	1,00,000	1,12,000	1,00,000
Payments:						
Purchases	48,000	64,000	80,000	64,000	48,000	80,000
Wages and Salaries	9,000	8,000	10,000	10,000	9,000	9,000
Interest on Loan	3,000	-----	-----	3,000	-----	-----
Tax Payment	-----	-----	-----	5,000	-----	-----
Total Payment (B)	60,000	72,000	90,000	82,000	57,000	89,000
Minimum Cash Balance	20,000	20,000	20,000	20,000	20,000	20,000
Total Cash Required (C)	80,000	92,000	1,10,000	1,02,000	77,000	1,09,000
Surplus/ (Deficit) (A)-(C)	64,000	16,000	(22,000)	(2,000)	35,000	(9,000)
Investment/Financing: Total effect of (Invest)/ Financing (D)	(64,000)	(16,000)	22,000	2,000	(35,000)	9,000
Closing Cash Balance (A) + (D) - (B)	20,000	20,000	20,000	20,000	20,000	20,000

Cash Budget & Budgeted Income Statement

Problem-8

On 30th September, 2013, the Balance Sheet of Dani Sugar & Co. retailers of sugar, was as under:

Liabilities	*(₹)*	*Assets*		*(₹)*
Capital	*20,000*	*Equipments (at cost)*	*₹ 20,000*	
		Less: Depreciation	*5,000*	*15,000*

Reserves and Surplus	*10,000*	*Stock*	*20,000*
Trade Creditors	*40,000*	*Trade Debtors*	*15,000*
Audit Fees	*15,000*	*Balance at Bank*	*35,000*
	85,000		*85,000*

The firm is developing a system of forward planning and on 1st October 2013 it supplies the following information:–

Month	***Credit Sales (₹)***	***Cash Sales (₹)***	***Credit Purchases (₹)***
Sep'13 (Actual)	*15,000*	*14,000*	*40,000*
Oct'13 (Budgeted)	*18,000*	*5,000*	*23,000*
Nov'13 (Budgeted)	*20,000*	*6,000*	*27,000*
Dec'13 (Budgeted)	*25,000*	*8,000*	*26,000*

All trade debtors are allowed one month's credit and are expected to settle promptly. All trade creditors are paid in the month following delivery.

On 1st October 2013, all the equipment was replaced at a cost of ₹ 30,000. ₹ 14,000 was allowed in exchange for the old equipment and a net payment of ₹ 16,000 was made. Depreciation is to be provided at the rate of 10% per annum.

The audit fees will be paid in December 2013.

The following expenses will be paid:

– *Wage ₹ 3,000 per month.*

– *Administration ₹ 1,500 per month.*

Rent ₹ 3,600 for the year to 30th September 2014 (to be paid in Oct'13)

The gross profit % on sale is estimated at 25%.

Required

(i) *Prepare a Cash Budget for the month of Oct, Nov & Dec.*

(ii) *Prepare an Income Statement for the three months ending 31st Dec'13*

Solution

(i) Cash Budget for October, November and December, 2013

Particulars	Oct (₹)	Nov (₹)	Dec (₹)
Opening Balance at Bank (Overdraft)	35,000	(9,100)	(12,600)
Receipts:			
Sales : Credit	15,000	18,000	20,000
Cash	5,000	6,000	8,000
Total Receipts (A)	55,000	14,900	15,400
Payments:			
Creditors	40,000	23,000	27,000
Equipment	16,000	-----	-----
Audit Fees	-----	-----	15,000
Wages	3,000	3,000	3,000
Administration	1,500	1,500	1,500
Rent	3,600	-----	-----
Total Payments (B)	64,100	27,500	46,500
Closing Balance (Overdraft) (A – B)	(9,100)	(12,600)	(31,100)

(ii) Budgeted Income Statement for the 3 Months ended 31st December 2013

Particulars	(₹)	(₹)
Sales		82,000
Less: Cost of Goods Sold:		
Material (₹20,000 + ₹76,000 – ₹43,500)	52,500	
Wages	9,000	61,500
Gross Profit		20,500
Less: Administration	4,500	
Rent	900	
Depreciation	750	
Loss on Sale of Old Equipment	1,000	7,150
Net Profit		13,350

Working Notes

(i) **Statement Showing "Cash & Credit Sales"**

Particulars	Credit Sales (₹)	Cash Sales (₹)	Total Sales (₹)
Oct'13	18,000	5,000	23,000
Nov'13	20,000	6,000	26,000
Dec'13	25,000	8,000	33,000
Total	63,000	19,000	82,000

(ii) Gross Profit for 3 months = 25% of ₹ 82,000

= ₹ 20,500

(iii) Cost of Goods Sold = ₹ 82,000 – ₹ 20,500

= ₹ 61,500

(iv) Material Consumed = Cost of Goods Sold – Wages

= ₹ 61,500 – ₹ 9,000

= ₹ 52,500

(v) Closing Stock = Opening Stock + Purchases – Material Consumed

= ₹ 20,000 + ₹ 76,000 – ₹ 52,500

= ₹ 96,000 – ₹ 52,500

= ₹ 43,500

Functional Budgets

Problem-9

DEF Ltd manufactures and sells a single product and has estimated sales revenue of ₹ 397.80 lacs during the year based on 20% profit on selling price. Each unit of product requires 6 kg of material A and 3 kg of material B and processing time of 4 hours in machine shop and 2 hours in assembly shop. Factory overheads are absorbed at a blanket rate of 20% of direct labour. Variable selling & distribution overheads are ₹ 6 per unit sold and fixed selling & distribution overheads are estimated to be ₹ 7,20,000.

The other relevant details are as under:

Purchase Price……………………………….	*Material A*	*₹ 16 per kg*	
	Materials B	*₹ 10 per kg*	
Labour Rate…………………………………..	*Machine Shop*	*₹ 14 per hour*	
	Assembly Shop	*₹ 7 per hour*	
	Finished Stock	*Material A*	*Material B*
Opening Stock………………………………..	*25,000 units*	*75,000 kg*	*40,000 kg*
Closing Stock…………………………………	*30,000 units*	*80,000 kg*	*55,000 kg*

Required

(i) *Calculate number of units of product proposed to be sold and selling price per unit,*

(ii) *Production Budget in units and*

(iii) *Material Purchase Budget in units.*

Solution

(i) Workings

Statement Showing "Total Variable Cost *for the year*"

Particulars	**Amount (₹)**
Estimated Sales Revenue	3,97,80,000
Less: Desired Profit Margin on Sale @ 20%	79,56,000
Estimated Total Cost	3,18,24,000
Less: Fixed Selling and Distribution Overheads	7,20,000
Total Variable Cost	3,11,04,000

Statement Showing "Variable Cost *per unit*"

Particulars	**Variable Cost p.u. (₹)**
Direct Materials:	
A: 6 Kg. @ ₹16 per Kg.	96
B: 3 Kg. @ ₹10 per Kg.	30
Labour Cost:	
Machine Shop: 4 hrs. @ ₹14 per hour	56
Assembly Shop: 2 hrs. @ ₹7 per hour	14
Factory Overheads: 20% of (₹56 + ₹14)	14
Variable Selling & Distribution Expenses	6
Total Variable Cost *per unit*	216

Number of Units Sold	=	Total Variable Cost / Variable Cost *per unit*
	=	₹3,11,04,000 / ₹216
	=	1,44,000 units
Selling Price *per unit*	=	Total Sales Value / Number of Units Sold
	=	₹3,97,80,000 / 1,44,000 units
	=	₹276.25

(ii) **Production Budget (units)**

Particulars	Units
Budgeted Sales	1,44,000
Add: Closing Stock	30,000
Total Requirements	1,74,000
Less: Opening Stock	25,000
Required Production	1,49,000

(iii) **Materials Purchase Budget (Kg.)**

Particulars	Material A	Material B
Requirement for Production	8,94,000 (1,49,000 units × 6 Kg.)	4,47,000 (1,49,000 units × 3 Kg.)
Add: Desired Closing Stock	80,000	55,000
Total Requirements	9,74,000	5,02,000
Less: Opening Stock	75,000	40,000
Quantity *to be purchased*	8,99,000	4,62,000

Problem-10

A Company is engaged in manufacturing two products 'KX' and 'KY'. Product 'KX' uses one unit of component 'KP' and two units of component 'KQ'. Product 'KY' uses two units of component 'KP', one unit of component 'KQ' and two units of component 'KR'. Component 'KR' which is assembled in the factory uses one unit of component 'KQ'.

Component 'KP' and 'KQ' are purchased from the market. The company has prepared the following forecast of sales and inventory for the next year:

Particulars	***Product 'KX'***	***Product 'KY'***
Sales (in units)	*40,000*	*75,000*
At the end of the year	*5,000*	*10,000*
At the beginning of the year	*15,000*	*25,000*

The production of both the products and the assembling of the component 'KR' will be spread out uniformly throughout the year. The company at present orders its inventory of 'KP' and 'KQ' in quantities equivalent to 3 months production. The company has compiled the following data related to two components:

Particulars	***'KP'***	***'KQ'***
Price per unit (₹)	*40*	*16*
Order placing cost per order (₹)	*3,000*	*3,000*
Carrying cost per annum	*10%*	*10%*

Required

(i) *Prepare a Budget of production and requirements of components during next year.*

(ii) *Suggest the optimal order quantity of components 'KP' and 'KQ'.*

Solution

Production Budget for Product X & Y

Particulars	**'KX' Units**	**'KY' Units**
Inventory at the end of the year	5,000	10,000
Sales Forecast	40,000	75,000
Total Requirements	45,000	85,000
Less: Beginning Inventory	15,000	25,000
Production	30,000	60,000

Budgeted Requirements of Components 'KP', 'KQ' and 'KR'

Components	**'KP'**	**'KQ'**	**'KR'**
For Product '**KX**': Production 30,000 units			
'**KP**': 30,000 × 1 per unit	30,000	–	–
'**KQ**': 30,000 × 2 per unit	–	60,000	–
For Product '**KY**': Production 60,000 units			
'**KP**': 60,000 × 2 per unit	1,20,000	–	–

'KQ': 60,000 × 1 per unit	–	60,000	
'KR': 60,000 × 2 per unit	–	–	1,20,000
For comp '**KR**': Production 1,20,000 comp			
'KQ': 1,20,000 × 1 per component '**KR**'	–	1,20,000	–
Total Requirements	1,50,000	2,40,000	1,20,000

Optimum Order Quantity

'**KP**'

$$\text{EOQ} \sqrt{\frac{2 \times 1{,}50{,}000 \times 3{,}000}{40 \times 10\%}}$$

= 15,000 components

'**KQ**'

$$\sqrt{\frac{2 \times 2{,}40{,}000 \times 3{,}000}{16 \times 10\%}}$$

= 30,000 components

Problem-11

Super Products Ltd. manufactures and sells a single product and has estimated a sales revenue of ₹ 126 lakhs this year based on a 20% profit on selling price. Each unit of the product requires 3 lbs. of material A and 1.1/2 lbs. of material B, for manufacture as well as a processing time of 7 hours in the Machine Shop and 2.1/2 hours on the Assembly Section. Overheads are absorbed at a blanket rate of 33.1/3% on Direct Labour. The factory works 5 days of 8 hours a week in a normal 52 weeks a year. On an average statutory holidays, leave and absenteeism and idle time amount to 96 hours, 80 hours and 64 hours respectively, in a year.

The other details are as under:

Purchase Price	*Material A*	*₹ 6 per lb.*	
	Material B	*₹ 4 per lb.*	
Comprehensive Labour Rate	*Machine Shop*	*₹ 4.00 per hour*	
	Assembly Section	*₹ 3.20 per hour*	
No. of Employees	*Machine Shop*	*600*	
	Assembly Section	*180*	
	Finished Goods	*Material A*	*Material B*
Opening Stock	*20,000 Units*	*54,000 lbs.*	*33,000 lbs*
Closing Stock (Estimated)	*25,000 Units*	*30,000 lbs.*	*66,000 lbs*

Required

(i) *Calculate the number of units of the product proposed to be sold,*

(ii) Purchases to be made of Materials A and B during the year in rupees and

(iii) Capacity utilisation of Machine Shop and Assembly Section, along with your comments.

Solution

(i) Statement of the Number of Units of the Product Proposed to be Sold

Selling Price *per unit*	₹90
Total Sales Revenue	₹1,26,00,000
Number of Units of the Product (proposed to be sold)	1,40,000 units (₹1,26,00,000 / ₹90)

Working Notes

Selling Price *per unit* of the Product

	₹
Direct Material:	
A: 3.0 lbs × ₹ 6	18
B: 1.5 lbs × ₹ 4	6
Direct Labour:	
Machine Shop: 7 hrs × ₹ 4	28
Assembly Section: 2.5 hrs × ₹ 3.20	8
Overhead 33 ⅓% of Direct Labour [(₹28+₹8) × 33.33...%]	12
Total Cost *per unit*	72
Add: Profit 20% of Selling Price (or 25% on Cost)	18
Selling Price *per unit*	90

(ii) Materials A & B to be Purchased (in Rupees)

Material	Consumption (lbs)	Closing Balance (lbs)	Opening Balance (lbs)	Purchase (lbs.)	Purchase Price (₹)	Amount (₹)
A	4,35,000 (1,45,000* × 3)	30,000	54,000	4,11,000	6	24,66,000
B	2,17,500 (1,45,000* × 1.5)	66,000	33,000	2,50,500	4	10,02,000
					Total	34,68,000

(*) Number of units of finished goods to be manufactured during the year

= Sales + Closing Stock – Opening Stock

= 1,40,000 + 25,000 – 20,000

= 1,45,000 units

(iii) Capacity Utilisation Statement - Machine Shop & Assembly Section

Particulars	Machine Shop	Assembly Section
Hours Available#	11,04,000 (600 person × 1,840 hrs.)	3,31,200 (180 persons × 1,840 hrs.)
Hours Required	10,15,000 (1,45,000 units × 7 hrs.)	3,62,500 (1,45,000 units × 2.5 hrs.)
Surplus/(Deficit) Hours	89,000	(31,300)
Capacity Utilization	91.94%	109.45%

(#) Hours Available [5 Days × 8 Hrs. × 52 Weeks – Idle Time (96 + 80 + 64)]

Comments

Above statement shows that there are 89,000 excess hours in the machine shop and also a shortage of 31,300 hours in the assembly section. If the workers are interchangeable, the assembly section should utilise the services of workers which may be moved from the machine shop to meet the production target of 1,45,000 units. If the workers are not interchangeable, the assembly section may either resort to overtime working or increase the strength of workers to achieve the budgeted production.

Problem-12

Smart Electronics is manufacturing for export, four models of Television Sets. The major components viz., Cabinet, High Voltage Transformer and the Speaker are bought out by the Company. Picture Tubes for three out of the four models are purchased from other firms. Four Cabinet styles (A, B, C and D), two kinds of Transformers (X and Y): Three kinds of speakers and three types of picture tubes are assembled in the following ways in the final product:–

Model	*Cabinet*	*Transformer*	*Speaker*	*Picture Tube*
Standard	*A @ ₹ 200*	*X @ ₹ 200*	*5” Cone @ ₹ 300*	*OWN*
Deluxe	*B @ ₹ 300*	*X @ ₹ 200*	*5” Cone @ ₹ 300*	*BEL @ ₹ 1,200*
Aristocrat	*C @ ₹ 500*	*Y @ ₹ 300*	*6” Cone @ ₹ 400*	*BEL @ ₹ 1,200*
Royal	*D @ ₹ 700*	*Y @ ₹ 300*	*12” Cone @ ₹ 600*	*TELETUBE @ ₹ 1,600*

The Company expects the following inventories in hand on 1st Jan 2014:–

Finished Sets:

Standard — 46; Deluxe — 73; Aristocrat — 64; Royal — 69

Sub-Assemblies:

Cabinet:

A — 30; B — 40; C — 20; D — 25

Transformers:

X—31; Y—17

Speakers:

5" Cone — 27; 6" Cone — 47; 12" Cone —18

Picture Tubes:

OWN — 20; BEL — 17; TELTUBE — 34

The Sales Manager estimates that sales of the quarter, January – March 2014, will be:–

Standard — 200; Deluxe — 600; Aristocrat — 500; Royal — 300

The following inventory quantities have been budgeted for 31st March 2014:–

Finished Sets:

25 in each model

Sub-Assemblies:

Cabinet—15 (each model)

Transformers—20 (each type)

Speakers—30 (each type)

Picture Tube

OWN — 30; BEL— 40; TELTUBE—20

Required

Prepare the purchase budget for the various items stated above for the quarter Jan—Mar'14.

Solution

Production Budget for Television Sets

Model	Sales Budgeted	Closing Inventory	Total	Opening Inventory	Production
Standard	200	25	225	46	179
Deluxe	600	25	625	73	552
Aristocrat	500	25	525	64	461
Royal	300	25	325	69	256

Materials Purchase Budget [Cabinet]

Type	Model	Production	Closing Inventory	Opening Inventory	Purchase
A	Standard	179	15	30	164
B	Deluxe	552	15	40	527
C	Aristocrat	461	15	20	456
D	Royal	256	15	25	246

Materials Purchase Budget [Transformer]

<table>
<tr><th>Type</th><th>Model</th><th>Production</th><th>Closing Inventory</th><th>Opening Inventory</th><th>Purchase</th></tr>
<tr><td rowspan="2">X</td><td>Standard</td><td>179</td><td rowspan="2">20</td><td rowspan="2">31</td><td rowspan="2">720</td></tr>
<tr><td>Deluxe</td><td>552</td></tr>
<tr><td rowspan="2">Y</td><td>Aristocrat</td><td>461</td><td rowspan="2">20</td><td rowspan="2">17</td><td rowspan="2">720</td></tr>
<tr><td>Royal</td><td>256</td></tr>
</table>

Materials Purchase Budget [Speakers]

<table>
<tr><th>Type</th><th>Model</th><th>Production</th><th>Closing Inventory</th><th>Opening Inventory</th><th>Purchase</th></tr>
<tr><td rowspan="2">5” Cone</td><td>Standard</td><td>179</td><td rowspan="2">30</td><td rowspan="2">27</td><td rowspan="2">734</td></tr>
<tr><td>Deluxe</td><td>552</td></tr>
<tr><td>6” Cone</td><td>Aristocrat</td><td>461</td><td>30</td><td>47</td><td>444</td></tr>
<tr><td>12” Cone</td><td>Royal</td><td>256</td><td>30</td><td>18</td><td>268</td></tr>
</table>

Materials Purchase Budget [Picture Tube]

Type	Model	Production	Closing Inventory	Opening Inventory	Purchase
BEL	Deluxe	552	40	17	1,036
	Aristocrat	461			
TELTUBE	Royal	256	20	34	242

Purchase Budget (Consolidated)

Type	Items	Qty.	Rate (₹)	Amount (₹)
Cabinet	A	164	200	32,800
	B	527	300	1,58,100
	C	456	500	2,28,000
	D	246	700	1,72,200
Transformer	X	720	200	1,44,000
	Y	720	300	2,16,000
Speaker	5” Cone	734	300	2,20,200
	6” Cone	444	400	1,77,600
	12” Cone	268	600	1,60,800
Picture Tube:	BEL	1,036	1,200	12,43,200
	TELTUBE	242	1,600	3,87,200
			Total	31,40,100

Problem-13

KFA Ltd. manufactures three products K, F and A in two production departments X and D, in each of which are employed two grades of labour. The cost accountant is preparing the annual budgets for the next year and he has asked you to prepare, using the data given below:

(a) *The production budget in units for products K, F and A.*

(b) *The direct wages budget for departments X and D with the labour costs of product K, F and A and total shown separately:*

Product: (₹ '000)		*Product K*	*Product F*	*Product A*
Finished Stocks:		*(₹ '000)*	*(₹ '000)*	*(₹ '000)*
Budgeted Stocks are				
1st Jan. Next year		*720*	*540*	*1,800*
31st Dec. Next year		*600*	*570*	*1,000*
All Stocks are Valued at Standard Cost per unit		*₹ 24*	*₹ 15*	*₹ 20*
Standard Profit Calculated as % of Selling Price		*20%*	*25%*	*16.66…%*
	Total	***Product K***	***Product F***	***Product A***
Budgeted Sales:	*(₹ '000)*	*(₹ '000)*	*(₹ '000)*	*(₹ '000)*
South	*6,600*	*1,200*	*1,800*	*3,600*
West	*5,100*	*1,500*	*1,200*	*2,400*
North	*6,380*	*1,500*	*800*	*4,080*
	18,080	*4,200*	*3,800*	*10,080*
Normal Loss in Production		*10%*	*20%*	*5%*
Standard Labour Times per unit and Standard Rate per hour				
	Rate	***Product K***	***Product F***	***Product A***
Department X:	***(₹)***	***(Hours)***	***(Hours)***	***(Hours)***
Grade 1	*1.80*	*2.0*	*3.0*	*1.0*
Grade 2	*1.60*	*1.5*	*2.0*	*1.5*
Department D:				
Grade 1	*2.00*	*3.0*	*1.0*	*1.0*
Grade 2	*1.80*	*2.0*	*1.5*	*2.5*

Solution

(i) Production Budget (in Units) for Product K, F And A

Product ('000 units)	K	F	A
Sales Volume	140	190	420
Stock Increase / (Decrease)	(5)	2	(40)
Saleable Output	135	192	380
Normal Loss in Production Process	15	48	20
Input to Production	150	240	400

(ii) Direct Wages Budget for Departments X & D

Particulars	K		F		A		Total
	Std. Hrs.	(₹) '000	Std. Hrs.	(₹) '000	Std. Hrs.	(₹) '000	(₹) '000
Department X:							
Grade 1@ ₹ 1.80/hr.	300	540	720	1,296	400	720	2,556
Grade 2@ ₹ 1.60/hr.	225	360	480	768	600	960	2,088
Total (A)		900		2,064		1,680	4,644
Department D:							
Grade 1 @ ₹ 2.00/hr.	450	900	240	480	400	800	2,180
Grade 2 @ ₹ 1.80/hr.	300	540	360	648	1,000	1,800	2,988
Total (B)		1,440		1,128		2,600	5,168
Total Direct Wages (A+B)		2,340		3,192		4,280	9,812

Workings

(i) Unit Selling Price:

K: ₹ 24 × (100 ÷ 80) = ₹ 30

F: ₹ 15 × (100 ÷ 75) = ₹ 20

A: ₹ 20 × (100 ÷ 83.33..) = ₹ 24

(ii) Budgeted Sales Volume (in '000):

K: ₹ 4,200 ÷ ₹ 30 = 140

F: ₹ 3,800 ÷ ₹ 20 = 190

A: ₹ 10,080 ÷ ₹ 24 = 420

(iii) Stock Increases/ (Decrease) ('000 units):

K: {(₹ 720 – 600) ÷ ₹ 24} = (5)

F: {(₹ 540 – 570) ÷ ₹ 15} = 2

A: {₹ (1,800 – 1,000) ÷ ₹20} = (40)

(iv) Budgeted Good Production ('000 units):

K: 140 – 5 = 135

F: 190 + 2 = 192

A: 420 – 40 = 380

(v) Normal Loss in Production ('000 units):

K: 135 × (10 ÷ 90) = 15

F: 192 × (20 ÷ 80) = 48

A: 380 ×(5 ÷ 95) = 20

Problem-14

EXE Ltd manufacturing three types of products P, Q and R and market them at ₹450, ₹550 and ₹650 per unit respectively. The current ratio of sales in quantity of P, Q and R is 1: 2: 4.

Relevant Data of P, Q & R (per unit)

Product	*Quantity of Parts required therein (In nos.)*				*Labour Hrs.*		*Variable Overhead (₹)*
	Frame	*S*	*T*	*U*	*Skilled*	*Unskiiled*	
P	*1*	*10*	*2*	*8*	*6*	*8*	*9*
Q	*1*	*2*	*14*	*10*	*4*	*6*	*11*
R	*1*	*6*	*10*	*2*	*3*	*6*	*7*

The present purchase price per part is ₹ 45, ₹ 15, ₹ 15 and ₹ 5 for Frame, S, T and U respectively. The wages rate per hours for Skilled and Unskilled workers is ₹ 6 and ₹ 5 respectively.

The opening stocks as on 1.11.2013 stood at 500, 1,000, 3,000, 1,500, 1,000, 20,000 and 10,000 for P, Q, R, Frames, S, T and U respectively. The company maintains closing stock of products and parts at 90% of the opening stocks.

The workers work for 8 hours a day for 25 days in a month.

The share of fixed overheads per month comes to ₹ 15,75,000; ₹ 5,80,000; and ₹ 8,45,000 for production, administration and selling & distribution respectively.

The yearly profit as projected up to October, 2014 is ₹ 120 lakhs.

Required

Present the following for November, 2013;

(i) Sales Budget in quantity as well as in value for P, Q and R.

(ii) Production Budget.

(iii) Parts Usage Budget.

(iv) Purchase Budget in quantity as well as in value.

(v) Manpower Budget showing labour hours and wages payable for both types of workers.

Solution

(i) Sales Budget in Quantity as well as in Value A, B & C

Products	P	Q	R	Total
Sales Budget (in quantity) (Refer to W.N. 2)	2,500	5,000	10,000	17,500
Sales Value (in ₹)	11,25,000 (2,500 × ₹ 450)	27,50,000 (5,000 × ₹ 550)	65,00,000 (10,000 × ₹ 650)	1,03,75,000

(ii) Production Budget (in Units)

Products	P	Q	R
Sales *in units* (Refer to W.N. 2)	2,500	5,000	10,000
Add: Closing Stock *in units* (90% of Opening Stock)	450	900	2,700
Less : Opening Stock *in units*	500	1,000	3,000
Production Budget *in units*	2,450	4,900	9,700

(iii) Parts Usage Budget

Products	Units to be Produced	Parts of Material Required			
		Frame	S	T	U
P	2,450	2,450	24,500	4,900	19,600
Q	4,900	4,900	9,800	68,600	49,000
R	9,700	9,700	58,200	97,000	19,400
Total		17,050	92,500	1,70,500	88,000

(iv) Purchase Budget (in Quantity as well as in Value)

Name of Parts	Frame	S	T	U
Parts Usage (in units)	17,050	92,500	1,70,500	88,000
Add : Closing Stock	1,350	900	18,000	9,000
Less : Opening Stock	1,500	1,000	20,000	10,000
Units to be Purchased	16,900	92,400	1,68,500	87,000
Purchase Value (₹)	7,60,500 (16,900 x ₹ 45)	13,86,000 (92,400 x ₹ 15)	25,27,500 (1,68,500 x ₹15)	4,35,000 (87,000 x ₹5)

(v) Manpower Budget Showing Labour Hours & Wages Payable

Products	Total Labour Hours		
	Units to be Produced	Skilled Workers	Un Skilled Workers
P	2,450	14,700	19,600
Q	4,900	19,600	29,400
R	9,700	29,100	58,200
	Total	63,400	1,07,200
Wages Payable (₹)		3,80,400 (63,400 × ₹ 6)	5,36,000 (1,07,200 × ₹ 5)

Working Note

1. Variable Cost *per unit* of Products P, Q & R

Products :	P (₹)	Q (₹)	R (₹)
Cost of Parts :			
Frame	45	45	45
S	150	30	90
T	30	210	150
U	40	50	10
Wages of Skilled Labour	36	24	18
Wages of Un – Skilled Labour	40	30	30
Variable Overheads	09	11	07
Total Variable Cost *per unit*	350	400	350

2. **Sales Quantity** of Products A, B and C :

Products	**P** **X** **(₹)**	**Q** **2X** **(₹)**	**R** **4X** **(₹)**	**(₹)**
Selling Price (p.u.)	450	550	650	
Less: Variable Cost (p.u.) (Refer to Note 1)	350	400	350	
Contribution (p.u.)	100	150	300	
Total Contribution	100X	300X	1,200X	1,600X

Also, Required Contribution p.m. = Profit + Fixed Cost

= ₹10,00,000 + ₹30,00,000

= ₹40,00,000

Since 1,600 X = ₹40,00,000

Or X = 2,500 units

Hence, the sales quantity of products P, Q and R respectively are: 2,500 units; 5,000 units and 10,000 units.

Problem-15

A single product company estimated its sales for the next year quarter wise as under:

Quarter	*Sales Units*
I……………………………………………………	*60,000*
II……………………………………………………	*75,000*
III…………………………………………………..	*82,500*
IV…………………………………………………..	*90,000*

The opening stock of finished goods is 20,000 units and the company expects to maintain the closing stock of finished goods at 32,500 units at the end of the year. The production pattern in each quarter is based on 80% of the sales of the current quarter and 20% of the sales of the next quarter.

The opening stock of raw materials in the beginning of the year is 20,000 Kg. and the closing stock at the end of the year is required to be maintained at 10,000 Kg. Each unit of finished output required 2 Kg. of raw materials.

The company proposes to purchase the entire annual requirement of raw materials in the first three quarters in the proportion and at the prices given below:

Quarter	*Purchase of raw materials % total annual requirement in quantity*	*Price per Kg. (₹)*
I	*30%*	*2*
II	*50%*	*3*
III	*20%*	*4*

The value of the opening stock of raw materials in the beginning of the year is ₹ 40,000.

Required

Present the following for the next year, quarter wise-

(i) Production budget in units.

(ii) Raw material consumption budget in quantity.

(iii) Raw material purchase budget in quantity and value.

Solution

(i) Total Annual Production (In Units)

Particulars	**Units**
Sales in 4 Quarters	3,07,500
Add: Desired Closing Balance	32,500
Total	3,40,000
Less: Opening Balance	20,000
Total number of units to be produced in the next year	3,20,000

Production Budget (In Units)

Particulars	**Q-I**	**Q-II**	**Q-III**	**Q-IV**	**Total**
Sales	60,000	75,000	82,500	90,000	3,07,500
Production in Current Quarter (80% of the sale of current quarter)	48,000	60,000	66,000	72,000	
Production for Next Quarter (20% of the sale of next quarter)	15,000	16,500	18,000	24,500*	
Total Production	63,000	76,500	84,000	96,500*	3,20,000

*Difference in Balancing Figure

(ii) Raw Material Consumption Budget (In Quantity)

Particulars	Q-I	Q-II	Q-III	Q-IV	Total
Units to be produced in each quarter (1)	63,000	76,500	84,000	96,500	3,20,000
Raw material consumption per unit (Kg.) (2)	2	2	2	2	
Total raw material consumption Kg.) (1x2)	1,26,000	153,000	1,68,000	1,93,000	6,40,000

(iii) Raw Material Purchase Budget (In Quantity)

Particulars	Kg.
Raw material required for Production	6,40,000
Add: Desired Closing Balance of Raw Material	10,000
Total	6,50,000
Less: Opening Balance	20,000
Material to be purchased	6,30,000

Raw Material Purchase Budget (In Value)

Quarters (1)	% of Annual Requirement (Qty.) for Purchasing Raw Material (2)	Quantity of Raw Material to be Purchased (Kg.) (3)	Rate per Kg. (₹) (4)	Amount (₹) (5)=(3)x(4)
I	30	1,89,000 (6,30,000 × 30%)	2	3,78,000
II	50	3,15,000 (6,30,000 × 50%)	3	9,45,000
III	20	1,26,000 (6,30,000 × 20%)	4	5,04,000
		6,30,000		18,27,000

Problem-16

SIAM Ltd. manufactures two products using one type of material and one grade of labour. Shown below is an extract from the company's working papers for the next period's budget.

Particulars	*Product A*	*Product B*
Budgeted Sales (Units)	*1,800*	*2,400*
Budgeted Material Consumption per Product (Kg.) *[Budgeted Material Cost ₹12 per Kg.]*	*5*	*3*
Standard Hours Allowed per product *[Budgeted Wage Rate ₹8 per hour]*	*5*	*4*

Overtime premium is 50% and is payable, if a worker works for more than 40 hours a week. There are 45 direct workers.

The target productivity ratio (or efficiency ratio) for the productive hours worked by the direct workers in actually manufacturing the products is 80%; in addition the non-productive downtime is budgeted at 20% of the productive hours worked.

There are twelve 5-day weeks in the budget period and it is anticipated that sales and production will occur evenly throughout the whole period.

It is anticipated that stock at the beginning of the period will be:

Product A 510 units; Product B 1,200 units; Raw material 2,150 Kg.

The target closing stock, expressed in terms of anticipated activity during budget period are - Product A 15 days sales; Product B 20 days sales; Raw material 10 days consumption.

Required

(i) the material purchases budget, and

(ii) the wages budget for the direct workers, showing the quantities and values, for the next period.

Solution

(i) Material Purchase Budget
(in quantities and value)

Particulars	**Total**
Material Consumption (Kg.) A (1,740 units x 5 Kg.= 8,700) B (2,000 units x 3 Kg.= 6,000)	14,700
Add: Closing Balance of Material (Kg.) (W.N. 3)	2,450
Less: Anticipated Opening Balance of Material (Kg.)	2,150
Total Quantity of Material (Kg.) to be purchased	15,000
Total Value of Material to be purchased (15,000 Kg. x ₹12)	₹1,80,000

(ii) Direct Workers Wages Budget

(Showing hours required and wages paid)

Particulars	Total
Standard Hours for Budgeted Production A (1,740 units x 5 hrs.= 8,700) B (2,000 units x 4 hrs.= 8,000)	16,700
Standard Hours for Budgeted Production at Targeted Efficiency Ratio (W.N. 4)	20,875
Add: Non Productive Downtime (20% x 20,875 hours)	4,175
Total Labour Hours Required	25,050
Less: Normal Labour Hours (45 workers x 12 weeks x 5 days x 8 hours)	21,600
Difference (Overtime hours)	3,450
Wages for normal hours (21,600 hours x ₹ 8)	₹1,72,800
Overtime Wages (3,450 x ₹12)	₹41,400
Total Wages	₹2,14,200

Working Notes

1. Computation of Closing Stock Balance of Products A and B

Budgeted Period of Sales (In days) = 12 weeks x 5 days = 60 days

Closing Stock of Product A (Units) (15 days sales)

$$= \frac{1{,}800 \text{ units} \times 15 \text{ days}}{60 \text{ days}}$$

= 450 units

Closing stock of Product B (units) (20 days sales)

$$= \frac{2{,}400 \text{ units} \times 20 \text{ days}}{60 \text{ days}}$$

= 800 units

2. Production Budget (Units)

Particulars	Products	
	A	B
Sales in units (60 days)	1,800	2,400
Add: Closing Stock (W.N. 1)	450	800
Total	2,250	3,200
Less: Anticipated Opening Balance	510	1,200
Total Number of Units to be produced	1,740	2,000

3. Closing Balance of Material (Kg.)

Closing Balance of Material(10 days consumption)

$$= \frac{14,700 \text{ kg}}{60 \text{ days}} \times 10 \text{ days}$$

$$= 2,450 \text{ Kg.}$$

4. Standard Hours for Budgeted Production at targeted 80% efficiency ratio

$$= \frac{16,700 \text{ hrs.}}{80} \times 100$$

$$= 20,875 \text{ hrs.}$$

Problem-17

Balrampur Mfg. Ltd. produces and sells a single product. Sales budget for the calendar year 2014 by quarter is as under:

Quarter	*No. of units to be sold*	*Quarter*	*No. of units to be sold*
i	*12,000*	*iii*	*16,500*
Ii	*15,000*	*iv*	*18,000*

The year 2014 is expected to open with an inventory of 4,000 units of finished product and close with an inventory of 6,500 units.

Production is customarily scheduled to provide for two-thirds of the current quarter's sales demand plus one third of the following quarter's demand.

The standard materials 10 lbs. @ 50 paise per lb.

Direct labour 1 hour 30 minutes @ ₹ 4 per hour.

Variable overheads 1 hour 30 minutes @ ₹ 1 per hour.

Fixed overheads ₹ 1,80,000 p.a.

Required

(i) *Prepare a Production Budget for 2014, by quarters, showing the number of units to be produced, and the total costs of direct labour, variable overheads and fixed overheads.*

(ii) *If the budgeted selling price per unit is ₹ 17, what would be the budgeted profit for the year as a whole?*

(iii) *In which quarter of the year is the company expected to break even?*

Solution

Production Budget *for the year* 2014 (by Quarters)

Particulars	Units to be Produced				
	Q.I	Q.II	Q.III	Q.IV	Total
2/3 of the Current Quarter's Sales	8,000	10,000	11,000	12,000	41,000
1/3 of the Following Quarter's Sales	5,000	5,500	6,000	6,500	23,000
No. of units to be produced	13,000	15,500	17,000	18,500	64,000*

(*) ₹61,500 + ₹6,500 - ₹4,000

Statement Showing Total Cost of Direct Material, Direct Labour, Variable Overheads and Fixed Overhead

Particulars	Q.I	Q.II	Q.III	Q.IV	Total
Unit (to be produced)	13,000	15,500	17,000	18,500	64,000
	(₹)	(₹)	(₹)	(₹)	(₹)
Direct Material Cost [W.N.1]	65,000	77,500	85,000	92,500	3,20,000
Direct Labour Cost [W.N.2]	78,000	93,000	1,02,000	1,11,000	3,84,000
Variable Overhead Cost [W.N.3]	19,500	23,250	25,500	27,750	96,000
Fixed Overhead Cost [W.N.4]	45,000	45,000	45,000	45,000	1,80,000
Total Cost	2,07,500	2,38,750	2,57,500	2,76,250	9,80,000

Working Notes

Particulars		Q.I	Q.II	Q.III	Q.IV	Total
1.	Direct Materials in (lbs.) [@ 10 lbs. per unit]	1,30,000	1,55,000	1,70,000	1,85,000	6,40,000
	Direct Material Cost [@ ₹ 0.50 per lb.] In (₹)	65,000	77,500	85,000	92,500	3,20,000
2.	Direct Labour Hours [@ 1.5 hours per unit]	19,500	23,250	25,500	27,750	96,000
	Direct Labour Cost [@ ₹ 4.00 per hour in (₹)]	78,000	93,000	1,02,000	1,11,000	3,84,000
3.	Variable Overhead Cost [@ ₹ 1 per hour] In (₹)	19,500	23,250	25,500	27,750	96,000
4.	Fixed overhead cost has been divided equally over the four quarters					

Budgeted Profit Statement for the Whole Year

	₹
Total Sales Revenue (61,500 × ₹ 17)	10,45,500
Total Variable Cost * (61,500 × ₹ 12.50)	7,68,750
Contribution	2,76,750
Fixed Cost	1,80,000
Profit *for the year*	96,750

(*) Variable Cost *per unit:*

Direct Material Cost (10 lbs × ₹ 0.50)	5.00
Direct Labour Cost (1.5 hours × ₹ 4.00)	6.00
Variable Overhead Cost (1.5 hrs. × ₹1.00)	1.50
Total	12.50

Break Even Point

$$\text{Break Even Point} = \frac{\text{Fixed Cost}}{\text{Contribution per Unit}} = \frac{₹\ 1,80,000}{₹\ 4.50} = 40,000 \text{ units}$$

The total sales in units by the end of 3rd quarter will amount to 43,500. Accordingly, the company will break even only in the latter part of the 3rd quarter.

Problem-18

Valley Ltd. produces and markets a very popular product called 'X'. The company is interested in presenting its budget for the second quarter of 2014.

The following information are made available for this purpose:

(a) It expects to sell 50,000 bags of 'X' during the second quarter of 2014 at the selling price of ₹ 9 per bag.

(b) Each bag of 'X' requires 2.5 kgs. of a raw – material called 'Y' and 7.5 kgs. of raw – material called 'Z'.

(c) Stock levels are planned as follows:

Particulars	***Beginning of Quarter***	***End of Quarter***
Finished Bags of 'X' (Nos.)	*15,000*	*11,000*
Raw – Material 'Y' (Kgs.)	*32,000*	*26,000*
Raw – Material 'Z' (Kgs.)	*57,000*	*47,000*
Empty Bag (Nos.)	*37,000*	*28,000*

(d) *'Y' cost ₹ 1.20 per Kg., 'Z' costs 20 paise per Kg. and 'Empty Bag' costs 80 paise each.*

(e) *It requires 9 minutes of direct labour to produce and fill one bag of 'X'. Labour cost is ₹ 5 per hour.*

(f) *Variable manufacturing costs are ₹ 0.45 bag. Fixed manufacturing costs ₹ 30,000 per quarter.*

(g) *Variable selling and administration expenses are 5% of sales and fixed administration and selling expenses are ₹ 25,000 per quarter.*

Required

(i) *Prepare a production budget for the said quarter.*

(ii) *Prepare a raw – material purchase budget for 'Y', 'Z' and 'Empty Bags' for the said quarter in quantity as well as in rupees.*

(iii) *Compute the budgeted variable cost to produce one bag of 'X'.*

(iv) *Prepare a statement of budgeted net income for the said quarter and show both per unit and total cost data.*

Solution

(i) Production Budget of 'X' for the Second Quarter

Particulars	**Bags (Nos.)**
Budgeted Sales	50,000
Add: Desired Closing stock	11,000
Total Requirements	61,000
Less: Opening stock	15,000
Required Production	46,000

(ii) Raw–Materials Purchase Budget in Quantity as well as in ₹ for 46,000 Bags of 'X'

Particulars	**'Y' Kgs.**	**'Z' Kgs.**	**Empty Bags Nos.**
Production Requirements Per bag of 'X'	2.5	7.5	1.0
Requirement for Production	1,15,000 (46,000 × 2.5)	3,45,000 (46,000 × 7.5)	46,000 (46,000 × 1)
Add: Desired Closing Stock	26,000	47,000	28,000

Total Requirements	1,41,000	3,92,000	74,000
Less: Opening Stock	32,000	57,000	37,000
Quantity *to be purchased*	1,09,000	3,35,000	37,000
Cost per Kg./Bag	₹1.20	₹ 0.20	₹ 0.80
Cost of Purchase (₹)	1,30,800	67,000	29,600

(iii) Computation of Budgeted Variable Cost of Production of 1 Bag of 'X'

Particulars	**(₹)**
Raw – Material	
Y 2.5 Kg @1.20	3.00
Z 7.5 Kg. @0.20	1.50
Empty Bag	0.80
Direct Labour (₹ 5 × 9 minutes / 60 minutes)	0.75
Variable Manufacturing Overheads	0.45
Variable Cost of Production *per bag*	6.50

(iv) Budgeted Net Income for the Second Quarter

Particulars	**Per Bag (₹)**	**Total (₹)**
Sales Value (50,000 Bags)	9.00	4,50,000
Less: Variable Cost:		
Production Cost	6.50	3,25,000
Admn. & Selling Expenses (5% of Sales Price)	0.45	22,500
Budgeted Contribution	2.05	1,02,500
Less: Fixed Expenses:		
Manufacturing		30,000
Admn. & Selling		25,000
Budgeted Net Income		47,500

Problem-19

Chetak Ltd. produces and markets three products - Chairs, Tables and Benches. The company is interested in presenting its budget for the next quarter ending 31st March, 2014. It expects to sell 4,200 Chairs, 800 Tables and 500 Benches during the said period at the selling *price of ₹ 50, ₹ 85 and ₹ 158 per unit respectively. The following information are made available for the purpose.*

(a) Material and Labour requirements:

Particulars	*Chairs*	*Tables*	*Benches*
Timber per unit (in cu. ft.)	*0.50*	*1.20*	*2.50*
Upholstery per unit (in sq. yds.)	*0.25*	*---*	*---*
Carpenter's time (minutes per unit)	*45*	*60*	*75*
Fixer and Finisher's time (minutes per unit)	*15*	*15*	*30*

Timber costs ₹ 50 per cu. ft. and Upholstery costs ₹ 20 per sq. yd. Fixing and Finishing materials costs 5% of the cost of Timber and Upholstery. Carpenter gets ₹ 6 per hour while the Fixer and Finisher gets ₹ 4.80 per hour.

(b) Inventory Levels planned:

Particulars	*Timber (Cu. Ft.)*	*Upholstery (Sq. Yds.)*	*Chairs (Nos.)*	*Tables (Nos.)*	*Benches (Nos.)*
Opening	*600*	*400*	*400*	*100*	*50*
Closing	*650*	*260*	*200*	*300*	*50*

(c) Fixed Overheads would be ₹ 8,000 per month.

Required

(i) Prepare a 'Production Budget' showing quantities to be manufactured.

(ii) Prepare a 'Raw Materials Purchase Budget' in quantities as well as in rupees.

(iii) Draw a 'Direct Wages Cost Budget'.

(iv) Present a 'Statement of Variable Cost of Manufacture' per unit of all three products.

(v) Find out the 'Budgeted Net Income' for the said quarter.

Solution

(i) Production Budget (in Units)

Particulars	Chairs	Tables	Benches
Units to be Sold	4,200	800	500
Add: Planned Cl. Stock	200	300	50
Less: Planned Opening Stock	400	100	50
Units to be Manufactured	4,000	1,000	500

(ii) Raw Materials Purchase Budget (in Quantities)

Particulars	Timber (Cft.)	Upholstery (Sq. Yds.)
Materials required for Production (W.N. 1)	4,450	1,000
Add: Planned Closing Stock	650	260
Less: Planned Opening Stock	600	400
Raw Materials to be Purchased	4,500	860

Material Purchase Budget (in ₹)

Particulars	Quantities to be Purchased	Rate (₹)	Amount (₹)
Timber (Cft.)	4,500	50	2,25,000
Upholstery (Sq. Yds)	860	20	17,200
Total			2,42,200

(iii) Direct Wages Cost Budget

Particulars	Total (Hrs.)	Rate p.h. (₹)	Amount (₹)
Carpenter's Time and Wages (W.N. 1)	4,625	6.00	27,750
Fixer and Finisher's Time and Wages (W.N.1)	1,500	4.80	7,200
Total			34,950

(iv) Variable Cost *per unit*

Particulars	Chairs (₹)	Tables (₹)	Benches (₹)
Raw Materials:			
Timber	25.00 (0.50 × ₹ 50)	60.00 (1.20 × ₹ 50)	125.00 (2.50 × ₹ 50)
Upholstery	5.00 (0.25 × ₹ 20)	-----	-----
Fixing and Finishing (W.N. 2)	1.50	3.00	6.25
Wages:			
Carpenter	4.50 (₹ 6 × 45/60)	6.00 (₹ 6 × 60/60)	7.50 (₹ 6 × 75/60)

Fixer and Finisher	1.20 (₹ 4.80 × 15/60)	1.20 (₹ 4.80 × 15/60)	2.40 (₹ 4.80 × 30/60)
Total Variable Cost (per unit)	37.20	70.20	141.15

(v) Budgeted Net Income Statement for the Quarter

Particulars	Chairs (₹)	Tables (₹)	Benches (₹)	Total (₹)
Selling Price per unit (₹)	50.00	85.00	158.00	
Less: Variable Cost per unit (₹)	37.20	70.20	141.15	
Contribution per unit (₹) ...(A)	12.80	14.80	16.85	
Units to be Sold ...(B)	4,200	800	500	
Total Contribution (₹) ...(A) x (B)	53,760	11,840	8,425	74,025
Less: Fixed Cost (₹)				24,000
Budgeted Net Income (₹)				50,025

Working Notes

1. Requirements as to Raw Materials Carpenter's Time and Fixer's and Finisher's Time

Particulars	Chair	Tables	Benches	Total
Units to be Manufactured	4,000	1,000	500	
Timber (Ctf.)	2,000 (4,000 × 0.50)	1,200 (1,000 × 1.20)	1,250 (500 × 2.50)	4,450
Upholstery (Sq. Yds.)	1,000 (4,000 × 0.25)	-----	-----	1,000
Carpenter's Time (Hrs.)	3,000 (4,000 × 45 / 60)	1,000 (1,000 × 1)	625 (500 × 75 / 60)	4,625
Fixer and Finisher's Time (Hrs.)	1,000 (4,000 × 15/60)	250 (1,000 × 15/60)	250 (500 × 30/60)	1,500

2. Fixing and Finishing Material Cost (per unit)

Particulars	Chair (₹)	Tables (₹)	Benches (₹)
Total Cost of Timber and Upholstery	30	60	125
Fixing and Finishing Material Cost (5% of total cost of timber and upholstery)	1.50 (₹ 30 × 5/100)	3.00 (₹ 60 × 5/100)	6.25 (₹ 125 × 5/100)

Principal Budget Factor

Problem-20

JCL Corporation manufactures and sells two products RB and RD. Three types of materials, A, B and C are required for producing these products. Projected information for 2015-16 is given below:

Product	*Projected sales for 2015-16*	*Inventory (in units)*		*Direct Labour Requirement*
	Units	*On 1-4-2015*	*On 31-3-2016*	*Hours/Unit*
RB	*75,000*	*25,000*	*31,250*	*4*
RD	*50,000*	*10,000*	*11,250*	*6*

Raw material stock and usage are as follows:

Direct Material	*Requirement per unit*		*Inventory on 1-4-2015*	*Inventory on 31-3-2016*
	RB	*RD*		
A	*5.00 kg*	*5.00 kg.*	*40,000 kg*	*45,000 kg*
B	*2.50 kg*	*3.00 kg*	*36,250 kg*	*40,000 kg*
C	*0*	*1.00 kg*	*7,500 kg*	*8,750 kg*

Required

Prepare the following for 2015-16-

(i) *Production budget (in units)*

(ii) *Direct material purchase budget in quantities for A, B and C.*

(iii) *After (i) and (ii), you are told that only 6,00,000 labour hours will be available for production. If there is no requirement to hold the stated level of finished goods closing inventory, what would be the principal budget factor? Substantiate your view with appropriate figures.*

Solution

(i) **Statement Showing "Production Budget"**

Particulars	'RB' (units)	'RD' (units)
Inventory (at the end of the year)	31,250	11,250
Add: Projected Sales	75,000	50,000
Total Requirements	1,06,250	61,250
Less: Beginning inventory	25,000	10,000
Production	81,250	51,250

(ii) **Statement Showing "Direct Material Purchase Budget"**

Particulars	Material 'A' (Kg.)	Material 'B' (Kg.)	Material 'C' (Kg.)
Requirement for Production 'RB'	4,06,250 (81,250 units × 5 Kg.)	2,03,125 (81,250 units × 2.50 Kg.)	---
Requirement for Production 'RD'	2,56,250 (51,250 units × 5 Kg.)	1,53,750 (51,250 units × 3 Kg.)	51,250 (51,250 units × 1 Kg.)
Total Requirement	6,62,500	3,56,875	51,250
Add: Closing inventory	45,000	40,000	8,750
Less: Beginning inventory	40,000	36,250	7,500
Purchase	6,67,500	3,60,625	52,500

(iii) **Statement Showing "Direct Labour Hours Required vs Available"**

Particulars	'RB' Units	'RD' Units	Total
Maximum Sales	75,000	50,000	
Less: From Stock	25,000	10,000	
Required Goods for Pdn.	50,000	40,000	
Direct Labour Requirement	2,00,000 (50,000 units × 4 hrs.)	2,40,000 (40,000 units × 6 hrs.)	4,40,000 hrs.
Direct Labour Available			6,00,000 hrs.

∵ Direct Labour Hrs. (Requirement) is < Direct Labour Hrs. (Availability)

∴ **Principal Budget Factor is Sales (units)**

Budgeted Financials

Problem-21

Star Ltd. manufactures two products A and B. The summarised Balance Sheet of the company as at 31st March, 2012 is as under:–

Equity and Liabilities	***(₹)***
Shareholder's funds	
Share Capital	*12,00,000*
Reserve and Surplus	*96,000*
Current Liabilities	
Trade Payables	*48,000*
Short-Term Provisions	
Provision for Income Tax	*60,000*
Total	*14,04,000*
Assets	***(₹)***
Non-Current Assets	
Fixed Assets (Net)	*9,00,000*
Current Assets	
Inventories	*3,54,000*
Trade Receivables	*90,000*
Cash and Cash Equivalents	*60,000*
Total	*14,04,000*

The following information has been furnished to you for the preparation of the budget for the year ending 31st March, 2013:–

(i) Sales forecast :–

Product A 24,000 units at ₹ 30 per unit.

Product B 15,000 units at ₹ 40 per unit.

(ii) Raw Materials :–

Particulars	Products	
	A	B
Material X @ ₹ 3 per kg.	2 kgs.	4 kgs.
Material Y @ ₹ 1 per kg.	1 kg.	2 kgs.

(iii) Direct Labour:–

Dep. P: 2 Hrs @ ₹ 1 per hour for A.

1 Hrs. @ ₹ 2 per hour for B.

Dep. Q: 1 Hrs. @ ₹ 3 per hour for A

1 Hrs. @ ₹ 3 per hour for B.

(iv) Overheads :–

Particulars	Dept. P (₹)	Dept. Q (₹)
Fixed Overheads per annum :–		
Depreciation	48,000	12,000
Others	96,000	30,000
Variable Overheads per hour	0.50	1.50

(v) Inventories :–

(a) Raw Materials:

Opening Stock

X 36,000 kgs.
Y 6,000 kgs. } ₹ 1,14,000

Closing Stock

X 48,000 kgs.

Y 12,000 kgs.

(b) Finished Goods:

Opening Stock

A 600 Units
B 6,000 Units } ₹ 2,40,000

Closing Stock

A 6,600 units

B 3,000 units

(vi) *Selling, Distribution and Administration expenses are estimated at ₹ 1,80,900 per annum.*

(vii) *The cost of raw material purchases, direct wages, factory overheads, selling, distribution and administration overheads of the year will be met in full in cash during the year. The estimated position of debtors and creditors as on 31st March, 2013 is ₹ 1,50,000 and ₹ 48,000 respectively. Income tax provision standing at the beginning of the year will be paid during the year. Rate of income tax is 30%. An equipment purchased at ₹ 1,20,000 will be paid during the year.*

Required

Prepare for the year ending 31st March, 2013-

(a) *Cost of Goods Sold Budget.*

(b) *Cash Budget.*

(c) *Projected Balance Sheet as at 31st March, 2013 in the same format as given in the problem.*

The detailed working for each of the above should be shown.

Solution

Working Notes

1. Production Budget (Units)

Particulars	**A**	**B**
Sales	24,000	15,000
Add : Closing Stock	6,600	3,000
Total	30,600	18,000
Less : Opening Stock	600	6,000
Production	30,000	12,000

2. Direct Material Cost

Particulars	**A** (₹)	**B** (₹)	**Total** (₹)
Material X @ ₹ 3 per Kg.	6	12	
Material Y @ ₹ 1 per Kg.	1	2	

Material Cost (per unit) ...(a)	7	14	
Production (units) ...(b)	30,000	12,000	
Direct Material Cost (₹) ...(a) × (b)	2,10,000	1,68,000	3,78,000

3. Direct Labour Cost

Particulars	A (₹)	B (₹)	Total (₹)
Dept. P : 2 hr @ ₹ 1 per hr. for A	2		
1 hr. @ ₹ 2 per hr. for B		2	
Dept. Q : 1 hr. @ ₹ 3 per hr. for A	3		
1 hr. @ ₹ 3 per hr. for B		3	
Direct Labour Cost (per unit) ...(a)	5	5	
Production (units) ...(b)	30,000	12,000	
Direct Labour Cost (₹) ...(a) × (b)	1,50,000	60,000	2,10,000

4. Direct Labour Hours

Particulars	Dept. P	Dept. Q
A: P 30,000 × 2 hrs Q 30,000 × 1 hr.	60,000	30,000
B: P 12,000 × 1 hrs Q 12,000 × 1 hr.	12,000	12,000
Total	72,000	42,000

5. Overhead Recovery Rate

Particulars	Dept. P	Dept. Q
Fixed Overheads:	(₹)	(₹)
Depreciation	48,000	12,000
Others	96,000	30,000
Total	1,44,000	42,000
Direct Labour Hours	72,000	42,000
Fixed Overhead (rate per hr.) ...(a)	2.00	1.00
Variable Overhead (rate per hr.) ...(b)	0.50	1.50
Total Overhead (rate per hr.) ...(a) + (b)	2.50	2.50

6. **Overhead Expenses**

Particulars	Dept P (₹)	Dept Q (₹)	Total (₹)
Fixed (other than Depreciation)	96,000	30,000	
Variable [72,000 hr × ₹ 0.50; 42,000 hr × ₹ 1.50]	36,000	63,000	
Total Overheads (other than Dep.) …(a)	1,32,000	93,000	225,000
Depreciation …(b)	48,000	12,000	60,000
Total Overheads …(a) + (b)	1,80,000	1,05,000	285,000

7. **Cost Sheet**

Particulars	Products		
	A (₹)	B (₹)	Total (₹)
Direct Material (per unit)	7.00	14.00	
Direct Wages (per unit)	5.00	5.00	
Overhead (per unit) [Dept. P]	5.00	2.50	
[Dept. Q]	2.50	2.50	
Total Cost (per unit) ...(a)	19.50	24.00	
Production …(b)	30,000	12,000	
Total Cost …(a) × (b)	5,85,000	2,88,000	8,73,000

8. **Sales**

Particulars		(₹)
A	24,000 units × ₹ 30	7,20,000
B	15,000 units × ₹ 40	6,00,000
	Total	13,20,000

9. **Trade Receivables**

Particulars	(₹)
Opening Balance	90,000
Add: Sales	13,20,000
Total	14,10,000
Less: Closing Balance	1,50,000
Cash Receipts	12,60,000

10. Raw Material

Particulars	Material		Total
	X (Kg.)	Y (Kg.)	(₹)
Consumption for 'A'	60,000	30,000	
Consumption for 'B'	48,000	24,000	
Total Consumption	1,08,000	54,000	
Add: Closing Stock	48,000	12,000	
Total	1,56,000	66,000	
Less: Opening Stock	36,000	6,000	
Material to be Purchase	1,20,000	60,000	
Purchase Price per Kg.	₹ 3	₹ 1	
Purchase Value (₹)	3,60,000	60,000	4,20,000

11. Trade Payables

Particulars	(₹)
Opening Balance	48,000
Add: Purchases	4,20,000
Total	4,68,000
Less: Closing Balance	48,000
Paid	4,20,000

12. Inventories as on 31.03.2013

Particulars	(₹)
Raw Material : 'X' 48,000 units × ₹ 3 = ₹1,44,000 'Y' 12,000 units × ₹ 1 = ₹12,000	1,56,000
Finished Goods : 'A' 6,600 × ₹ 19.50 = ₹1,28,700 'B' 3,000 × ₹ 24.00 = ₹72,000	2,00,700

13. Fixed Assets as at 31.03.2013

Particulars	(₹)
Opening Values of Fixed Assets	9,00,000
Add: Additions	1,20,000
Less: Depreciation	60,000
	9,60,000

Computation of Requirements

(a) Cost of Goods Sold Budget

Particulars	**(₹)**
Direct Materials (Note 2)	3,78,000
Direct Wages (Note 3)	2,10,000
Overheads (Note 6)	2,85,000
Total	8,73,000
Add : Opening Stock (Balance Sheet)	2,40,000
Total	11,13,000
Less: Closing Stock (Note 12)	2,00,700
Cost of Goods sold	9,12,300

(b) Cash Budget

Particulars		**(₹)**
Opening Balance (Balance Sheet)		60,000
Receipts (Note 9)		12,60,000
Total Receipts	…(A)	13,20,000
Payments :		
Creditors (Note 11)		4,20,000
Direct Wages (Note 3)		2,10,000
Overheads (Note 6)		2,25,000
Selling, Distribution and Administration Expenses		1,80,900
Income Tax		60,000
Capital Expenditure		1,20,000
Total Payments	…(B)	12,15,900
Closing Balance	…(A) – (B)	1,04,100

(c) Projected Balance Sheet as at March, 31, 2013

Equity and Liabilities	**(₹)**
Shareholder's Funds	
Share Capital	12,00,000
Reserve and Surplus*	2,54,760
Current Liabilities	
Trade Payables	48,000
Short-term Provisions	
Provision for Income Tax	68,040
Total	15,70,800

Assets	**(₹)**
Non-Current Assets	
Fixed Assets (Net)	9,60,000
Current Assets	
Inventories	3,56,700
Trade Receivables	1,50,000
Cash and Cash Equivalents	1,04,100
Total	15,70,800

* **Reserve & Surplus**

Particulars	**(₹)**
Sales (Note 8)	13,20,000
Less: Cost of Goods Sold	9,12,300
Gross Profit	4,07,700
Less: Selling Dist. & Admn. Expenses	1,80,900
Profit before tax	2,26,800
Less: Provisions for Tax (30%)	68,040
Profit after tax	1,58,760
Add: Opening Balance of Reserve & Surplus	96,000
Closing Balance of Reserve Surplus	2,54,760

Key Factor

Problem-22

Aakar Ltd. furnishes you the following information relating to four varieties of products manufactured by them during the year 2011

	A	***B***	***C***	***D***
Output (units)	*32,000*	*20,000*	*16,000*	*24,000*
	₹ Per Unit			
Selling Price	*300*	*600*	*750*	*500*
Direct Materials	*60*	*140*	*160*	*60*
Direct Wages	*50*	*80*	*150*	*60*
Variable Overhead	*100*	*160*	*300*	*120*
Fixed Overhead	*100*	*160*	*300*	*120*

Anticipation of the company for the Budget for the year 2012 is as follows:

(a) Expected increments are as follows in pursuant of Inflation:

(i) Direct Material 10%

(ii) Direct Wages 20%

(iii) Variable Overheads 20%

(b) Fixed Overhead will increase by ₹160,000

(c) The market will take up an increase of 10% in the price, if Volume of Sales in quantities is maintained at the same level as in the year 2011

In order to fight inflation the Marketing Team puts forth the following proposals:

(a) Product A: The price of product A will be further increased by 20% (making in all a total increase of 30%) resulting thereby in a reduction in the volume of Sales by 10%

(b) Product B: Substitution on direct materials of product B by cheaper materials will bring about a reduction in direct material cost by ₹30 per unit. This will reduce the sales volume in units by10%.

(c) Product C: An allowance of special sales commission of 4% on the increased price on all quantities sold will increase the sales volume by 20%

(d) Product D: A reduction in selling price by 10% on the price of 2011 will yield an increase in sales volume by 30%

The direct labour hour rate in 2011 is ₹4.00 per hour and the number of direct labour hours cannot be increased in the year 2012.

Required

(i) Present a statement showing Profitability for the year 2011.

(ii) Prepare a budget for the year 2012 after taking into consideration the effects of inflation in costs and prices only.

(iii) Evaluate the proposals put forth by the Marketing Team and set an optimum product mix after taking into consideration the inflation in costs and prices but subject to the constraint of available labour hours.

Solution

(i) Statement of Profit of 2011

	A	B	C	D	Total
Sales Units	32,000	20,000	16,000	24,000	92,000
	(₹In Lacs)				
Sales	96.00	120.00	120.00	120.00	456.00

Direct Material	19.20	28.00	25.60	14.40	87.20
Direct Wages	16.00	16.00	24.00	14.40	70.40
Variable Overhead	32.00	32.00	48.00	28.80	140.80
Variable Cost	67.20	76.00	97.60	57.60	298.40
Contribution	28.80	44.00	22.40	62.40	157.60
Fixed Overhead	32.00	32.00	48.00	28.80	140.80
Profit/(Loss)	(3.20)	12.00	(25.60)	33.60	16.80

Direct Labour Hours per Unit	12.50	20.00	37.50	15.00	
Direct Labour Hours Required	400,000	400,000	600,000	360,000	1,760,000

(ii) Statement of Budget 2012 (After Impact of Inflation)

	A	B	C	D	Total
Sales Units	32,000	20,000	16,000	24,000	92,000
	(₹In Lacs)				
Sales	105.60	132.00	132.00	132.00	501.60
Direct Material	21.12	30.80	28.16	15.84	95.92
Direct Wages	19.20	19.20	28.80	17.28	84.48
Variable Overhead	38.40	38.40	57.60	34.56	168.96
Variable Cost	78.72	88.40	114.56	67.68	349.36
Contribution	26.88	43.60	17.44	64.32	152.24
Fixed Overhead (140.80+1.60)					142.40
Profit/(Loss)					9.84

	A	B	C	D	Total
Direct Labour Hours	400,000	400,000	600,000	360,000	1,760,000
Contribution per Labour Hour (₹)	6.72	10.90	2.91	17.87	8.65

(iii) Statement of Profit 2012 - Proposals of Marketing Team

	A	B	C	D	Total
Sales Units	28,800	18,000	19,200	31,200	97,200
	(₹In Lacs)				
Sales	112.32	118.80	158.40	140.40	529.92
Less: Commission	---	---	6.34	---	6.34
Net Sales	112.32	118.80	152.06	140.40	523.58
Direct Material	19.01	22.32	33.79	20.59	95.71
Direct Wages	17.28	17.28	34.56	22.46	91.58

Variable Overhead	34.56	34.56	69.12	44.93	183.17
Variable Cost	70.85	74.16	137.47	87.98	370.46
Contribution	41.47	44.64	14.59	52.42	153.12
Fixed Overhead					142.40
Profit/ (Loss)					10.72

	A	B	C	D	Total
Labour Hrs. Required	3,60,000	3,60,000	7,20,000	4,68,000	1,908,000
Contribution per Labour Hours (₹)	11.52	12.40	2.03	11.20	

Revised Position on the basis of the 'Proposal of Marketing Team' and Product Mix after taking into consideration the 'Inflation in Costs and Prices' but subject to the 'Constraint of Available Labour Hours'.

	A	B	C*	D*	Total
Sales Units	28,800	18,000	16,000	24,000	86,800
	(₹ In Lacs)				
Sales	112.32	118.80	132.00	132.00	495.12
Less: Commission	---	---	---	---	---
Net Sales	112.32	118.80	132.00	132.00	495.12
Direct Material	19.01	22.32	28.16	15.84	85.33
Direct Wages	17.28	17.28	28.80	17.28	80.64
Variable Overhead	34.56	34.56	57.60	34.56	161.28
Variable Cost	70.85	74.16	114.56	67.68	327.25
Contribution	41.47	44.64	17.44	64.32	167.87
Fixed Overhead					142.40
Profit/(Loss)					25.47

	A	B	C	D	Total
Labour Hrs Required	360,000	360,000	600,000	360,000	1,680,000
Contribution per Labour Hour (₹)	11.52	12.40	2.91	17.87	

**By following the strategy of Marketing Team, Contribution per Labour Hour has reduced in case of Product C & D. Therefore strategy of Marketing Team should be followed in Case of Product A&B only.*

Inventory Control

Problem-23

Bintan-Indo Manufacturers Ltd. (BIML) is specialist in the manufacturing of Industrial Products. They manufacture and market two types of products under the name 'X' and 'Y'. Company produces two products from three basic raw materials 'A', 'B', and 'C'. Company follows a 13-period reporting cycle for budgeting purpose. Each period is four weeks long and has 20 working days. Data relating to the purchase of raw materials are presented below:

Raw Material	Purchase Price (Per Kg)	Standard Purchase Lot (Kg)	Reorder Point (Kg)	Projected Inventory Status at the end of 5th period (Kg)		Lead Time in Working Days
				On Hand	On Order	
A	₹ 1.00	90,000	72,000	96,000	90,000	10
B	₹ 2.00	30,000	45,000	54,000	-	25
C	₹ 1.00	60,000	60,000	84,000	60,000	20

Past experience has shown that adequate inventory levels for 'X' and 'Y' can be maintained if 40 percent of the next period's projected sales are on hand at the end of a reporting period. Other relevant information is as follows:

Product	Raw Material Specifications			Projected Inventory Levels	Projected Sales		
	A	B	C	At the end of current (5th) period	6th Period	7th Period	8th Period
	Kg	Kg	Kg	Units	Units	Units	Units
X	1.25	0.50	-	18,000	45,000	52,500	57,000
Y	2.00	-	1.50	16,800	42,000	27,000	24,000

The sales of 'X' and 'Y' do not vary significantly from month to month. Consequently, the safety stock incorporated into the reorder point for each of the raw materials in adequate to compensate for variations in the sales of the finished products.

Raw materials orders are placed the day the quantity on hand falls below the reorder point. BIML's suppliers are very trustworthy so that the given lead times are reliable.

The outstanding orders for raw materials 'A' and 'C' are due to arrive on the 10th and 4th working day of the 6th period, respectively. Payments for all raw material orders are remitted by the 10th day of the delivery.

Required

Determine the following items for raw materials 'A', 'B', and 'C' for inclusion in the 6th period report to management:

(i) Projected quantities (in Kg) to be issued to production.

(ii) Projected quantities (in Kg) ordered and the date (in terms of working days) the order is to be placed.

(iii) The projected inventory balance (in Kg) at the end of the period.

(iv) The payments for purchases with due date.

Solution

(i) Projected Raw Material Issues (Kg)

	'A'	'B'	'C'
'X' (48,000 units-Refer Note)	60,000	24,000	---
'Y' (36,000 units-Refer Note)	72,000	---	54,000
Projected Raw Material Issues	1,32,000	24,000	54,000

Note:

- Based on this experience and the projected sales, the BIML has budgeted production of 48,000 units of 'X' and 36,000 units of 'Y' in the sixth period.

  = 52,500 × 40% + 45,000 – 18,000

  = 48,000

  = 27,000 × 40% + 42,000 – 16,800

  = 36,000

- Production is assumed to be uniform for both products within each four-week period.

(ii)/ (iii)

Projected Inventory Activity and Ending Balance (Kg)

Particulars	'A'	'B'	'C'
Average Daily Usage	6,600	1,200	2,700
Beginning Inventory	96,000	54,000	84,000
Orders Received:			
Ordered in 5th Period	90,000	-	60,000
Ordered in 6th Period	90,000	-	-
Sub Total	276,000	54,000	144,000
Issues	132,000	24,000	54,000
Projected Ending Inventory Balance	144,000	30,000	90,000

Note

- Ordered 90,000 Kg of 'A' on fourth working day.
- Order for 90,000 Kg of 'A' ordered during fifth period received on tenth working day.
- Order for 90,000 Kg of 'A' ordered on fourth working day of sixth period received on fourteenth working day.
- Ordered 30,000 Kg of 'B' on eighth working day.
- Order for 60,000 Kg of 'C' ordered during fifth period received on fourth working day.
- No orders for 'C' would be placed during the sixth period.

(iv) Projected Payments for Raw Material Purchases

Raw Material	Day/Period Ordered	Day/Period Received	Quantity Ordered	Amount Due	Day/Period Due
'A'	20th/5th	10th /6th	90,000 Kg	₹ 90,000	20th/6th
'C'	4th/5th	4th /6th	60,000 Kg	₹ 60,000	14th/6th
'A'	4th/6th	14th /6th	90,000 Kg	₹ 90,000	4th/7th
'B'	8th/6th	13th /7th	30,000 Kg	₹ 60,000	3rd /8th

☞

Raw Material 'A'

Re Order Point (Kg)	72,000	
Standard Purchase Lot (Kg)	90,000	
Lead Time (Days)	10 Days	
On Order (Kg)	90,000	(Due to Arrive on 10th Day)
Average Daily Usage (Kg)	6,600	
Closing Inventory at the end of 5th Pd.	96,000	

6th Period

Day	Kg-Received	Kg-Issued	Kg-Balance	Remark
			96,000	Inventory in hand in Beginning
1	-	6,600	89,400	
2	-	6,600	82,800	
3	-	6,600	76,200	
4	-	6,600	69,600	**Order to be place** 90,000Kg (Standard Lot Size) as Re- Order Point is 72,000 Kg. Order will receive on 14th as lead time is 10 days.
5	-	6,600	63,000	
6	-	6,600	56,400	
7	-	6,600	49,800	
8	-	6,600	43,200	
9	-	6,600	36,600	
10	90,000	6,600	1,20,000	**Order Received**, To be paid by 20th of 6th Period (Payment to be remitted by the 10th day of the delivery)
11	-	6,600	1,13,400	
12	-	6,600	1,06,800	
13	-	6,600	1,00,200	
14	90,000	6,600	1,83,600	**Order Received**, To be paid by 4th of 7th Period (Payment to be remitted by the 10th day of the delivery)
15	-	6,600	1,77,000	
16	-	6,600	1,70,400	
17	-	6,600	1,63,800	
18	-	6,600	1,57,200	
19	-	6,600	1,50,600	
20	-	6,600	1,44,000	

Budget Variance

Problem-24

Sterling Works Ltd. has at the factory three production Departments, Machine Shop, Fabrication and Assembly which are the responsibility of the shop Superintendent. The shop superintendent along with Materials Manager, Planning Superintendent and Maintenance Engineer report to the Works Manager at the factory. The office administration, sales and publicity come under the sales Manager who along with the Works Manager report to the Managing Director of the Company. The following data relating to a month's performance are culled out from the books of the company:

Particulars	***Budget (₹)***	***Variance from Budget (₹)***
Sales Commission	*800*	*50 A*
Raw Material & Components		
– Machine Shop	*900*	*20 A*
Publicity Expenses	*1,100*	*100 A*
Printing & Stationery	*3,200*	*200 F*
Travelling Expenses	*4,000*	*200 A*
Wages – Machine Shop	*800*	*10 F*
– Fabrication	*600*	*20 A*
– Assembly	*720*	*10 A*
Material – Assembly	*760*	*40 A*
– Fabrication	*460*	*10 A*
Utilities – Machine shop	*320*	*10 A*
– Assembly	*470*	*60 F*
– Fabrication	*560*	*30 F*
– Maintenance	*400*	*20 A*
– Stores	*210*	*40 F*
– Planning	*180*	*20 A*
Shop Superintendent's Office		
– Salaries & Expenses	*1,100*	*22F*
Depreciation – Factory	*3,880*	*40A*
Works Manager's Office		
– Salaries & Administration	*3,810*	*40 A*
General Office Salaries & Administration	*4,270*	*30 A*
Managing Director's Salary & Administration	*2,800*	*20 F*

Required

(i) Treating the Machine shop, Fabrication and Assembly as Cost Centres, prepare Cost Sheets for each centre with the help of this addition information:

The shop superintendent devotes his time amongst Machine shop, fabrication and Assembly in the ratio 4 : 3 : 4. Other Factory Overheads are absorbed on the basis of Direct Labour in each Cost centre.

Office, Administration, Selling and Distribution Overheads are borne equally by the Cost Centres.

(ii) Treating Machine shop, Fabrication and Assembly as Responsibility Centres prepare a Responsibility Accounting report for the shop Superintendent.

Solution

(i) Cost Sheet for Machine Shop, Fabrication and Assembly Treating them as Cost Centres

Particulars	Machine Shop		Fabrication		Assembly	
	Budget (₹)	Actual (₹)	Budget (₹)	Actual (₹)	Budget (₹)	Actual (₹)
Raw Material and Components	900	920	460	470	760	800
Wages	800	790	600	620	720	730
Utilities	320	330	560	530	470	410
Prime Cost	2,020	2,040	1,620	1,620	1,950	1,940
Shop Superintendent's Office Salary & Expenses (4 : 3 :4)	400	392	300	294	400	392
Other Factory Overheads (W. N. 1)	3,200	3,160	2,400	2,480	2,880	2,920
Factory Cost	5,620	5,592	4,320	4,394	5,230	5,252
Administration, Selling & Distribution Overheads (W. N. 2)	5,390	5,443	5,390	5,443	5,390	5,444
Total Cost	11,010	11,035	9,710	9,837	10,620	10,696

Working Notes

Particulars		Budget (₹)	Actual (₹)
(1)	**Factory Overheads :**		
	Maintenance	400	420
	Stores	210	170
	Planning	180	200
	Depreciation	3,880	3,920
	Works Establishment	3,810	3,850
	Total	8,480	8,560
	Percentage on Direct Labour	400% $\left(\frac{8,480 \times 100}{2,120}\right)$	400% $\left(\frac{8,560 \times 100}{2,140}\right)$
(2)	**Administration, Selling and Distribution Overheads :**		
	Sales Commission	800	850
	Publicity	1,100	1,200
	Printing & Stationery	3,200	3,000
	Travelling	4,000	4,200
	General Office Establishment	4,270	4,300
	Managing Director's Establishment	2,800	2,780
		16,170	16,330

(ii) Responsibility Accounting Reports for The Machine Shop, Fabrication & Assembly as Reasonability Centres

	Budget (₹)	Actual (₹)	Variance (₹)
A. Machine shop			
Material	900	920	20 A
Labour	800	790	10 F
Utilities	320	330	10 A
Total A	2,020	2,040	20 A

B. Fabrication			
Material	460	470	10 A
Labour	600	620	20 A
Utilities	560	530	30 F
Total B	1,620	1,620	-----
C. Assembly			
Materials	760	800	40 A
Labour	720	730	10 A
Utilities	470	410	60 F
Total C	1,950	1,940	10 F
Total (A+B+C)	**5,590**	**5,600**	**10 A**

Note

As shop superintendent's office – salaries and expenses included his salary also, it has been assumed that these are not controlled by him, hence not included.

Budget Ratio

Problem-25

A company manufactures two products X and Y. Product X requires 8 hours to produce while Y requires 12 hours. In April, 2004, of 22 effective working days of 8 hours a day, 1,200 units of X and 800 units of Y were produced. The company employs 100 workers in production department to produce X and Y. The budgeted hours are 1,86,000 for the year.

Required

Calculate Capacity, Activity and Efficiency ratio and establish their relationship.

Solution

Particulars	***Standard Hours Produced***		
	Product X	***Product Y***	***Total***
Output (units)	1,200	800	
Hours *per unit*	8	12	
Standard Hours	9,600	9,600	19,200

Actual Hours Worked: (100 workers × 8 hours × 22 days) 17,600

Budgeted Hours *per month*: (1,86,000 / 12) 15,500

Capacity Ratio	$= \frac{\text{Actual Hours}}{\text{Budgeted Hours}} \times 100 = \frac{17,600}{15,500}$	113.55%
Efficiency Ratio	$= \frac{\text{Standard Hours Produced}}{\text{Actual Hours}} \times 100 = \frac{19,200}{17,600} \times 100$	109.09%
Activity Ratio	$= \frac{\text{Standard Hours Produced}}{\text{Budget Hours}} \times 100 = \frac{19,200}{15,500} \times 100$	123.87%

Relationship: Activity Ratio = Efficiency Ratio $\times$ Capacity Ratio

$$= \frac{109.09 \times 113.55}{100} \qquad 123.87\%$$

Problem-26

If the 'activity ratio' and 'capacity ratio' of a company are 104% and 96% respectively, find out its 'efficiency ratio'

Solution

The various ratios are calculated as under:

(i) Activity Ratio $= \frac{\text{Standard Hours (for actual production)}}{\text{Budgeted Hours}} \times 100$

(ii) Capacity Ratio $= \frac{\text{Actual Hours (worked)}}{\text{Budgeted Hours}} \times 100$

(iii) Efficiency Ratio $= \frac{\text{Standard Hours (for actual production)}}{\text{Actual Hours (worked)}} \times 100$

From the above, it is clear that the efficiency Ratio can be obtained by dividing Activity Ratio by Capacity Ratio.

Efficiency Ratio (in percentage) = $\frac{\text{Activity Ratio}}{\text{Capacity Ratio}} \times 100$

$$= \frac{104\%}{96\%} \times 100 = 108.33\%$$

Problem-27

Calculate from the following figures:

(i) Efficiency ratio,

(ii) Activity, Ratio and

(iii) Capacity Ratio:

Budgeted Production	*880 units*
Standard Hours per unit	*10*
Actual Production	*750 units*
Actual Working Hours	*6,000*

Solution

(i) Efficiency Ratio $= \dfrac{\text{Standard Hours (for actual production)}}{\text{Actual Hours (worked)}} \times 100$

$= \dfrac{750 \text{ units} \times 10 \text{ hrs.}}{6{,}000 \text{ hrs.}} \times 100$

$= 125\%$

(ii) Activity Ratio $= \dfrac{\text{Standard Hours (for actual production)}}{\text{Budgeted Hours}} \times 100$

$= \dfrac{750 \text{ units} \times 10 \text{ hrs.}}{880 \text{ units} \times 10 \text{ hrs.}} \times 100$

$= 85.23\%$

(iii) Capacity Ratio $= \dfrac{\text{Actual Hours (worked)}}{\text{Budgeted Hours}} \times 100$

$= \dfrac{6{,}000 \text{ hrs.}}{880 \text{ units} \times 10 \text{ hrs.}} \times 100$

$= 68.15\%$

Problem-28

ABC Ltd. has produced the following figures relating to production for the week ended 27th Jan

	Production (in units)	
	Budgeted	*Actual*
Product A	*800*	*800*
Product B	*800*	*600*
Product C	*200*	*280*

Standard production times were:

	Standard hours per unit
Product A	*10*
Product B	*5*
Product C	*2*

During the week, 11,200 hours were worked on production.

Required

You are required to calculate the production volume ratio and efficiency ratio for the week ended 27st *Jan.*

Solution

Production Volume Ratio $= \dfrac{\text{StandardHoursProduced}}{\text{BudgetedHours}} \text{x} 100$

$= \dfrac{(800\text{x}10)+(600\text{x}5)+(280\text{x}2)}{(800\text{x}10)+(800\text{x}5)+(200\text{x}2)} \text{x} 100$

$=$ 93.23%

Efficiency Ratio $= \dfrac{\text{StandardHoursProduced}}{\text{ActualHours}} \text{x} 100$

$= \dfrac{(800\text{x}10)+(600\text{x}5)+(280\text{x}2)}{11{,}200} \text{x} 100$

$=$ 103.21%

Miscellaneous

Problem-29

Following information are extracted from monthly budgets of Victoria Ltd.

	November	*December*
Beginning WIP Inventory	*36,000*	*???*
Beginning Finished Goods Inventory	*44,000*	*???*
Variable Cost of Goods Sold	*1,23,000*	*???*
Direct Material Usage	*50,000*	*56,000*
Direct Labour	*53,100*	*69,000*
Variable Overhead	*25,000*	*29,000*
Variable Cost of Goods Manufactured	*1,09,000*	*1,14,800*
Ending WIP Inventory	*???*	*???*
Ending Finished Goods Inventory	*???*	*45,000*

Required

Find out missing figures.

Solution

Analysis of WIP Account

	November	**December**
Opening WIP	36,000	**55,100**
Add: Direct Materials Usage	50,000	56,000
Add: Direct Labor	53,100	69,000
Add: Variable Overhead	25,000	29,000
Total Inflow into WIP	1,64,100	2,09,100
Less: Variable Cost of Goods Manufactured	1,09,000	1,14,800
Ending WIP	**55,100**	**94,300**

Analysis of Finished Goods Inventory Account

	November	December
Opening Finished Goods	44,000	**30,000**
Add: Cost of Goods Manufactured	1,09,000	1,14,800
Cost of Goods Available for Sale	1,53,000	1,44,800
Less: Cost of Goods Sold	1,23,000	**99,800**
Ending Finished Goods Inventory	**30,000**	45,000

SECTION - C

Preparation and Monitoring Procedures

Problem-1

"Because a single budget system is normally used to serve several purposes, there is a danger that they may conflict with each other".

Required

Do you agree? Discuss.

Solution

A single budget system may be conflicting in planning and motivation, and planning and performance evaluation roles as below:

(i) Planning and motivation roles – Demanding budgets that may not be achieved may be appropriate to motivate maximum performance but they are unsuitable for planning purposes. For these, a budget should be a set based on easier targets that are expected to be met.

(ii) Planning and performance evaluation roles - For planning purposes budgets are set in advance of the budget period based on an anticipated set of circumstances or environment. Performance evaluation should be based on a comparison of active performance with an adjusted budget to reflect the circumstance under which managers actually operated.

Problem-2

"It's frustrating working with Denial. He's very dominant and expects everything to be done his way. We have done more and better work to get up to budget, and the minute we make it he tightens the budget on us. We can't work any faster and still maintain quality. We always seem to be interrupting the big jobs for all those small rush orders. The accountants seem to know everything that's happening in my department, sometimes even before I do. I thought all that budget and accounting stuff was supposed to help, but it just gets me into trouble. I'm trying to put out quality work; they're trying to save money. This is a dead end job. I don't see much of a future here." said Mr. Singh, manager of the machine shop of Global Mfg. Ltd. a UK based Company.

Mr. Singh had just attended the monthly performance evaluation meeting for plant department heads. These meetings had been held on the third Friday of each month since Mr. Denial, MBA from Manchester University, had joined the Indian operations a year earlier. Mr. Singh *had just been given the worst evaluation he had ever received in his long career with Global Mfg. Ltd. He was the most respected of the experienced machinists in the company. Old Plant Manager had often stated that the company's success was due to the high quality of the work of machinists like Mr. Singh. He had been with Global Mfg. Ltd. for many years and was promoted to supervisor of the machine shop when the company expanded and moved to its present location. As supervisor, Mr. Singh stressed the importance of craftsmanship and told his workers that he wanted no careless work coming from his department.*

When Mr. Denial became the plant manager, he directed that monthly performance comparisons be made between actual and budgeted costs for each department. The departmental budgets were intended to encourage the supervisors to reduce inefficiencies and to seek cost reduction opportunities. The company controller was instructed to have his staff 'tighten' the budget slightly whenever a department attained its budget in a given month; this was done to reinforce the plant supervisor's desire to reduce costs. Mr. Denial often stressed the importance of continued progress toward attaining the budget; he also made it know that he kept a file of these performance reports for future reference.

You are required to identify the problems which appear to exist in budgetary control system and explain how budgetary control system could be revised to improve the effectiveness.

Solution

The budgetary control system appears to have several very important shortcomings which reduce its effectiveness and may in fact cause it to interfere with good performance. Some of the shortcomings are explained below.

Lack of Coordinated Goals: Mr. Singh had been led to believe *high quality output* is the goal; it now appears *low cost* is the goal. He does not know what the goals are and thus cannot make decisions which lead toward reaching the goals.

Influences of Uncontrollable Factors: The actual performance relative to budget is greatly influenced by uncontrollable factors i.e. rush orders. Thus, the variance reports serve little purpose for evaluation of performance.

The Short-Run Perspectives: The monthly evaluation and the budget tightening on a monthly basis result in a very short-run perspective. This will result in inappropriate decisions.

The improvements in the budgetary control system must correct the deficiencies described above. Accordingly:

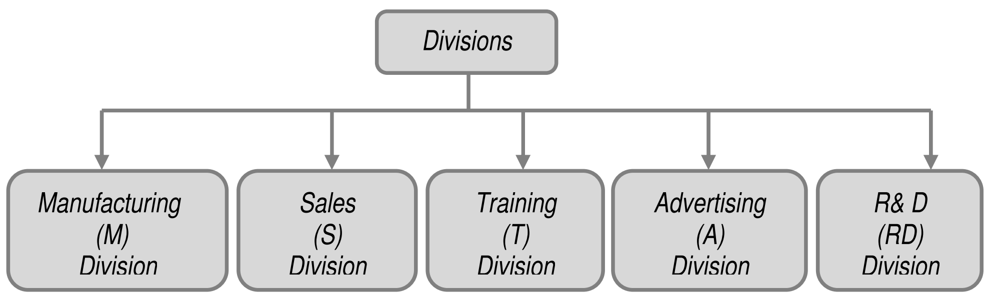
- Budgetary control system must more clearly define the company's objectives.
- Budgetary control system must develop an accounting reporting system which better matches controllable factors with supervisor responsibility and authority.
- Establish budget values for appropriate time periods which do not change monthly simply as a result of a change in the prior month's performance.

The entire company from top management down must be educated in sound budgetary procedures so that all parties will understand the total process and recognize the benefit to be gained.

Zero Based Budgeting

Problem-3

Metro Communication Limited is a state-owned large public company in the telecommunications sector. One of its main planning and control tools is the preparation and use of traditional annual budgets. Its divisional structure is as under:



Division T, A and RD incur substantial amount on discretionary expenses.

Required

Identify the possibilities of introducing a Zero Based Budgeting system for Division T, A and RD.

Solution

Discretionary costs are those that are incurred, typically each year, in an amount that is approved as part of the normal budget process. However, there is no clear relationship between the volume of services and the amount of cost that must be incurred. Manager must decide and justify the level that is deemed to be appropriate. This justification is to be made a fresh without making reference to previous level of spending in his/her department.

Zero based budgeting is undoubtedly most effective in terms of discretionary costs. The bottom line of a zero based budgeting is that it is important to understand what types of objectives are being accomplished by discretionary cost centers and what resources being devoted to accomplishing various objectives. This will allows a prioritization, so that organization can evaluate the likely impact of substantial increase or decrease in the resources allocated to the discretionary center.

Accordingly, ZBB has extensive potential application to the division T, A and RD.

Problem-4

In each of the following independent situations, state with a brief reason whether 'Zero Based Budgeting' (ZBB) or 'Traditional Budgeting' (TB) would be more appropriate for year II.

(i) A company producing a certain product has done extensive ZBB exercise in year I. The activity level is expected to marginally increase in year II.

(ii) The sale manager of a company selling three products has intuitive feeling that in year II, sales will increase for one product and decrease for the other two. His expectation can not be substantiated with figures.

(iii) The top management would like to delegate responsibility to the functional managers for their results during year II.

(iv) Resources are heavily constrained and allocation for budget requirements is very strict.

Solution

(i) The company has done extensive exercise in year-I that can be used as a basis for budgeting in year-II by incorporating increase in costs / revenue at expected activity level. Hence, **Traditional Budgeting** would be more appropriate for the company in year-II.

(ii) In Traditional Budgeting system budgets are prepared on the basis of previous year's budget figures with expected change in activity level and corresponding adjustment in the cost and prices. But under Zero Base Budgeting (ZBB) the estimations or projections are converted into figures. Since, sales manager is unable to substantiate his expectations into figures so **Traditional Budgeting** would be preferred against Zero Base Budgeting.

(iii) **Zero Base Budgeting** would be appropriate as ZBB allows top-level strategic goals to be implemented into the budgeting process by tying them to specific functional areas of the organization, where costs can be first grouped, then measured against previous results and current expectations.

(iv) Zero Base Budgeting allocates resources based on order of priority up to the spending cut-off level (maximum level upto which spending can be made). In an organisation where resources are constrained and budget is allocated on requirement basis, **Zero Base Budgeting** is more appropriate method of budgeting.

5 Standard Costing

Basic Concepts

Administrative Cost Variance	Measurement of the extent of any over- or underspend on administrative costs.
Budget Variance	Difference, for each cost or revenue element in a budget, between the budgeted amount and the actual cost or revenue. Where flexible budgeting is employed, it is the difference between the flexed budget and the actual value.
Cost	As a noun – The amount of cash or cash equivalent paid or the fair value of other consideration given to acquire an asset at the time of its acquisition or construction. As a verb – To ascertain the cost of a specified thing or activity. The word cost can rarely stand alone and should be qualified as to its nature and limitations.
Direct Material Total Variance	Measurement of the difference between the standard material cost of the output produced and the actual material cost incurred. Where the quantities of material purchased and used are different, the total variance should be calculated as the sum of the usage and price variances.
Direct Material Price Variance	Difference between the actual price paid for purchased materials and their standard cost. The material price variance may also be calculated at the time of material withdrawal from stores. In this case, the stock accounts are maintained at actual cost, price variances being extracted at the time of material usage rather than of purchase. The latter method is not usually recommended because one of the advantages of a standard costing system is the valuation of all stock at standard costs.
Direct Material Usage Variance	Measures efficiency in the use of material, by comparing standard material usage for actual production with actual material used, the difference is valued at standard cost.

	The direct material usage variance may be divided into mix and yield variances if several materials are mixed in standard proportions.
Direct Material Mix Variance	Subdivision of the material usage variance. If different materials can be substituted the mix variance measures the cost of any variation from the standard mix of materials.
Direct Material Yield Variance	Subdivision of the material usage variance. Measures the effect on cost of any difference between the actual usage of material and that justified by the output produced.
Direct Labour Total Variance	Indicates the difference between the standard direct labour cost of the output which has been produced and the actual direct labour cost incurred.
Direct Labour Rate Variance	Indicates the actual cost of any change from the standard labour rate of remuneration.
Direct Labour Efficiency Variance	Standard labour cost of any change from the standard level of labour efficiency.
Direct Labour Idle Time Variance	This variance occurs when the hours paid exceed the hours worked and there is an extra cost caused by this idle time. Its computation increases the accuracy of the labour efficiency variance.
Direct Labour Mix Variance	Subdivision of the direct labour efficiency variance. If grades of labour can be substituted the mix variance measures the cost of any variation from the standard mix of grades.
Direct Labour Yield Variance	Subdivision of the direct labour efficiency variance. Measures the effect on cost of any difference between the actual usage of labour and that justified by the output produced.
Fixed Production Overhead Total Variance	The difference between the fixed production overhead absorbed by actual production and the actual fixed production overhead incurred.
Fixed Production Overhead Volume Variance	A measure of the over- or under-absorption of overhead cost caused by actual production volume differing from that budgeted.
Fixed Overhead Capacity/ Efficiency Variance	Little used subdivision of the fixed production overhead volume variance.
Fixed Production Overhead Expenditure Variance	The difference between the fixed production overhead which should have been incurred in the period, and that which was incurred.

Joint Variance	A variance which is caused by both the prices and quantities of inputs differing from the specifications in the original standard.
Market Size Variance	A subdivision of the sales volume contribution or margin variance, applicable when the actual market size of a product or product group is known. It indicates the change in contribution or margin caused by a change in the size of the market.
Market Share Variance	A subdivision of the sales volume contribution or margin variance, applicable when the actual market size of a product or product group is known. It indicates the change in contribution or margin caused by a change in market share.
Marketing Cost Variance	Where marketing cost contains both fixed and variable components, separate variances should be calculated.
Operational Variance	Classification of variances in which non-standard performance is defined as being that which differs from an ex post standard. Operational variances can relate to any element of the standard product specification.
Planning Variance	Classification of variances caused by ex-ante budget allowances being changed to an ex post basis. Also known as a revision variance.
Standard	Benchmark measurement of resource usage or revenue or profit generation, set in defined conditions. Standards can be set on a number of bases: (i) on an ex ante estimate of expected performance; (ii) on an ex post estimate of attainable performance; (iii) on a prior period level of performance by the same organisation; (iv) on the level of performance achieved by comparable organisations; or (v) on the level of performance required to meet organisational objectives. Standards may also be set at attainable levels that assume efficient levels of operation, but that include allowance for normal loss, waste and machine down time, or at ideal levels that make no allowance for the above losses, and are only attainable under the most favourable conditions. The effect of different levels on staff motivation will be an important influence on the type of standards that are used.
Standard Cost Card/Standard Product	Document or digital record detailing for each individual product, the standard inputs required for production as well as the standard selling price. Inputs are normally divided into

Specification	labour, material and overhead categories, and both price and quantity information is shown for each.
Standard Direct Labour Cost	Planned cost of direct labour. Standard Direct Labour Cost equals to Standard Direct Labour Time for One Unit of Product multiply by Standard Labour Rate. There are separate calculations for different processes and/or grades of labour.
Standard ex ante	Before the event. An ex ante budget or standard is set before a period of activity commences.
Standard, ex post	After the event. An ex post budget, or standard, is set after the end of a period of activity, when it can represent the optimum achievable level of performance in the conditions which were experienced. Thus the budget can be flexed, and standards can reflect factors such as unanticipated changes in technology and in price levels. This approach may be used in conjunction with sophisticated cost and revenue modelling to determine how far both the plan and the achieved results differed from the performance that would have been expected in the circumstances which were experienced.
Standard Hour or Minute	Amount of work achievable, at standard efficiency levels, in an hour or minute.
Standard Performance – Labour	Level of efficiency which appropriately trained, motivated and resourced employees can achieve in the long-run.
Standard Costing	Control technique that reports variances by comparing actual costs to pre-set standards so facilitating action through management by exception.
Sales Mix Contribution/Profit Margin Variance	Subdivision of the sales volume contribution/profit margin variance. The change in the contribution/profit margin caused by a change in the mix of the products or services sold.
Sales Price Variance	Change in revenue caused by the actual selling price differing from that budgeted.
Sales Quantity Contribution/ Profit Variance	Subdivision of the sales volume contribution/ profit variance. It is relevant if there are multiple products and the actual sales mix differs from the budgeted sales mix. In these situations this variance, together with the sales mix contribution/profit variance, will comprise the sales volume contribution/profit variance (for all products).
Sales Volume Contribution/ Profit Variance	Measure of the effect on contribution/profit of not achieving the budgeted volume of sales.

Sales Volume Revenue Variance	Change in sales revenue caused by sales volume differing from that budgeted. This variance is logical but little used because it cannot be combined with contribution/profit variances in reconciling budget with actual contribution/profit. In principle, if several products are considered, the sales mix revenue variance and total sales volume revenue variance can be calculated.
Total Profit Variance	Difference between the actual profit and the profit in the budget. The total profit variance is the sum of all the subsidiary variances.
Variance	Difference between a planned, budgeted or standard cost and the actual cost incurred. The same comparisons may be made for revenues.
Variance Analysis	Evaluation of performance by means of variances, whose timely reporting should maximise the opportunity for managerial action.
Variable Production Overhead Total Variance	Measures the difference between variable overhead that should be used for actual output and variable production overhead actually used. The variable production overhead efficiency and rate variances are subdivisions of this variance.
Variable Production Overhead Efficiency Variance	Standard variable overhead cost of any change from the standard level of efficiency. This is directly analogous to the calculation of direct labour efficiency variance and implicitly assumes that variable overhead is recovered on a direct labour hour base. However, the formula can equally be used if variable overhead is recovered on a machine or process hour base.
Variable Production Overhead Expenditure Variance	Indicates the actual cost of any change from the standard rate per hour. Hours refer to either labour or machine hours depending on the recovery base chosen for variable production overhead.

(*) Source CIMA's Official Terminology

Formulae

Direct Material Variances

Direct Material Total Variance[#]

[Standard Cost[*] – Actual Cost]

(The difference between the Standard Direct Material Cost *of the actual production volume* and the Actual Cost of Direct Material)

[(SQ × SP) – (AQ × AP)]

Direct Material Price Variance	**Direct Material Usage Variance**
[Standard Cost of Actual Quantity – Actual Cost]	[Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity]
(The difference between the Standard Price and Actual Price for the Actual Quantity)	(The difference between the Standard Quantity *specified for actual production* and the Actual Quantity *used*, at Standard Purchase Price)
[(SP – AP) × AQ] *Or* [(SP × AQ) – (AP × AQ)]	[(SQ – AQ) × SP] *Or* [(SQ × SP) – (AQ × SP)]

Direct Material Mix Variance	**Direct Material Yield Variance**
[Standard Cost of Actual Quantity in Standard Proportion – Standard Cost of Actual Quantity]	[Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity in Standard Proportion]
(The difference between the Actual Quantity *in standard proportion* and Actual Quantity *in actual proportion*, at Standard Purchase Price)	(The difference between the Standard Quantity *specified for actual production* and Actual Quantity *in standard proportion*, at Standard Purchase Price)
[(RAQ – AQ) × SP] *Or* [(RAQ × SP) – (AQ × SP)]	[(SQ – RAQ) × SP] *Or* [(SQ × SP) – (RAQ × SP)]
Alternative Formula [Total Actual Quantity (units) × {*Average* Standard Price *per unit* of Standard Mix Less *Average* Standard Price *per unit* of Actual Mix}]	***Alternative Formula*** [*Average* Standard Price *per unit* of Standard Mix × {Total Standard Quantity (units) Less Total Actual Quantity (units)}]

Note:

SQ = Standard Quantity = Expected Consumption for Actual Output

AQ = Actual Quantity *of Material Consumed*

RAQ = Revised Actual Quantity = Actual Quantity Rewritten in Standard Proportion

SP = Standard Price per Unit

AP = Actual Price per Unit

(*) = Standard Cost refers to 'Standard Cost of Standard Quantity for Actual Output'

(#) = Direct Material Total Variance (also known as material cost variance)

Material Purchase Price Variance

[Standard Cost of Actual Quantity – Actual Cost]

(The difference between the Standard Price and Actual Price *for the actual quantity of material purchased*)

[(SP – AP) × PQ]

Or

[(SP × PQ) – (AP × PQ)]

Note:

PQ = Purchase Quantity

SP = Standard Price

AP = Actual Price

Direct Labour Variances

Direct Labour Total Variance[1]

[Standard Cost[2] – Actual Cost]

(The difference between the <u>Standard Direct Labour Cost</u> and the <u>Actual Direct Labour Cost</u> *incurred for the production achieved*)

[(SH × SR) – (AH* × AR)]

Direct Labour Rate Variance

[Standard Cost of Actual Time – Actual Cost]

(The difference between the <u>Standard Rate</u> *per hour* and <u>Actual Rate</u> *per hour* for the <u>Actual Hours</u> *paid*)

[(SR – AR) × AH*]

Or

[(SR × AH*) – (AR × AH*)]

Direct Labour Idle Time Variance

[Standard Rate per Hour x Actual Idle Hours]

(The difference between the <u>Actual Hours</u> *paid* and <u>Actual Hours</u> *worked* at <u>Standard Rate)</u>

[(AH* – AH#) × SR]

Or

[(AH* × SR) – (AH# × SR)]

Direct Labour Efficiency Variance

[Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time]

(The difference between the <u>Standard Hours</u> *specified for actual production* and <u>Actual Hours</u> *worked* at <u>Standard Rate</u>)

[(SH – AH#) × SR]

Or

[(SH × SR) – (AH# × SR)]

Direct Labour Mix Variance Or Gang Variance

[Standard Cost of Actual Time *Worked* in Standard Proportion – Standard Cost of Actual Time *Worked*]

(The difference between the <u>Actual Hours</u> *worked in standard proportion* and <u>Actual Hours</u> *worked in actual proportion*, at <u>Standard Rate</u>)

[(RAH – AH#) × SR]

Or

[(RAH × SR) – (AH# × SR)]

Direct Labour Yield Variance Or Sub-Efficiency Variance

[Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time *Worked* in Standard Proportion]

(The difference between the <u>Standard Hours</u> *specified for actual production* and <u>Actual Hours</u> *worked in standard proportion*, at <u>Standard Rate</u>)

(SH – RAH) × SR

Or

(SH × SR) – (RAH × SR)

Alternate Formula	***Alternate Formula***
[Total Actual Time *Worked* (hours) × {*Average* Standard Rate *per hour* of Standard Gang Less *Average* Standard Rate *per hour* of Actual Gang@}] @ *on the basis of hours worked*	[*Average* Standard Rate *per hour* of Standard Gang × {Total Standard Time (hours) Less Total Actual Time *Worked* (hours)}]

Note:

SH = Standard Hours = Expected time (Time allowed) for Actual Output

AH* = Actual Hours *paid for*

AH# = Actual Hours *worked*

RAH = Revised Actual Hours = Actual Hours (worked) rewritten in Standard Proportion

SR = Standard Rate per Labour Hour

AR = Actual Rate per Labour Hour Paid

(2) = Standard Cost refers to 'Standard Cost of Standard Time for Actual Output'

(1) = Direct Labour Total Variance (also known as labour cost variance)

In the absence of idle time

Actual Hours Worked = Actual Hours Paid

☞

Idle Time is a period for which a workstation is available for production but is not used due to e.g. shortage of tooling, material or operators. During Idle Time, Direct Labour Wages are being paid but no output is being produced. The cost of this can be identified separately in an Idle Time Variance, so that it is not 'hidden' in an adverse Labour Efficiency Variance.

Some organizations face Idle Time on regular basis. In this situation the Standard Labour Rate may include an allowance for the cost of the expected idle time. Only the impact of any unexpected or abnormal Idle Time would be included in the Idle Time Variance.

Fixed Production Overhead Variances

Fixed Overhead Total Variance@
(Absorbed Fixed Overheads) *Less* (Actual Fixed Overheads)

Fixed Overhead Expenditure Variance
(Budgeted Fixed Overheads)
Less
(Actual Fixed Overheads)

Fixed Overhead Volume Variance
(Absorbed Fixed Overheads)
Less
(Budgeted Fixed Overheads)

Fixed Overhead Capacity Variance
(Budgeted Fixed Overheads for Actual Hours#)
Less
(Budgeted Fixed Overheads)

Fixed Overhead Efficiency Variance
(Absorbed Fixed Overheads)
Less
(Budgeted Fixed Overheads for Actual Hours#)

Or

Fixed Overhead Capacity Variance
(Budgeted Fixed Overheads for Actual Hours#)
Less
(Possible Fixed Overheads)

Fixed Overhead Calendar Variance
(Possible Fixed Overheads)
Less
(Budgeted Fixed Overheads)

Fixed Overhead Efficiency Variance
(Absorbed Fixed Overhead)
Less
(Budgeted Fixed Overheads for Actual Hours#)

 # Actual Hours (Worked)

Note:

Standard Fixed Overheads for Production (Absorbed)

= Standard Fixed Overhead Rate per Unit × Actual Production in Units

= Standard Fixed Overhead Rate per Hour × Standard Hours for Actual Production

Budgeted Fixed Overheads

= It represents the amount of fixed overhead which should be spent according to the budget or standard during the period

= Standard Fixed Overhead Rate per Unit × Budgeted Production in Units

= Standard Fixed Overhead Rate per Hour × Budgeted Hours

Actual Fixed Overheads Incurred

Budgeted Fixed Overheads for Actual Hours

= Standard Fixed Overhead Rate per Hour × Actual Hours

Possible Fixed Overheads

= Expected Fixed Overhead for Actual Days Worked

$$= \frac{\text{Budgeted Fixed Overhead}}{\text{Budgeted Days}} \times \text{Actual Days}$$

(@)

= Fixed Overhead Total Variance also known as 'Fixed Overhead Cost Variance'

Fixed Overhead Efficiency Variance
(Absorbed Fixed Overheads) – (Budgeted Fixed Overheads for Actual Hours)
Or
(Standard Fixed Overhead Rate per Hour × Standard Hours for Actual Output) – (Standard Fixed Overhead Rate per Hour × Actual Hours)
Or
Standard Fixed Overhead Rate per Hour × (Standard Hours for Actual Output – Actual Hours)

Fixed Overhead Capacity Variance
(Budgeted Fixed Overheads for Actual Hours) – (Budgeted Fixed Overheads)
Or
(Standard Fixed Overhead Rate per Hour × Actual Hours) – (Standard Fixed Overhead Rate per Hour × Budgeted Hours)
Or
Standard Fixed Overhead Rate per Hour × (Actual Hours – Budgeted Hours)

Fixed Overhead Volume Variance-I

(Absorbed Fixed Overheads) – (Budgeted Fixed Overheads)

Or

(Standard Fixed Overhead Rate per Unit × Actual Output) – (Standard Fixed Overhead Rate per Unit × Budgeted Output)

Or

Standard Fixed Overhead Rate per Unit × (Actual Output – Budgeted Output)

Fixed Overhead Volume Variance-II

(Absorbed Fixed Overheads) – (Budgeted Fixed Overheads)

Or

(Standard Fixed Overhead Rate per Hour × Standard Hours for Actual Output) – (Standard Fixed Overhead Rate per Hour × Budgeted Hours)

Or

Standard Fixed Overhead Rate per Hour × (Standard Hours for Actual Output – Budgeted Hours)

Or

Standard Fixed Overhead Rate per Hour × (Standard Hours per Unit × Actual Output – Standard Hours per Unit × Budgeted Output)

Or

(Standard Fixed Overhead Rate per Hour × Standard Hours per Unit) × (Actual Output – Budgeted Output)

Or

Standard Fixed Overhead Rate per Unit × (Actual Output – Budgeted Output)

☞

Overhead Variances can also be affected by idle time. It is usually assumed that Overheads are incurred when labour is working, not when it is idle. Accordingly, hours worked has been considered for the calculation of Variable and Fixed Overheads Variances.

Variable Production Overhead Variances

Variable Overhead Total Variance@
(Standard Variable Overheads for Production – Actual Variable Overheads)

Variable Overhead Expenditure (Spending) Variance	**Variable Overhead Efficiency Variance**
(Budgeted Variable Overheads for Actual Hours#) *Less* (Actual Variable Overheads)	(Standard Variable Overheads for Production) *Less* (Budgeted Variable Overheads for Actual Hours#)

Actual Hours (Worked)

Note:

Standard Variable Overheads for Production/Charged to Production

= Standard/Budgeted Variable Overhead Rate per Unit × Actual Production (Units)

= Standard Variable Overhead Rate per Hour × Standard Hours for Actual Production

Actual Overheads Incurred

Budgeted Variable Overheads for Actual Hours

= Standard Variable Overhead Rate per Hour × Actual Hours

(@)

= Variable Overhead Total Variance also known as 'Variable Overhead Cost Variance'

Variable Overhead Efficiency Variance

(Standard Variable Overheads for Production) – (Budgeted Overheads for Actual Hours)

Or

(Standard Variable Overhead Rate per Hour × Standard Hours for Actual Output) – (Standard Variable Overhead Rate per Hour × Actual Hours)

Or

Standard Variable Overhead Rate per Hour × (Standard Hours for Actual Output – Actual hours)

Variable Overhead Expenditure Variance

(Budgeted Variable Overheads for Actual Hours) – (Actual Variable Overheads)

Or

(Standard Rate per Hour × Actual Hours) – (Actual Rate per Hour × Actual Hours)

Or

Actual Hours × (Standard Rate per Hour – Actual Rate per Hour)

Sales Variances (Turnover or Value)

Sales Variance

(Actual Sales) *Less* (Budgeted Sales)

[(AP × AQ) – (BP × BQ)]

Sales Price Variance	**Sales Volume Variance**
(Actual Sales) *Less* (Standard Sales)	(Standard Sales) *Less* (Budgeted Sales)
[(AP × AQ) – (BP × AQ)] *Or* [AQ × (AP – BP)]	[(BP × AQ) – (BP × BQ)] *Or* [BP × (AQ – BQ)]

Sales Mix Variance	**Sales Quantity Variance**
(Standard Sales) *Less* (Revised Standard Sales)	(Revised Standard Sales) *Less* (Budgeted Sales)
[(BP × AQ) – (BP × RAQ)] *Or* [BP × (AQ – RAQ)]	[(BP × RAQ) – (BP × BQ)] Or [BP × (RAQ – BQ)]
Alternative Formula [Total Actual Quantity (units) × {*Average* Budgeted Price *per unit* of Actual Mix Less *Average* Budgeted Price *per unit* of Budgeted Mix}]	***Alternative Formula*** [*Average* Budgeted Price *per unit* of Budgeted Mix × {Total Actual Quantity (units) Less Total Budgeted Qty (units)}]

Market Size Variance	**Market Share Variance**
[Budgeted Market Share % × (Actual Industry Sales Quantity *in units* – Budgeted Industry Sales Quantity *in units*) × (Average Budgeted Price *per unit*)]	[(Actual Market Share % – Budgeted Market Share %) × (Actual Industry Sales Quantity *in units*) × (Average Budgeted Price *per unit*)]

Note:

BQ	=	Budgeted Sales Quantity
AQ	=	Actual Sales Quantity
RAQ	=	Revised Actual Sales Quantity
	=	Actual Quantity Sold Rewritten in Budgeted Proportion
BP	=	Budgeted Selling Price per Unit
AP	=	Actual Selling Price per Unit

Market Size Variance

Budgeted Market Share % × (Actual Industry Sales Quantity *in units* – Budgeted Industry Sales Quantity *in units*) × (Average Budgeted Price *per unit*)

Or

(Budgeted Market Share % × Actual Industry Sales Quantity *in units* – Budgeted Market Share % × Budgeted Industry Sales Quantity *in units*) × (Average Budgeted Price *per unit*)

Or

(Required Sales Quantity *in units* –Total Budgeted Quantity *in units*) × (Average Budgeted Price *per unit*)

Market Share Variance

(Actual Market Share % – Budgeted Market Share %) × (Actual Industry Sales Quantity *in units*) × (Average Budgeted Price *per unit*)

Or

(Actual Market Share % × Actual Industry Sales Quantity *in units* – Budgeted Market Share % × Actual Industry Sales Quantity *in units*) × (Average Budgeted Price *per unit*)

Or

(Total Actual Quantity *in units*– Required Sales Quantity *in units*) × (Average Budgeted Price *per unit*)

Market Size Variance + Market Share Variance

(Required Sales Quantity *in units* – Total Budgeted Quantity *in units*) × (Average Budgeted Price per *unit*)

Add

(Total Actual Quantity *in units*– Required Sales Quantity *in units*) × (Average Budgeted Price *per unit*)

Equals to

(Total Actual Quantity *in units* – Total Budgeted Quantity *in units*) × (Average Budgeted Price *per unit*)

Sales Quantity Variance

Sales Variances (Margin)

Sales Margin Variance

(Actual Margin) *Less* (Budgeted Margin)

[(AQ × AM) – (BQ × BM)]

Sales Margin Price Variance	**Sales Margin Volume Variance**
(Actual Margin) *Less* (Standard Margin)	(Standard Margin) *Less* (Budgeted Margin)
[(AM × AQ) – (BM × AQ)] *Or* [AQ × (AM – BM)]	[(BM × AQ) – (BM × BQ)] *Or* [BM × (AQ – BQ)]

Sales Margin Mix Variance	**Sales Margin Quantity Variance**
(Standard Margin) *Less* (Revised Standard Margin)	(Revised Standard Margin) *Less* (Budgeted Margin)
(AQ × BM) – (RAQ × BM) *Or* BM × (AQ – RAQ)	(RAQ × BM) – (BQ × BM) *Or* BM × (RAQ – BQ)
Alternative Formula [Total Actual Qty (units) × {*Average* Budgeted Margin *per unit* of Actual Mix Less *Average* Budgeted Margin *per unit* of Budgeted Mix}]	***Alternative Formula*** [*Average* Budgeted Margin *per unit* of Budgeted Mix × {Total Actual Qty (units) Less Total Budgeted Qty (units)}]

Market Size Variance	**Market Share Variance**
[Budgeted Market Share % × (Actual Industry Sales Quantity *in units* – Budgeted Industry Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)]	[(Actual Market Share % – Budgeted Market Share %) × (Actual Industry Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)]

Note:

BQ	=	Budgeted Sales Quantity
AQ	=	Actual Sales Quantity
RAQ	=	Revised Actual Sales Quantity
	=	Actual Quantity Sold Rewritten in Budgeted Proportion
BM	=	Budgeted Margin
	=	Budgeted price per Unit – Standard Cost per Unit
AM	=	Actual Margin
	=	Actual Sales Price per Unit – Standard Cost per Unit

Market Size Variance

Budgeted Market Share % × (Actual Industry Sales Quantity *in units* – Budgeted Industry Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)

Or

(Budgeted Market Share % × Actual Industry Sales Quantity *in units* – Budgeted Market Share % × Budgeted Industry Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)

Or

(Required Sales Quantity *in units* –Total Budgeted Quantity *in units*) × (Average Budgeted Margin *per unit*)

Market Share Variance

(Actual Market Share % – Budgeted Market Share %) × (Actual Industry Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)

Or

(Actual Market Share % × Actual Industry Sales Quantity *in units* – Budgeted Market Share % × Actual Industry Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)

Or

(Total Actual Quantity *in units*– Required Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)

Market Size Variance + Market Share Variance

(Required Sales Quantity *in units* – Total Budgeted Quantity *in units*) × (Average Budgeted Margin per *unit*)

Add

(Total Actual Quantity *in units*– Required Sales Quantity *in units*) × (Average Budgeted Margin *per unit*)

Equals to

(Total Actual Quantity *in units* – Total Budgeted Quantity *in units*) × (Average Budgeted Margin *per unit*)

Sales Margin Quantity Variance

Reconciliations (Budgeted / Standard Profit / Actual Profit)

Reconciliation Statement-I
Budgeted Profit to Actual Profit

Budgeted Profit				❑
(Budgeted Quantity × Budgeted Margin)				
Effect of Variances				
Material Cost Variance				
Material Price Variance		❑		
Material Usage Variance				
Material Mix Variance	❑			
Material Yield Variance	❑	❑	❑	
Labour Cost Variance				
Labour Rate Variance		❑		
Labour Idle Time Variance		❑		
Labour Efficiency Variance				
Labour Mix Variance	❑			
Labour Sub-Efficiency Variance	❑	❑	❑	
Variable Overhead Cost Variances				
Variable Overhead Expenditure Variance		❑		
Variable Overhead Efficiency Variance		❑	❑	
Fixed Overhead Cost Variances				
Fixed Overhead Expenditure Variance		❑		
Fixed Overhead Volume Variance				
Fixed Overhead Capacity Variance	❑			
Fixed Overhead Efficiency Variance	❑	❑	❑	
Sales Margin Variance				
Sales Margin Price Variance		❑		
Sales Margin Volume Variance				
Sales Margin Mix Variance	❑			
Sales Margin Quantity Variance	❑	❑	❑	❑
Actual Profit				❑

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Reconciliation Statement-II
Budgeted Profit to Actual Profit

Budgeted Profit				❑
(Budgeted Quantity × Budgeted Margin)				
Effect of Variances				
Material Cost Variance				
Material Price Variance		❑		
Material Usage Variance				
Material Mix Variance	❑			
Material Yield Variance	❑	❑	❑	
Labour Cost Variance				
Labour Rate Variance		❑		
Labour Idle Time Variance		❑		
Labour Efficiency Variance				
Labour Mix Variance	❑			
Labour Sub-Efficiency Variance	❑	❑	❑	
Variable Overhead Cost Variances				
Variable Overhead Expenditure Variance		❑		
Variable Overhead Efficiency Variance		❑	❑	
Fixed Overhead Cost Variances				
Fixed Overhead Expenditure Variance		❑		
Fixed Overhead Volume Variance[1&2]				
Fixed Overhead Capacity Variance	NA			
Fixed Overhead Efficiency Variance	NA	NA	❑	
Sales Contribution Variances[3]				
Sales Contribution Price Variance		❑		
Sales Contribution Volume Variance				
Sales Contribution Mix Variance	❑			
Sales Contribution Quantity Variance	❑	❑	❑	❑
Actual Profit				❑

☞

(1) Relation between Sales Margin Volume Variance & Sales Contribution Volume Variance		
Sales Margin Volume Variance	=	Budgeted Margin Per Unit × (Actual Quantity − Budgeted Quantity)
	Or	
Sales Margin Volume Variance	=	[Standard (or Budgeted) Contribution Per Unit − Standard Fixed Overheads Per Unit] × (Actual Quantity − Budgeted Quantity)
	Or	
Sales Margin Volume Variance	=	[Standard Contribution Per Unit × (Actual Quantity − Budgeted Quantity)] − [Standard Fixed Overheads Per Unit × (Actual Quantity − Budgeted Quantity)]
	Or	
Sales Margin Volume Variance	=	Sales Contribution Volume Variance − Fixed Overhead Volume Variance
	Or	
Sales Contribution Volume Variance	=	Sales Margin Volume Variance + Fixed Overhead Volume Variance
Note: Production units equals to Sales units for both actual & budget.		
(2) Fixed Overhead Volume Variance does not arise in a Marginal Costing system-Why?		
Fixed Overhead Volume Variance does not arise in a Marginal Costing system. In an Absorption Costing system it stands for the value of the under-or- over absorbed Fixed Overhead due to a change in production volume (Budgeted Vs Actual). When Marginal Costing is in use there is no Overhead Volume Variance, because Marginal Costing does not absorb Fixed Overhead. Fixed Overhead Expenditure Variance is the only variance for Fixed Overhead in a Marginal Costing system. It is calculated as in an Absorption Costing system. Sales Margin Volume Variance in Marginal Costing System also known as Sales Volume Contribution Variance. This variance calculates the Standard Contribution gained or lost as a result of an increase or decrease in sales volume.		
(3) Sales Contribution Variance Formulas		
Sales Contribution Volume Variance	=	[Standard Contribution Per Unit × (Actual Quantity − Budgeted Quantity)]
Sales Contribution Mix Variance	=	[Standard Contribution Per Unit × (Actual Quantity − Revised Actual Quantity)]
Sales Contribution Quantity Variance	=	[Standard Contribution Per Unit × (Revised Actual Quantity − Budgeted Quantity)]
(4) Relation between Sales Price Variance & Sales Contribution Price Variance		
Sales Price Variance is equal to Sales Contribution Price Variance. (This is because, for the actual quantity sold, standard cost remaining constant, change in selling price will have equal impact on turnover and contribution)		
(5) Relation between Sales Volume Variance & Sales Contribution Volume Variance		
Sales Contribution Volume Variance	=	Sales Volume Variance × Budgeted PV Ratio

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Reconciliation Statement-III
Standard Profit to Actual Profit

Standard Profit				❑
(Actual Quantity × Budgeted Margin)				
Effect of Variances				
Material Cost Variance				
Material Price Variance		❑		
Material Usage Variance				
Material Mix Variance	❑			
Material Yield Variance	❑	❑	❑	
Labour Cost Variance				
Labour Rate Variance		❑		
Labour Idle Time Variance		❑		
Labour Efficiency Variance				
Labour Mix Variance	❑			
Labour Sub-Efficiency Variance	❑	❑	❑	
Variable Overhead Cost Variances				
Variable Overhead Expenditure Variance		❑		
Variable Overhead Efficiency Variance		❑	❑	
Fixed Overhead Cost Variances				
Fixed Overhead Expenditure Variance		❑		
Fixed Overhead Volume Variance				
Fixed Overhead Capacity Variance	❑			
Fixed Overhead Efficiency Variance	❑	❑	❑	
Sales Margin Variance				
Sales Margin Price Variance		❑		
Sales Margin Volume Variance				
Sales Margin Mix Variance	NA			
Sales Margin Quantity Variance	NA	NA	❑	❑
Actual Profit				❑

SECTION - A

Variance Analysis

Question-1

Describe three distinct groups of variances that arise in standard costing.

Answer

The three distinct groups of variances that arise in standard costing are:

(i) Variances of efficiency. These are the variance, which arise due to efficiency or inefficiency in use of material, labour etc.

(ii) Variances of prices and rates: These are the variances, which arise due to changes in procurement price and standard price.

(iii) Variances due to volume: These represent the effect of difference between actual activity and standard level of activity.

Question-2

How are cost variances disposed off in a standard costing system? Explain.

Answer

There is no unanimity of opinion among Cost Accountants regarding the disposition of variances. The following are commonly used methods for their disposition.

(i) Transfer all variances to Profit and Loss Account. Under this method, stock of work-in-progress, finished stock and cost of sales are maintained at standard cost and variances arising are transferred to profit and loss account.

(ii) Distributing variances on pro-rata basis over the cost of sales, work-in-progress and finished goods stocks by using suitable basis.

(iii) Write off quantity variance to profit and loss account and spread price variance over to cost of sales, work in progress and finished goods. The reason behind apportioning variance to inventories and cost of sales is that they represent costs although they are derived as variances.

Question-3

"Standard costing variances centre around comparison of actual Performance with the standard and the standards or plans are normally based on the environment anticipated when

the targets are set and if the current environment is different from that anticipated, such analysis cannot measure managerial performance". Comment on the statement and how will you deal with the situation with reference to material and labour variances.

Answer

The statement give in the question highlights practical difficulties faced by our industries today.

"When the current environmental conditions are different from the anticipated environmental conditions (prevailing at the time of setting standard or plans) the use of routine analysis of variance for measuring managerial performance is not desirable / suitable."

The variance analysis can be useful for measuring managerial performance if the variances computed are determined on the basis of revised targets / standards based on current actual environmental conditions. In order to deal with the above situation i.e. to measure managerial performance with reference to material, labour and sales variances, it is necessary to proceed and compute the following variances.

Material Variances:

In the case of Material Purchase Price Variance, suppose the Standard Price of Raw Material determined was ₹ 5.00 per unit, the General Market Price per unit at the time of purchase was ₹ 5.20 and Actual Price paid per unit was ₹ 5.18 on the purchase of say 10,000 units of Raw Material.

In this case the variances to be computed should be:

Uncontrollable Material Purchase Price Planning Variance:

= (Standard Price p.u. – General Market Price p.u.) x Actual Quantity Purchased

= (₹ 5.00 – ₹ 5.20) x 10,000 units

= ₹2,000 (A)

Controllable Material Purchase Price Efficiency Variance:

= (General Market Price p.u. – Actual Price Paid p.u.) x Actual Quantity Purchased

= (₹ 5.20 – 5.18) x 10,000 units

= ₹ 200 (F)

In the case of Material Usage Variance, suppose the Standard Quantity per unit be 5 Kgs., Actual Production units be 250 and Actual Quantity of Material used is 1,450 kgs. Standard Cost of Material per Kg. was ₹1. Because of shortage of Skilled Labour it was felt necessary to use Unskilled Labour and that increased Material Usage by 20%. The variances to be computed to deal with the current environmental conditions will be:

Uncontrollable Material Usage Planning Variances:

= (Original Std. Quantity in Kgs. – Revised Std. Quantity in Kgs.) x Standard Price per Kg.

= (1,250 Kgs. – 1,500 Kgs) x ₹1

= ₹ 250 (A)

Controllable Material Usage Efficiency Variance:

= (Revised Standard Quantity in Kgs. – Actual Quantity Used in Kgs.) x Std. Price per Kg.

= (1,500 Kgs. – 1,450 Kgs.) x ₹1

= ₹50 (F)

Labour Variances:

Like Material Variances, here also Labour Efficiency and Wage Rate Variances should also be adjusted to reflect changes in environmental conditions that prevailed during the period. The Labour Efficiency Variances would be equivalent to the following two variances.

Uncontrollable Labour Efficiency Planning Variance

Controllable Labour Efficiency Variance

The above variances would arise when Unskilled Labour is substituted for Skilled Labour.

Similarly, one Uncontrollable and other Controllable Variance would arise in the case of Wage Rate Variance as well under current environmental conditions.

Question-4

"Overhead variances should be viewed as interdependent rather than independent". Explain.

Answer

The operations of a firm are so inter linked that the level of performance in one area of operation will affect the performance in other areas. Improvements in one area may lead to improvements in other areas. A sub-standard performance in one area may be compensated by a favourable performance in another area. Because of such interdependency among activities in the firm, the managers should not jump to conclusions merely based on the label of variances namely favourable or unfavourable. They should remember that there is a room for trade off amongst variances. Hence, variances need to be viewed as 'attention directors' rather than problem solvers. Thus, a better picture will be captured when overhead variance are not viewed in isolation but in an integrated manner.

Question-5

"Calculation of variances in standard costing is not an end in itself, but a means to an end." Discuss.

Answer

The crux of standard costing lies in variance analysis. Standard costing is the technique whereby standard costs are predetermined and subsequently compared with the recorded actual costs. It is a technique of cost ascertainment and cost control. It establishes predetermined estimates of the cost of products and services based on management's standards of efficient operation. It thus lays emphasis on "what the cost should be". These should be costs are when compared with the actual costs. The difference between standard cost and actual cost of actual output is defined as the variance.

The variance in other words in the difference between the actual performance and the standard performance. The calculations of variances are simple. A variance may be favourable or unfavourable. If the actual cost is less than the standard cost, the variance is favourarable but if the actual cost is more than the standard cost, the variance will be unfavourable. They are easily expressible and do not provide detailed analysis to enable management of exercise control over them. It is not enough to know the figures of these variances from month to month. We in fact are required to trace their origin and causes of occurrence for taking necessary remedial steps to reduce / eliminate them.

A detailed probe into the variance particularly the controllable variances helps the management to ascertain:

(i) the amount of variance

(ii) the factors or causes of their occurrence

(iii) the responsibility to be laid on executives and departments and

(iv) corrective actions which should be taken to obviate or reduce the variances.

Mere calculation and analysis of variances is of no use. The success of variance analysis depends upon how quickly and effectively the corrective actions can be taken on the analysed variances. In fact variance gives information. The manager needs to act on the information provided for taking corrective action. Information is the means and action taken on it is the end. In other words, the calculation of variances in standard costing is not an end in itself, but a means to an end.

Single Plan/ Partial Plan

Question-6

State the features of Partial plan of Standard Cost Accounting procedure.

Answer

Features of Partial Plan of Standard Cost Accounting procedure:

Standard cost operations can be recorded in the books of account by using partial plan, Features of partial plan of standard costing procedure are as follows:

(i) Partial plan system uses current standards in which the inventory will be valued at current standard cost figure.

(ii) Under this method WIP account is charged at the actual cost of production for the month and is credited with the standard cost of the month's production of finished product.

(iii) The closing balance of WIP is also shown at standard cost. The balance after making the credit entries represent the variance from standard for the month.

(iv) The analysis of variance is done after the end of the month.

SECTION - B

Computation of Material Variances

Problem-1

The standard material cost for a normal mix of one tonne of chemical Xing based on:

Chemical	*Usage*	*Price per Kg.*
A	*240 Kg.*	*₹ 6*
B	*400 Kg.*	*₹12*
C	*640 Kg.*	*₹10*

During a month, 6.25 tonnes of X were produced from:

Chemical	*Consumption (Tonnes)*	*Cost (₹)*
A	*1.6*	*11,200*
B	*2.4*	*30,000*
C	*4.5*	*47,250*

Required

Analyse the variances.

Solution

BASIC WORKINGS

Statement Showing "Standard and Actual Cost"

Chemical	Std. Qty.	Std. Price *per tonne*	Std. Cost	Actual Qty. (tonne)	Actual Price *per tonne*	Actual Cost
	SQ	SP	SQ x SP	AQ	AP	AQ x AP
A	1.5 tonnes $\left(\frac{240\text{Kg.}}{1,000\text{Kg.}} \text{x}6.25\text{tonnes}\right)$	₹6,000	₹9,000	1.6t	₹7,000 $\left(\frac{₹11,200}{1.6\text{tonnes}}\right)$	₹11,200
B	2.5 tonnes $\left(\frac{400\text{Kg.}}{1,000\text{Kg.}} \text{x}6.25\text{tonnes}\right)$	₹12,000	₹30,000	2.4t	₹12,500 $\left(\frac{₹30,000}{2.4\text{tonnes}}\right)$	₹30,000

C	4.0 tonnes $\left(\frac{640\text{Kg.}}{1{,}000\text{Kg.}} \text{x} 6.25\text{tonnes}\right)$	₹10,000	₹40,000	4.5t	₹10,500 $\left(\frac{₹47{,}250}{4.5\text{tonnes}}\right)$	₹47,250
Total	8 tonnes		₹79,000	8.5 t		₹88,450

Statement Showing "Standard Cost of Actual Quantity"

Chemical	Std. Price *per tonne*	Actual Qty.	Std. Cost of Actual Qty.
	SP	AQ	AQ x SP
A	₹6,000	1.6tonnes	₹9,600
B	₹12,000	2.4tonnes	₹28,800
C	₹10,000	4.5tonnes	₹45,000
Total		8.5 tonnes	₹83,400

COMPUTATION OF VARIANCES

Material Cost Variance = Standard Cost – Actual Cost

= SQ × SP – AQ × AP

(A) = ₹ 9,000 – ₹ 11,200

= ₹ 2,200 (A)

(B) = ₹ 30,000 – ₹ 30,000

= ₹ 0

(C) = ₹ 40,000 – ₹ 47,250

= ₹ 7,250 (A)

Total = ₹ 2,200 (A) + ₹ 0 + ₹ 7,250 (A)

= ₹ 9,450 (A)

Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

= AQ × SP – AQ × AP

Or

= AQ × (SP – AP)

(A) = 1.6 tonnes × (₹ 6,000 – ₹ 7,000)

= ₹ 1,600 (A)

(B) = 2.4 tonnes × (₹ 12,000 – ₹ 12,500)

= ₹ 1,200 (A)

(C)	=	4.5 tonnes × (₹ 10,000 – ₹ 10,500)
	=	₹ 2,250 (A)
Total	=	₹ 1,600 (A) + ₹ 1,200 (A) + ₹ 2,250 (A)
	=	₹ 5,050 (A)
Material Usage Variance	=	Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity
	=	SQ × SP – AQ × SP
		Or
	=	SP × (SQ – AQ)
(A)	=	₹ 6,000 × (1.5 tonnes – 1.6 tonnes)
	=	₹ 600 (A)
(B)	=	₹ 12,000 × (2.5 tonnes – 2.4 tonnes)
	=	₹ 1,200 (F)
(C)	=	₹ 10,000 × (4.0 tonnes – 4.5 tonnes)
	=	₹ 5,000 (A)
Total	=	₹ 600 (A) + ₹ 1,200 (F) + ₹ 5,000 (A)
	=	₹ 4,400 (A)
Material Mix Variance	=	Total Actual Quantity (units) × (*Average* Standard Price *per unit* of Standard Mix – Average Standard Price *per unit* of Actual Mix)
	=	$8.5 \text{ tonnes} \times \left(\frac{₹\ 79{,}000}{8 \text{ tonnes}} - \frac{₹\ 83{,}400}{8.5 \text{ tonnes}}\right)$
	=	₹ 537.5 (F)
Material Yield Variance	=	*Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]
	=	$\left(\frac{₹\ 79{,}000}{8 \text{ tonnes}}\right) \times (8 \text{ tonnes} - 8.5 \text{ tonnes})$
	=	₹ 4,937.5 (A)

Problem-2

The standard cost of a certain chemical mixture is as under:

40% of Material A @ ₹ 30 per kg

60% of Material B @ ₹ 40 per kg

A standard loss of 10% of input is expected in production. The following actual cost data is given for the period.

350 kg Material – A at a cost of ₹ 25

400 kg Material – B at a cost of ₹ 45

Actual weight produced is 630 kg.

Required

Calculate the following variances raw material wise and indicate whether they are favorable (F) or adverse (A):

(i) Cost variance

(ii) Price variance

(iii) Mix variance

(iv) Yield variance

Solution

BASIC CALCULATIONS

Actual Output produced is 630 Kg. The Standard Quantity of Material required for 630 Kg. of output is 700 Kg. $\left(\frac{630\text{Kg.}}{90} \text{x} 100\right)$

Statement Showing
"Computation of Standard Cost / Actual Cost / Revised Actual Quantity"

Material	Standard Cost			Actual Cost			Revised Actual Quantity [RAQ] (Kg.)
	Quantity [SQ] (Kg.)	Price [SP] (₹)	Amount [SQ × SP] (₹)	Quantity [AQ] (Kg.)	Price [AP] (₹)	Amount [AQ × AP] (₹)	
A	280 (40% of 700 Kg.)	30	8,400	350	25	8,750	300 (40% of 750 Kg.)
B	420 (60% of 700 Kg.)	40	16,800	400	45	18,000	450 (60% of 750 Kg.)
Total	700		25,200	750		26,750	750

Note:

SQ = Standard Quantity = Expected Consumption for Actual Output

AQ = Actual Quantity of *Material Consumed*

RAQ = Revised Actual Quantity = Actual Quantity Rewritten in Standard Proportion

SP = Standard Price per Unit

AP = Actual Price per Unit

COMPUTATION OF VARIANCES

Material Cost Variance	=	SQ × SP – AQ × AP
A	=	280 Kg. × ₹30 – 350 Kg. × ₹25
	=	₹350(A)
B	=	420 Kg. × ₹40 – 400 Kg. × ₹45
	=	₹1,200 (A)
Total	=	₹350 (A) + ₹1,200 (A)
	=	₹1,550 (A)
Material Price Variance	=	AQ × (SP – AP)
A	=	350 Kg. × (₹30 – ₹25)
	=	₹1,750 (F)
B	=	400 Kg. × (₹40 – ₹45)
	=	₹2,000 (A)
Total	=	₹1,750 (F) + ₹2,000 (A)
	=	₹250 (A)
Material Mix Variance	=	SP × (RAQ – AQ)
A	=	₹30 × (300 Kg – 350 Kg)
	=	₹1,500 (A)
B	=	₹40 × (450 Kg. – 400 Kg.)
	=	₹2,000 (F)
Total	=	₹1,500 (A) + ₹2,000 (F)
	=	₹500 (F)
Material Yield Variance	=	SP × (SQ – RAQ)
A	=	₹30 × (280 Kg. – 300 Kg)
	=	₹600 (A)
B	=	₹40 × (420 Kg. – 450 Kg.)
	=	₹1,200 (A)
Total	=	₹600 (A) + ₹1,200 (A)
	=	₹1,800 (A)

Computation of Labour Variances

Problem-3

The following information relates to the labour element of X Ltd.

Type of labour	*Skilled*	*Semi-skilled*	*Unskilled*	*Total*
No. of workers in the standard gang	*4*	*3*	*2*	*9*
Standard rate per hour (₹)	*6*	*3*	*1*	
Number of workers in actual gang				*9*
Actual rate per hour (₹)	*7*	*2*	*2*	

In a 40 hour week, the gang produced 270 standard hours. The actual number of semi-skilled workers is two times the actual number of unskilled workers.

The rate variance of semi-skilled workers is ₹ 160 (F).

Required

(i) The number of workers in each category

(ii) Total gang variance

(iii) Total sub-efficiency variance

(iv) Total labour rate variance

Indicate if the variances are Favourable (F) or Adverse (A or U).

Solution

(i) Computation of Total No. of Workers in Each Category

Category	No. of Workers	Actual Hours
Skilled	3 $\left(\frac{120\text{ hrs.}}{40\text{ hrs.}}\right)$	120 (Balancing Figure)
Semi-Skilled	4 $\left(\frac{160\text{ hrs.}}{40\text{ hrs.}}\right)$	160 (Working Note)
Un-Skilled	2 $\left(\frac{80\text{ hrs.}}{40\text{ hrs.}}\right)$	80 $\left(\frac{160\text{ hrs.}}{2}\right)$
Total	9	360*

(*) Total No. of Actual Hours is 360 hrs. (40 hrs. x 9 workers)

(ii) Total Gang Variance

= Total Actual Time *Worked* (hours) × {*Average* Standard Rate *per hour* of Standard Gang

Less *Average* Standard Rate *per hour* of Actual Gang@}

@*on the basis of hours worked*

$$= 360 \text{ hrs.} \times \left(\frac{₹1{,}050}{270 \text{ hrs.}} - \frac{₹6 \text{x} 120 \text{ hrs.} + ₹3 \text{x} 160 \text{ hrs.} + ₹1 \text{x} 80 \text{ hrs.}}{360 \text{ hrs.}} \right)$$

= ₹120 (F)

Alternate Formula

Gang Variance = Standard Cost of Actual Time *Worked* in Standard Proportion – Standard Cost of Actual Time Worked

Or = Revised Actual Hours × Standard Rate – Actual Hours × Standard Rate

Or = Standard Rate × (Revised Actual Hours - Actual Hours)

Skilled Workers = ₹6 × (160 hrs. – 120 hrs)

= ₹240 (F)

Semi-Skilled = ₹3 × (120 hrs. – 160 hrs)

= ₹120 (A)

Skilled Workers = ₹1 × (80 hrs. – 80 hrs)

= ₹ 0

Total = ₹ 240 (F) + ₹ 120 (A) + ₹ 0

= ₹ 120 (F)

(iii) Total Sub- Efficiency Variance

= *Average* Standard Rate *per hour* of Standard Gang × {Total Standard Time (hours) Less Total Actual Time *Worked* (hours)}

$$= \left(\frac{₹1{,}050}{270 \text{ hrs.}} \right) \text{x} (270 \text{ hrs.} - 360 \text{ hrs.})$$

= ₹350 (A)

Alternate Formula

Sub- Efficiency Variance

= Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time *Worked* in Standard Proportion

Or	=	Standard Hours x Standard Rate – Revised Actual Hours × Standard Rate
Or	=	Standard Rate × (Standard Hours – Revised Actual Hours)
Skilled Workers	=	₹6 × (120 hrs. – 160 hrs.)
	=	₹240 (A)
Semi-Skilled	=	₹3 × (90hrs. – 120 hrs.)
	=	₹90 (A)
Skilled Workers	=	₹1 × (60 hrs. – 80 hrs.)
	=	₹20 (A)
Total	=	₹240 (A) + ₹90 (A) + ₹20 (A)
	=	₹350 (A)

(iv) Labour Rate Variance

	=	Standard Cost of Actual Time – Actual Cost
Or	=	Standard Rate × Actual Hours – Actual Rate × Actual Hours
Or	=	Actual Hours × (Standard Rate – Actual Rate)
Skilled Workers	=	120 hrs. × (₹6 – ₹7)
	=	₹120 (A)
Semi- Skilled	=	160 hrs. × (₹3 – ₹2)
	=	₹160 (F)
Skilled Workers	=	80 hrs. × (₹1 – ₹2)
	=	₹80 (A)
Total	=	₹120 (A) + ₹160 (F) + ₹80 (A)
	=	₹40 (A)

WORKING NOTE

(i) Computation of 'Standard Hours' Category Wise

Category	No. of Workers	Standard Hours
Skilled	4	120 $\left(270\,\text{hrs.x}\frac{4\text{ workers}}{9\text{ workers}}\right)$

Semi-Skilled	3	90 $\left(270\,\text{hrs.x}\frac{3\text{ workers}}{9\text{ workers}}\right)$
Un-Skilled	2	60 $\left(270\,\text{hrs.x}\frac{2\text{ workers}}{9\text{ workers}}\right)$
Total	9	270

(ii) Computation of 'Actual Hours' Category Wise

Semi-Skilled Workers

Labour Rate Variance	=	Standard Cost of Actual Time – Actual Cost
Or	=	Standard Rate × Actual Hours – Actual Rate × Actual Hours
Or	=	Actual Hours × (Standard Rate – Actual Rate)
⇒ ₹ 160 (F)	=	Actual Hours × (₹ 3 – ₹ 2)
⇒ Actual Hours	=	160 Hours

(iii) Statement Showing "Standard & Actual Cost"

Category	Standard Cost			Actual Cost			Revised Actual Hrs. (In Std. Proportion)
	Hrs.	Rate	Amt.	Hrs.	Rate	Amt.	
Skilled	120	6	720	120	7	840	160 $\left(360\text{hrs.x}\frac{120\text{hrs.}}{270\text{hrs.}}\right)$
Semi-Skilled	90	3	270	160	2	320	120 $\left(360\text{hrs.x}\frac{90\text{hrs.}}{270\text{hrs.}}\right)$
Un-Skilled	60	1	60	80	2	160	80 $\left(360\text{hrs.x}\frac{60\text{hrs.}}{270\text{hrs.}}\right)$
Total	270		1,050	360		1,320	360

Computation of Overhead Variances

Problem-4

The following information has been extracted from the books of Goru Enterprises which is using standard costing system:

Actual output	=	*9,000 units*
Direct wages paid	=	*1,10,000 hours at ₹ 22 per hour, of which 5,000 hours, being idle time, were not recorded in production*
Standard hours	=	*10 hours per unit*
Labour efficiency variance	=	*₹ 3,75,000 (A)*
Standard variable Overhead	=	*₹ 150 per unit*
Actual variable Overhead	=	*₹ 16,00,000*

Required

(i) *Calculate idle time variance*

(ii) *Calculate total variable overhead variance*

(iii) *Calculate variable overhead expenditure variance*

(iv) *Calculate variable overhead efficiency variance.*

Solution

BASIC WORKING

Actual Output 9,000 units

Idle Time 5,000 hrs

Production Time (Actual) 1,05,000 hrs

Standard Hours for Actual Production 90,000 hours

(10 hours / unit × 9,000 units)

Labour Efficiency Variance = Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time

Or

= Std. Rate × (Std. Hours – Actual Hours *Worked*)

⇒ 3,75,000 (A) = Std. Rate × (90,000 hrs. – 1,05,000 hrs.)

⇒ Std. Rate = ₹ 25

Standard Variable Overhead = ₹ 150 / unit

Standard Hours = 10 hrs / unit

Standard Variable Overhead Rate / hr = ₹ 150 / 10 hrs

= ₹ 15 / hr

COMPUTATION OF REQUIREMENTS

(i)	**Idle Time Variance**	=	Standard Rate per Hour × Actual Idle Hours
		=	₹25 × 5,000 hrs
		=	1,25,000 (A)
(ii)	**Total Variable Overhead Variance**	=	Standard Variable Overhead for Production – Actual Variable Overheads
		=	₹15 × (10 hrs × 9,000 units) – ₹ 16,00,000
		=	₹13,50,000 – ₹ 16,00,000
		=	₹2,50,000 (A)
(iii)	**Variable Overhead Expenditure Variance**	=	Budgeted Overheads for Actual Hours *Worked* – Actual Variable Overheads
		=	₹ 15 × 1,05,000 hrs – ₹ 16,00,000
		=	₹ 15,75,000 – ₹ 16,00,000
		=	₹ 25,000 (A)
(iv)	**Variable Overhead Efficiency Variance**	=	Standard Variable Overhead for Output – Budgeted Overheads for Actual Hours
			Or
		=	Standard Rate *per hour* × (Standard Hours for actual output – Actual Hours *Worked*)
		=	₹15 × (90,000 hrs – 1,05,000 hrs)
		=	₹ 2,25,000 (A)

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Overheads can also be affected by Idle time. It is *usually assume* that overhead expenditure is incurred in active hours only.

Problem-5

In a manufacturing co. the standard units of production of the year were fixed at 1,20,000 units and overhead expenditures were estimated to be:

Fixed	*₹ 12,000*	*Variable*	*₹ 6,000*
Semi-Variable	*₹ 1,800*		

Actual production during April of the year was 8,000 units. Each month has 20 working days.

During the month there was one statutory holiday. The actual overheads amounted to:

Fixed	*₹ 1,190*	*Variable*	*₹ 480*
Semi-variable	*₹ 192*		

Semi-variable charges are considered to include 60 per cent expenses of fixed nature and 40 per cent of variable character.

Required

(a) Calculate Overhead Cost Variance

(b) Calculate Fixed Overhead Cost Variance

(c) Calculate Variable Overhead Cost Variance

(d) Calculate Fixed Overhead Volume Variance

(e) Calculate Fixed Overhead Expenditure Variance

(f) Calculate Calendar Variance.

Solution

COMPUTATION OF VARIANCES

Overhead Cost Variance	=	Absorbed Overheads – Actual Overheads
	=	(₹ 872.00 + ₹ 448.00) – (₹ 1,305.20 + ₹ 556.80)
	=	₹ 542.00 (A)
Variable Overhead Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
	=	₹ 448.00 – ₹ 556.80
	=	₹ 108.80 (A)
Fixed Overhead Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
	=	₹ 872.00 – ₹ 1,305.20
	=	₹ 433.20 (A)
Fixed Overhead Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹ 872.00 – ₹ 1,090.00
	=	₹ 218.00 (A)
Fixed Overhead Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads
	=	₹ 0.109 × 10,000 units – ₹ 1,305.20
	=	₹ 215.20 (A)

Calendar Variance = Possible Fixed Overheads – Budgeted Fixed Overheads

= ₹ 1,035.50 – ₹ 1,090.00

= ₹ 54.50 (A)

WORKING NOTE

Fixed Overheads = $\frac{\text{Budgeted Fixed Overheads}}{\text{Budgeted Output}} = \frac{₹12,000}{1,20,000\text{units}}$	₹ 0.100
Fixed Overheads element in *Semi-Variable* Overheads i.e. 60% of ₹ 1,800	₹ 1,080
Fixed Overheads = $\frac{\text{Budgeted Fixed Overheads}}{\text{Budgeted Output}} = \frac{₹1,080}{1,20,000\text{units}}$	₹ 0.009
Standard Rate of Absorption of Fixed Overheads *per unit* (₹ 0.100 + ₹ 0.009)	₹ 0.109
Fixed Overheads Absorbed on 8,000 units @ ₹ 0.109	₹ 872
Budgeted Variable Overheads	₹ 6,000
Add : Variable element in Semi-Variable Overheads 40% of ₹ 1,800	₹ 720
Total Budgeted Variable Overheads	₹ 6,720
Standard Variable Cost *per unit* = $\frac{\text{Budgeted Variable Overheads}}{\text{Budgeted Output}} = \frac{₹6,720}{1,20,000\text{units}}$	₹0.056
Standard Variable Overheads for 8,000 units @ ₹ 0.056	₹ 448
Budgeted Annual Fixed Overheads (₹ 12,000 + 60% of ₹ 1,800)	₹ 13,080
Possible Fixed Overheads = $\frac{\text{BudgetedFixedOverheads}}{\text{BudgetedDays}} \text{xActualDays}$ $= \left[\frac{₹1,090}{20\text{Days}} \text{x}19\text{Days}\right]$	₹ 1,035.50
Actual Fixed Overheads (₹ 1,190 + 60% of ₹ 192)	₹ 1,305.20
Actual Variable Overheads (₹ 480 + 40% of ₹ 192)	₹ 556.80

Problem-6

A company is engaged in manufacturing of several products. The following data have been obtained from the record of a machine shop for an average month:

Budgeted:

No. of working days	*24*
Working hours per day	*8*
No. of direct workers	*150*
Efficiency	*One standard hour per clock hour*

Down time	*10%*
Overheads	
Fixed	*₹ 75,400*
Variable	*₹ 90,720*

The actual data for the month of August 2013 are as follows:

Overheads	
Fixed	*₹ 78,800*
Variable	*₹ 70,870*
Net operator hours worked	*20,500*
Standard hours produced	*22,550*
There was a special holiday in August 2013.	

Required

(i) *Calculate efficiency, activity, calendar and standard capacity usages ratio.*

(ii) *Calculate all the relevant fixed overhead variances.*

(iii) *Calculate variable overheads expenditure and efficiency variance.*

Solution

BASIC WORKING

Maximum Hours	(24 Days × 8 Hours × 150 Workers)	28,800 Hours
Budgeted Hours	(28,800 Hours *less* 10%)	25,920 Hours
Actual Hours (given)		20,500 Hours
Standard Hours (produced)		22,550 Hours
Budgeted Working Days		24 Days
Actual Working Days		23 Days
Standard Rate (Fixed Overheads) *per hour* $\left(\frac{₹75,400}{25,920\text{ hrs.}}\right)$		₹ 2.908…
Standard Rate (Variable Overheads) *per hour* $\left(\frac{₹90,720}{25,920\text{ hrs.}}\right)$		₹ 3.5

RATIOS

Efficiency Ratio $= \frac{\text{Standard Hours}}{\text{Actual Hours}} \times 100$

$$= \frac{22{,}550\ \text{Hours}}{20{,}500\ \text{Hours}} \times 100$$

$$= 110\%$$

Activity Ratio $$= \frac{\text{Standard Hours}}{\text{Budgeted Hours}} \times 100$$

$$= \frac{22{,}550\ \text{Hours}}{25{,}920\ \text{Hours}} \times 100$$

$$= 87\%$$

Calendar Ratio $$= \frac{\text{Available Working Days}}{\text{Budgeted Working Days}} \times 100$$

$$= \frac{23\ \text{Days}}{24\ \text{Days}} \times 100$$

$$= 95.83\%$$

Standard Capacity Usage Ratio $$= \frac{\text{Budgeted Hours}}{\text{Max. Possible Hours in the Budgeted Period}} \times 100$$

$$= \frac{25{,}920\ \text{Hours}}{28{,}800\ \text{Hours}} \times 100$$

$$= 90\%$$

COMPUTATION OF VARIANCES

(i) Fixed Overhead Variances

Absorbed Fixed Overheads [SH × SR]	Budgeted Fixed Overheads [BH × SR]	Actual Fixed Overheads [AH × AR]	Budgeted Overheads for Actual Hours [SR × AH]	Possible Fixed Overheads
₹ 2.908… × 22,550 hrs.	25,920 hrs. × ₹ 2.908…	20,500 hrs. × ₹ 3.84…*	₹ 2.908... × 20,500 Hrs	$₹75{,}400 \times \frac{23\,\text{Days}}{24\,\text{Days}}$
₹ 65,597	₹ 75,400	₹ 78,800	₹ 59,633	₹ 72,258

**₹ 78,800 / 20,500 hrs.*

Note:

SR = Standard Rate *per Hour*

SH = Standard Hours = Expected Time for Actual Output

BH = Budgeted Hours = Expected Time for Budgeted Output

AR = Actual Rate *per Hour*

AH = Actual Hours

Fixed Overhead Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
	=	₹ 65,597 – ₹ 78,800
	=	₹ 13,203 (A)
Fixed Overhead Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads
	=	₹ 75,400 – ₹ 78,800
	=	₹ 3,400 (A)
Fixed Overhead Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹ 65,597 – ₹ 75,400
	=	₹ 9,803 (A)
Fixed Overhead Capacity Variance	=	Budgeted Fixed Overheads for Actual Hours – Possible Fixed Overheads
	=	₹ 59,633 – ₹ 72,258
	=	₹ 12,625 (A)
Fixed Overhead Calendar Variance	=	Possible Fixed Overheads – Budgeted Fixed Overheads
	=	₹ 72,258 – ₹ 75,400
	=	₹ 3,142 (A)
Fixed Overhead Efficiency Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual hours
	=	₹ 65,597 – ₹ 59,633
	=	₹ 5,964 (F)

(ii) Variable Overhead Variances

Standard Variable Overheads [SR × SH]	Actual Variable Overheads [AH × AR]	Budgeted Variable Overheads for Actual Hours [SR × AH]
₹ 3.5 × 22,550 hrs.	20,500 hrs. × ₹ 3.45…*	₹ 3.5 × 20,500 hrs.
₹ 78,925	₹ 70,870	₹ 71,750

**₹ 70,870/20,500 hrs.*

Note:

SR = Standard Rate *per hour*

SH = Standard Hours = Expected Time for Actual Output

AR = Actual Rate per *hour*

AH = Actual Hours

Variable Overhead Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
	=	₹ 78,925 – ₹ 70,870
	=	₹ 8,055 (F)
Variable Overhead Expenditure Variance	=	Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
	=	₹ 71,750 – 70,870
	=	₹ 880 (F)
Variable Overhead Efficiency Variance	=	Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual hours
	=	₹ 78,925 – ₹ 71,750
	=	₹ 7,175 (F)

Computation of Sales Variances

Problem-7

Japan Products Ltd. had drawn up the following Sales budget for August, 2013:-

'B' Product……………………………………..5,000 units at ₹ 100 each

'C' Product……………………………………..4,000 units at ₹ 200 each

'S' Product……………………………………..6,000 units at ₹ 180 each

The actual sales for August, 2013 were:

'B' Product…………………………………….. 5,750 units at ₹ 120 each

'C' Product……………………………………..4,850 units at ₹ 180 each

'S' Product……………………………………..5,000 units at ₹ 165 each

The costs per unit of B, C and S Product were ₹ 90, ₹ 170 and ₹ 130 respectively.

Required

Analyse the Sales Variances to show the effects on turnover & the effects on Profit.

Solution

BASED ON SALES MARGIN

BASIC CALCULATIONS

Statement Showing "Budgeted Margin, Actual Margin and Standard Margin"

Product Quantity (units)	Budgeted (units)	Budgeted Margin *per unit* (₹)	Budgeted Margin (₹)	Actual Quantity (units)	Actual Margin *per unit* (₹)	Actual Margin (₹)	Std. Margin (₹)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8=3 × 5**
B	5,000	10	50,000	5,750	30	1,72,500	57,500
C	4,000	30	1,20,000	4,850	10	48,500	1,45,500
S	6,000	50	3,00,000	5,000	35	1,75,000	2,50,000
Total	15,000		4,70,000	15,600		3,96,000	4,53,000

COMPUTATION OF VARIANCES

Sales Margin Variance	=	Actual Margin – Budgeted Margin
	=	AQ × AM – BQ × BM
For Product B	=	₹ 1,72,500 – ₹ 50,000
	=	₹ 1,22,500 (F)
For Product C	=	₹ 48,500 – ₹1,20,000
	=	₹ 71,500 (A)
For Product S	=	₹ 1,75,000 – ₹3,00,000
	=	₹ 1,25,000 (A)
Total (B+ C+S)	=	₹ 1,22,500 (F) + ₹ 71,500 (A) + ₹ 1,25,000 (A)
	=	₹ 74,000 (A)
Sales Margin Price Variance	=	Actual Margin – Standard Margin
	=	AQ × AM – AQ × BM
		Or
		AQ × (AM – BM)
For Product B	=	₹ 1,72,500 – ₹ 57,500
	=	₹ 1,15,000 (F)

For Product C	=	₹ 48,500 – ₹ 1,45,500
	=	₹ 97,000 (A)
For Product S	=	₹ 1,75,000 – ₹ 2,50,000
	=	₹ 75,000 (A)
Total (B + C + S)	=	₹ 1,15,000 (F) + ₹ 97,000 (A) + ₹ 75,000 (A)
	=	₹ 57,000 (A)
Sales Margin Volume Variance	=	Standard Margin – Budgeted Margin
	=	AQ× BM – BQ x BM
		Or
		BM × (AQ – BQ)
For Product B	=	₹ 57,500 – ₹ 50,000
	=	₹ 7,500 (F)
For Product C	=	₹ 1,45,500 – ₹ 1,20,000
	=	₹ 25,500 (F)
For Product S	=	₹ 2,50,000 – ₹ 3,00,000
	=	₹ 50,000 (A)
Total (B + C+S)	=	₹ 7,500 (F) + ₹ 25,500 (F) + ₹ 50,000 (A)
	=	₹ 17,000 (A)
Sales Margin Mix Variance	=	Total Actual Quantity (units) × (*Average* Budgeted Margin *per unit* of Actual Mix – *Average* Budgeted Margin *per unit* of Budgeted Mix)
	=	15,600 units × $\left(\frac{₹\ 4,53,000}{15,600\text{ units}} - \frac{₹\ 4,70,000}{15,000\text{units}}\right)$
	=	35,800 (A)
Sales Margin Quantity Variance	=	*Average* Budgeted Margin *per unit* of Budgeted Mix × [Total Actual Quantity (units) – Total Budgeted Quantity (units)]
	=	$\left(\frac{₹\ 4,70,000}{15,000\text{ units}}\right)$ × (15,600 Units – 15,000 Units)
	=	18,800 (F)

BASED ON SALES VALUE

BASIC CALCULATIONS

Statement Showing "Budgeted Sales, Actual Sales Value and Standard Sales"

Product Quantity (units)	Budgeted (units)	Budgeted Price *per unit* (₹)	Budgeted Sales (₹)	Actual Quantity (units)	Actual Price *per unit* (₹)	Actual Sales (₹)	Std. Sales (₹)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8=3 × 5**
B	5,000	100	5,00,000	5,750	120	6,90,000	5,75,000
C	4,000	200	8,00,000	4,850	180	8,73,000	9,70,000
S	6,000	180	10,80,000	5,000	165	8,25,000	9,00,000
Total	15,000		23,80,000	15,600		23,88,000	24,45,000

COMPUTATION OF VARIANCES

Sales Value Variance = Actual Sales – Budgeted Sales

= AP × AQ – BP × BQ

For Product B = ₹ 6,90,000 – ₹ 5,00,000 = ₹ 1,90,000 (F)

For Product C = ₹ 8,73,000 – ₹ 8,00,000 = ₹ 73,000 (F)

For Product S = ₹ 8,25,000 – ₹ 10,80,000 = ₹ 2,55,000 (A)

Total = ₹ 1,90,000 (F) + ₹ 73,000 (F) + ₹ 2,55,000 (A)

= ₹ 8,000 (F)

Sales Price Variance = Actual Sales – Standard Sales

= AP × AQ – BP × AQ

Or

= AQ × (AP – BP)

For Product B = 5,750 Units × (₹ 120.00 – ₹ 100.00) = ₹ 1,15,000 (F)

For Product C = 4,850 Units × (₹ 180.00 – ₹ 200.00) = ₹ 97,000 (A)

For Product S = 5,000 Units × (₹ 165.00 – ₹ 180.00) = ₹ 75,000 (A)

Total = ₹ 1,15,000 (F) + ₹ 97,000 (A) + ₹ 75,000 (A)

= ₹ 57,000 (A)

Sales Volume Variance = Standard Sales – Budgeted Sales

= BP × AQ – BP × BQ

Or

	= BP × (AQ – BQ)
For Product B	= ₹ 100 × (5,750 Units – 5,000 Units) = ₹ 75,000 (F)
For Product C	= ₹ 200 × (4,850 Units – 4,000 Units) = ₹ 1,70,000 (F)
For Product S	= ₹ 180 × (5,000 Units – 6,000 Units) = ₹ 1,80,000 (A)
Total	= ₹ 75,000 (F) + ₹ 1,70,000 (F) + ₹ 1,80,00 (A)
	= ₹ 65,000 (F)
Sales Mix Variance	= Total Actual Qty (units) × (*Average* Budgeted Price *per unit* of Actual Mix – *Average* Budgeted Price *per unit* of Budgeted Mix)
	= $15,600 \text{ Units} \times \left[\left(\frac{₹\ 24,45,000}{15,600 \text{ Units}}\right) - \left(\frac{₹\ 23,80,000}{15,000 \text{ Units}}\right)\right]$
	= 30,200 (A)
Sales Quantity Variance	= *Average* Budgeted Price *per unit* of Budgeted Mix × [Total Actual Qty (units) – Total Budgeted Qty (units)]
	= $\left(\frac{₹\ 23,80,000}{15,000 \text{ Units}}\right) \times (15,600 \text{ Units} - 15,000 \text{ Units})$
	= ₹95,200 (F)

Problem-8

The Sales Manager of a company engaged in the manufacture and sale of three products K, L and M gives you the following information for the month of October 2013: –

Budgeted Sales:

Product	*Units Sold*	*Selling Price per unit*	*Standard Contribution Margin per unit*
K	*2,000*	*₹12*	*₹6*
L	*2,000*	*₹ 8*	*₹4*
M	*2,000*	*₹5*	*₹1*

Actual Sales:

K	*1,500 units for ₹15,000*
L	*2,500 units for ₹17,500*
M	*3,500 units for ₹21,000*

Required

Calculate Sales Variances.

Solution

BASED ON SALES MARGIN

BASIC CALCULATIONS

Statement Showing "Budgeted Margin, Actual Margin and Standard Margin"

Product Quantity (units)	Budgeted (units)	Budgeted Margin *per unit* (₹)	Budgeted Margin (₹)	Actual Quantity (units)	Actual Margin *per unit* (₹)	Actual Margin (₹)	Std. Margin (₹)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8=3 × 5**
K	2,000	6	12,000	1,500	4	6,000	9,000
L	2,000	4	8,000	2,500	3	7,500	10,000
M	2,000	1	2,000	3,500	2	7,000	3,500
Total	6,000		22,000	7,500		20,500	22,500

COMPUTATION OF VARIANCES

Sales Margin Variance	=	Actual Margin – Budgeted Margin
	=	AQ × AM – BQ × BM
For Product K	=	₹ 6,000 – ₹ 12,000
	=	₹ 6,000 (A)
For Product L	=	₹ 7,500 – ₹8,000
	=	₹ 500 (A)
For Product M	=	₹ 7,000 – ₹2,000
	=	₹ 5,000 (F)
Total (K+ L+M)	=	₹ 6,000 (A) + ₹ 500 (A) + ₹ 5,000 (F)
	=	₹ 1,500 (A)
Sales Margin Price Variance	=	Actual Margin – Standard Margin
	=	AQ × AM – AQ × BM
		Or
		AQ × (AM – BM)
For Product K	=	₹ 6,000 – ₹ 9,000
	=	₹ 3,000 (A)

For Product L	=	₹ 7,500 – ₹ 10,000
	=	₹ 2,500 (A)
For Product M	=	₹ 7,000 – ₹ 3,500
	=	₹ 3,500 (F)
Total (K + L + M)	=	₹ 3,000 (A) + ₹ 2,500 (A) + ₹ 3,500 (F)
	=	₹ 2,000 (A)
Sales Margin Volume Variance	=	Standard Margin – Budgeted Margin
	=	AQ× BM – BQ x BM
		Or
		BM × (AQ – BQ)
For Product K	=	₹ 9,000 – ₹ 12,000
	=	₹ 3,000 (A)
For Product L	=	₹ 10,000 – ₹ 8,000
	=	₹ 2,000 (F)
For Product M	=	₹ 3,500 – ₹ 2,000
	=	₹ 1,500 (F)
Total (K + L+M)	=	₹ 3,000 (A) + ₹ 2,000 (F) + ₹ 1,500 (F)
	=	₹ 500 (F)
Sales Margin Mix Variance	=	Total Actual Quantity (units) × (*Average* Budgeted Margin *per unit* of Actual Mix – *Average* Budgeted Margin *per unit* of Budgeted Mix)
	=	$7{,}500 \text{ Units} \times \left(\frac{₹\ 22{,}500}{7{,}500 \text{ units}} - \frac{₹\ 22{,}000}{6{,}000 \text{units}}\right)$
	=	5,000 (A)
Sales Margin Quantity Variance	=	*Average* Budgeted Margin *per unit* of Budgeted Mix × [Total Actual Quantity (units) – Total Budgeted Quantity (units)]
	=	$\left(\frac{₹\ 22{,}000}{6{,}000 \text{ units}}\right)$ × (7,500 Units – 6,000 Units)
	=	5,500 (F)

BASED ON SALES VALUE

BASIC CALCULATIONS

Statement Showing "Budgeted Sales, Actual Sales Value and Standard Sales"

Product Quantity (units)	Budgeted (units)	Budgeted Price *per unit* (₹)	Budgeted Sales (₹)	Actual Quantity (units)	Actual Price *per unit* (₹)	Actual Sales (₹)	Std. Sales (₹)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8=3 × 5**
K	2,000	12	24,000	1,500	10	15,000	18,000
L	2,000	8	16,000	2,500	7	17,500	20,000
M	2,000	5	10,000	3,500	6	21,000	17,500
Total	6,000		50,000	7,500		53,500	55,500

COMPUTATION OF VARIANCES

Sales Value Variance = Actual Sales – Budgeted Sales

= AP × AQ – BP × BQ

For Product K = ₹ 15,000 – ₹ 24,000 = ₹ 9,000 (A)

For Product L = ₹ 17,500 – ₹ 16,000 = ₹ 1,500 (F)

For Product M = ₹ 21,000 – ₹ 10,000 = ₹ 11,000 (F)

Total = ₹ 9,000 (A) + ₹ 1,500 (F) + ₹ 11,000 (F)

= ₹ 3,500 (F)

Sales Price Variance = Actual Sales – Standard Sales

= AP × AQ – BP × AQ

Or

= AQ × (AP – BP)

For Product K = 1,500 Units × (₹ 10.00 – ₹ 12.00) = ₹ 3,000 (A)

For Product L = 2,500 Units × (₹ 7.00 – ₹ 8.00) = ₹ 2,500 (A)

For Product M = 3,500 Units × (₹ 6.00 – ₹ 5.00) = ₹ 3,500 (F)

Total = ₹ 3,000 (A) + ₹ 2,500 (A) + ₹ 3,500 (F)

= ₹ 2,000 (A)

Sales Volume Variance = Standard Sales – Budgeted Sales

= BP × AQ – BP × BQ

		Or
	=	BP × (AQ – BQ)
For Product A	=	₹ 12 × (1,500 Units – 2,000 Units) = ₹ 6,000 (A)
For Product B	=	₹ 8 × (2,500 Units – 2,000 Units) = ₹ 4,000 (F)
For Product C	=	₹ 5 × (3,500 Units – 2,000 Units) = ₹ 7,500 (F)
Total	=	₹ 6,000 (A) + ₹ 4,000 (F) + ₹ 7,500 (F)
	=	₹ 5,500 (F)
Sales Mix Variance	=	Total Actual Qty (units) × (*Average* Budgeted Price *per unit* of Actual Mix – *Average* Budgeted Price *per unit* of Budgeted Mix)
	=	$7{,}500 \text{ Units} \times \left[\left(\frac{₹\ 55{,}500}{7{,}500 \text{ Units}}\right) - \left(\frac{₹\ 50{,}000}{6{,}000 \text{ Units}}\right)\right]$
	=	7,000 (A)
Sales Quantity Variance	=	*Average* Budgeted Price *per unit* of Budgeted Mix × [Total Actual Qty (units) – Total Budgeted Qty (units)]
	=	$\left(\frac{₹\ 50{,}000}{6{,}000 \text{ Units}}\right) \times (7{,}500 \text{ Units} - 6{,}000 \text{ Units})$
	=	₹ 12,500 (F)

Computation of All Variances

Problem-9

The Standard Cost Sheet per unit for the product produced by Style Manufacturers is worked out on this basis:—

Direct Materials 1.3 tons @ ₹ 4.00 per ton

Direct Labour 2.9 hours @ ₹ 2.30 per hour

Factory Overhead 2.9 hours @ ₹ 2.00 per hour

Normal Capacity is 2,00,000 direct labour hours per month.

The Factory Overhead rate is arrived at on the basis of a Fixed Overhead of ₹ 1,00,000 per month and a Variable Overhead of ₹ 1.50 per direct labour hour.

In the month of May, 50,000 units of the product was started and completed. An investigation of the raw material inventory account reveals that 78,000 tons of raw material were transferred into and used by the factory during May. These goods cost ₹ 4.20 per ton. 1,50,000 hours of

Direct Labour were spent during May at a cost of ₹ 2.50 per hour. Factory Overhead for the month amounted to ₹ 3,40,000 out of which ₹ 1,02,000 was fixed.

Required

(a) *Compute and identify all variances under Material, Labour and overhead as favourable or adverse.*

(b) *Identify one or more departments in the company who might be held responsible for each variance.*

Solution

COMPUTATION OF VARIANCES

(i) Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

= (SP × AQ) – (AP × AQ)

Or

= (SP – AP) × AQ

= 78,000 tons × (₹ 4.00 – ₹ 4.20)

= ₹15,600 (A)

(ii) Material Usage Variance = Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity

= (SQ × SP) – (AQ × SP)

Or

= (SQ – AQ) × SP

= ₹4.00 × [(50,000 units × 1.3 tons) – 78,000 tons]

= ₹52,000(A)

(iii) Total Material Cost Variance = Standard Cost – Actual Cost

= (SQ × SP) – (AQ × AP)

= 65,000 tons × ₹4 – 78,000 tons × ₹4.2

= ₹67,600 (A)

(iv) Labour Rate Variance = Standard Cost of Actual Time – Actual Cost

= (SR × AH) – (AR × AH)

Or

= (SR – AR) × AH

		=	1,50,000 hrs. × (₹ 2.30 – ₹ 2.50)
		=	₹ 30,000 (A)
(v)	**Labour Efficiency Variance**	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
		=	(SH × SR) – (AH × SR)
			Or
		=	(SH – AH) × SR
		=	₹2.30 × [(50,000 units × 2.9 hrs.) – 1,50,000 hrs.]
		=	₹11,500 (A)
(vi)	**Total Labour Cost Variance**	=	Standard Cost – Actual Cost
		=	(SH × SR) – (AH × AR)
		=	(1,45,000 hrs. × ₹2.30) – (1,50,000 hrs. × ₹2.50)
		=	₹41,500 (A)
(vii)	**Variable Overhead Cost Variance**	=	Standard Variable Overheads for Production – Actual Variable Overheads
		=	(50,000 units × 2.9 hrs. × ₹1.50) – ₹2,38,000
		=	₹20,500 (A)
(viii)	**Fixed Overhead Expenditure Variance**	=	Budgeted Fixed Overheads – Actual Fixed Overheads
		=	₹1,00,000 – ₹1,02,000
		=	₹ 2,000 (A)
(ix)	**Fixed Overhead Volume Variance**	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
		=	2.9 hrs. × ₹0.50 × 50,000 units – ₹1,00,000
		=	₹ 27,500 (A)
(x)	**Fixed Overhead Capacity Variance**	=	Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads
		=	(1,50,000 hrs. × ₹0.50) – ₹1,00,000
		=	₹ 25,000 (A)
(xi)	**Fixed Efficiency Variance**	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours
		=	(2.9 hrs. × ₹0.50 × 50,000 units) – (1,50,000 hrs. × ₹0.50)
		=	₹ 2,500 (A)

(xii) Total Fixed Overhead Variance = Absorbed Fixed Overheads – Actual Fixed Overheads

= (2.9 hrs. × ₹0.50 × 50,000 units) – ₹1,02,000

= ₹ 29,500 (A)

IDENTIFICATION OF DEPARTMENT(S) WHO MIGHT BE HELD RESPONSIBLE FOR EACH VARIANCE

Name of Variance **Name of the Department**

Material Price Variance……………………….Purchase Department

Material Usage Variance…………………….Production Department / Factory Foreman

Labour Rate Variance………………………..Personnel Department / Manager Policy

Labour Efficiency Variance………………….Production Department / Factory Foreman

Overhead Variances………………………….Production Department / Factory Foreman

Problem-10

Thomson Exports Ltd. manufactures readymade shirts of a specific quantity in lots to each special order from its overseas customers.

The Standard Costs for one dozen of shirts are:

	₹
Direct Material (24metres @ ₹ 22)	*528*
Direct Labour (3 hours @ ₹ 98)	*294*
Overheads (3 hours @ ₹ 80)	*240*

During July, 2013 it worked on three orders, for which the month's job cost records show the following:

Lot No.	*Units*	*Materials used*	*Hours worked*
245 (UK)	*1,700 Doz.*	*40,440 Metres*	*5,130*
246 (US)	*1,200 Doz.*	*28,825 Metres*	*2,890*
247 (HK)	*1,000 Doz.*	*24,100 Metres*	*2,980*

Additional information:

(a) *The company bought 95,000 metres of materials during July at a cost of ₹ 21,28,000. The material price variance is recorded when materials are purchased. All inventories are carried at cost.*

(b) *Direct labour during July, 2013 amounted to ₹ 11,00,000, labour were paid at ₹ 100 per hour.*

(c) Overheads during the month amounted to ₹ 9,12,000.

(d) A total of ₹ 1,15,20,000 was budgeted for overheads for the year 2013-14, based on estimated production of the plant's normal capacity of 48,000 dozen shirts annually. Overheads at the level of production is 40% fixed and 60% variable. Overheads is applied on the basis of direct labour hours.

(e) There was no work in progress at the beginning of July. During July, lot nos. 245 and 247 were completed. All materials were issued for lot no. 246 which was 80% complete as regards conversion.

Required

(i) Computation of standard cost of production of the shirts per dozen as well as in total for lot Nos. 245, 246 and 247.

(ii) Find out the variation in quantity of material used and labour hours worked for each lot as well as in total.

(iii) Calculate the material price variance; labour rate variance; variable overheads efficiency variance and fixed overheads volume variance.

Solution

(i) COMPUTATION OF STANDARD COST OF PRODUCTION of the shirts per dozen as well as in total for Lot Nos. 245, 246, 247

Lot No.	Cost *per dozen* (₹)	Dozens	Total Standard Cost (₹)
245 (UK)	1,062#	1,700	18,05,400
246 (US)	955.20*	1,200	11,46,240
247 (HK)	1,062#	1,000	10,62,000
Total			40,13,640

 # Lot No. 245/247

100% as regards to material cost	*₹ 528.00*
100% as regards to conversion cost	*₹ 534.00*
	₹ 1,062.00

**Lot No. 246*

100% as regards to material cost	*₹ 528.00*
80% as regards to conversion cost	*₹ 427.20*
	₹ 955.20

(ii) STATEMENT OF VARIATION between standard quantity of material and actual quantity of material used for each lot as well as in total

Lot Nos.	Output (In Dozens)	Std. Qty. Per Dozen (In Metre)	Total Std. Quantity (In Metres)	Total Actual Quantity (In Metres)	Variation (In Metres)
245 (UK)	1,700	24	40,800	40,440	360 (F)
246 (US)	1,200	24	28,800	28,825	25 (A)
247 (HK)	1,000	24	24,000	24,100	100 (A)
Total			93,600	93,365	235 (F)

STATEMENT OF VARIATION between standard labour hours and actual labour hours worked for each lot as well as in total

Lot Nos.	Output (In Dozens)	Std. Labour Hours Per Dozen	Total Std. Labour Hours	Total Actual Labour Hours	Variation (In Hours)
245 (UK)	1,700	3	5,100	5,130	30 (A)
246 (US)	1,200	3	2,880 (1,200 Doz x 3 Hrs. x 80%)	2,890	10 (A)
247 (HK)	1,000	3	3,000	2,980	20 (F)
		Total	10,980	11,000	20 (A)

(iii) **CALCULATION OF VARIANCES**

Material Price Variance = Purchase Quantity × (Standard Price – Actual Price)

$$= 95{,}000 \text{ Metres} \times \left[₹\,22 - \frac{₹\,21{,}28{,}000}{95{,}000 \text{ Metres}}\right]$$

= ₹ 20,90,000 – ₹ 21,28,000

= ₹ 38,000(A)

Labour Rate Variance = Actual Hrs. × (Std. Rate *per hour* – Actual Rate *per hour*)

= 11,000 Hrs.× (₹ 98 – ₹ 100)

= ₹22,000 (A)

Variable Overhead Efficiency Variance = Std. Variable Overhead Rate *per hour** × (Std. Hours for Actual Output – Actual Hours)

= ₹ 48 × (10,980 Hrs. – 11,000 Hrs.)

= ₹ 960 (A)

**Standard Variable Overhead Rate per hour = 60% of ₹ 80 = ₹ 48*

Fixed Overhead Volume Variance	=	Std. Fixed Overhead Rate *per hour* ** × (Std. Hrs. for Actual Output – Budgeted Hours)
	=	₹ 32 × (10,980 Hrs. – 12,000 Hrs.)
	=	₹ 32,640 (A)

***Standard fixed overhead rate per hour = 40% of ₹ 80 = ₹ 32*

Problem-11

The following information relates to a manufacturing concern:

Standard	**₹**
Material A 24,000 kgs @ ₹ 3 per kg.	*72,000*
Material B 12,000 kgs @ ₹ 4 per kg	*48,000*
Wages 60,000 hours @ ₹ 4 per hour	*2,40,000*
Variable Overheads 60,000 hours @ ₹ per hour	*60,000*
Fixed Overheads 60,000 hours @ ₹ 2 per hour	*1,20,000*
Total Cost	*5,40,000*
Budgeted Profit	*60,000*
Budgeted Sales	*6,00,000*
Budgeted Production (units)	*12,000*
Actual	**₹**
Sales (9,000 units)	*4,57,500*
Material A Consumed 22,275 kgs.	*62,370*
Material B Consumed 10,890 kgs.	*44,649*
Wages Paid (48,000 hours)	*1,91,250*
Fixed Overhead	*1,20,900*
Variable Overhead	*45,000*
Labour Hours Worked	*47,700*
Closing (Work in Progress)	*900 units*
Degree of Completion	
Material A and B	*100%*
Wage and Overheads	*50%*

Required

Calculate all variances.

Solution

BASIC CALCULATIONS

Equivalent Production in Units

Particulars	Direct Materials		Labour & Overhead	
Units Completed	100%	9,000	100%	9,000
Work-in-Progress	100%	900	50%	450
Total Equivalent Units		9,900		9,450

Standard and Actual Cost of Material

Material	Standard Cost of 9,900 units			Actual Cost of 9,900 units			
	Qty. (Kg.) [SQ]	Rate (₹) [SP]	Amt (₹) [SQ × SP]	Qty. (Kg.) [AQ]	Rate (₹) [AP]	Amt (₹) [AQ × AP]	Amt (₹) [AQ × SP]
A	19,800	3	59,400	22,275	2.80*	62,370	66,825
B	9,900	4	39,600	10,890	4.10*	44,649	43,560
Total	29,700		99,000	33,165		1,07,019	1,10,385

**Actual Cost/Actual Quantity*

COMPUTATION OF VARIANCES

Direct Material Variances

Material Cost Variance = Standard Cost – Actual Cost

= SQ × SP – AQ × AP

(A) = ₹ 59,400 – ₹ 62,370

= ₹ 2,970 (A)

(B) = ₹ 39,600 – ₹ 44,649

= ₹ 5,049 (A)

Total = ₹ 2,970 (A) + ₹ 5,049 (A)

= ₹ 8,019 (A)

Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

= AQ × SP – AQ × AP

Or

= AQ × (SP – AP)

(A) = 22,275 Kg. × (₹ 3.00 – ₹ 2.80)

= ₹ 4,455 (F)

(B) = 10,890 Kg. × (₹ 4.00 – ₹ 4.10)

= ₹ 1,089 (A)

Total = ₹ 4,455 (F) + ₹ 1,089 (A)

= ₹ 3,366 (F)

Material Usage Variance = Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity

= SQ × SP – AQ × SP

Or

= SP × (SQ – AQ)

(A) = ₹ 3 × (19,800 Kg. – 22,275 Kg.)

= ₹ 7,425 (A)

(B) = ₹ 4 × (9,900 Kg. – 10,890 Kg.)

= ₹ 3,960 (A)

Total = ₹ 7,425 (A) + ₹ 3,960 (A)

= ₹ 11,385 (A)

Material Mix Variance = Total Actual Quantity (units) × (*Average* Standard Price *per unit* of Standard Mix – Average Standard Price *per unit* of Actual Mix)

$$= 33{,}165 \text{ Kg.} \times \left(\frac{₹\ 99{,}000}{29{,}700 \text{ Kg.}} - \frac{₹\ 1{,}10{,}385}{33{,}165 \text{ Kg.}} \right)$$

= ₹ 165 (F)

Material Yield Variance = *Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]

$$= \left(\frac{₹\ 99{,}000}{29{,}700 \text{ Kg.}} \right) \times (29{,}700 \text{ Kg.} - 33{,}165 \text{ Kg.})$$

= ₹ 11,550 (A)

Direct Labour Variances

Labour Cost Variance	=	Standard Cost – Actual Cost
	=	SH × SR – AH* × AR
	=	(9,450 units × 5 hours) × ₹ 4 – ₹1,91,250
	=	₹ 2,250 (A)
Labour Rate Variance	=	Standard Cost of Actual Time – Actual Cost
	=	SR × AH* – AR × AH*
		Or
	=	(SR – AR) × AH*
	=	$\left(₹4 - \frac{₹1{,}91{,}250}{48{,}000\text{hours}}\right) x48{,}000\text{ hours}$
	=	₹750 (F)
		AH refers to Actual Hours Paid*
Labour Efficiency Variance	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
	=	(SH × SR) – (AH# × SR)
		Or
	=	(SH – AH#) × SR
	=	₹4.00 × (9,450 units × 5 hours – 47,700 hours)
	=	₹ 1,800 (A)
Idle Time Variance	=	Standard Rate per Hour × Actual Idle Hours
	=	(AH* × SR) – (AH# × SR)
		Or
	=	(AH* – AH#) × SR
	=	₹4.00 × (48,000 hours – 47,700 hours)
	=	₹ 1,200 (A)
		AH# refers to Actual Hours Worked

Variable Overhead Variances

Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads

= 9,450 units × $\left(\frac{₹60,000}{12,000\text{units}}\right)$ – ₹ 45,000

= ₹ 2,250 (F)

Expenditure Variance = Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads

= 47,700 hours × ₹ 1 – ₹ 45,000

= ₹ 2,700 (F)

Efficiency Variances = Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours

= 9,450 units × $\left(\frac{₹60,000}{12,000\text{units}}\right)$ – 47,700 hours × ₹ 1

= ₹ 450 (A)

Fixed Overhead Variances

Cost Variance = Absorbed Fixed Overheads – Actual Fixed Overheads

= 9,450 units × $\left(\frac{₹1,20,000}{12,000\text{units}}\right)$ – ₹ 1,20,900

= ₹ 94,500 – ₹ 1,20,900

= ₹ 26,400 (A)

Expenditure Variance = Budgeted Fixed Overheads – Actual Fixed Overheads.

= ₹ 1,20,000 – ₹1,20,900

= ₹ 900 (A)

Volume Variance = Absorbed Fixed Overheads – Budgeted Fixed Overheads

= ₹ 94,500 – ₹ 1,20,000

= ₹ 25,500 (A)

Efficiency Variance = Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours

= ₹ 94,500 – ₹ 2.00 × 47,700 hours

= ₹ 900 (A)

Capacity Variance = Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads

= ₹ 2.00 × 47,700 hours – ₹ 1,20,000

= ₹ 24,600 (A)

Sales Variances

Value Variance = Actual Sales – Budgeted Sales

= AP × AQ – BP × BQ

= ₹ 4,57,500 – ₹6,00,000

= ₹ 1,42,500 (A)

Price Variance = Actual Sales – Standard Sales

= AP × AQ – BP × AQ

Or

= AQ × (AP – BP)

$$= 9{,}000 \text{ units} \times \left[\left(\frac{₹4{,}57{,}500}{9{,}000\text{units}}\right) - \left(\frac{₹6{,}00{,}000}{12{,}000\text{units}}\right)\right]$$

= 7,500 (F)

Volume Variance = Standard Sales – Budgeted Sales

= BP × AQ – BP × BQ

Or

= BP × (AQ – BQ)

= ₹50 × (9,000 units – 12,000 units)

= ₹1,50,000 (A)

Sales Margin Variances

Sales Margin Price Variance = Sales Price Variance

= 7,500 (F)

Sales Volume Variance = Sales Volume Variance × Budgeted Net Profit Ratio

$$= 1{,}50{,}000 \text{ (A)} \times \left(\frac{₹60{,}000}{₹6{,}00{,}000} \text{x}100\right)$$

= ₹ 15,000 (A)

Margin Variance = Sales Margin Price Variance + Sales Margin Volume Variance

= ₹7,500 (F) + ₹15,000 (A)

= ₹ 7,500 (A)

☞

Sales Price Variance is equal to **Sales Margin Price Variance**. This is because, for the actual quantity sold, standard cost remaining constant, change in selling price will have equal impact or turnover and profit.

Sales Margin Volume Variance is **equal** to **Sales Volume Variance × Budgeted Net Profit Ratio**

☞

Overhead Variances can also be affected by idle time. It is usually assumed that Overheads are incurred when labour is working, not when it is idle. Accordingly, hours worked has been considered for the calculation of Variable and Fixed Overheads Variances.

Problem-12

An engineering company manufactures a single product whose standard cost structure is as follows:

		₹
Direct Material	*(2.4 kg. at ₹ 30 per kg.)*	*72.00*
Direct Labour	*(6 hours at ₹ 4 per hour)*	*24.00*
Factory Overheads	*(6 hours at ₹ 75 per hour)*	*4.50*

The factory overhead is based on the following Flexible Budget:

	80%	**90%**	**100%**	**110%**
Production (Units)	*6,000*	*6,750*	*7,500*	*8,250*
	₹	₹	₹	₹
Variable Overheads	*18,000*	*20,250*	*22,500*	*24,750*
Fixed Overheads	*11,250*	*11,250*	*11,250*	*11,250*

Actual data for the month of December, 2013

Budgeted Production………………………………………..75,000 units

Material used…………………………………………………19,240 kg. at ₹ 31 per kg.

Direct Labour……………………………………………….. 46,830 hours at ₹ 4.20 per hour

Actual Factory Overhead…………………………………... ₹ 36,340

Production completed………………………………………7,620 units

Details of Work-in-progress: Opening 120 units materials fully supplied, .50% converted Closing 100 units, materials fully supplied, 50% converted

Required

Determine and analyses Material Cost Variance, Labour Cost Variance, and Overhead Cost Variance.

Solution

COMPUTATION OF VARIANCES

Direct Material Cost Variance	= Standard Cost – Actual Cost
	= Std. Qty. × Std. Price – Actual Qty. × Actual Price
	= (7,600 units × 2.4 kg). × ₹ 30 – 19,240 kg. × ₹ 31
	= ₹ 5,47,200 – ₹ 5,96,440
	= ₹ 49,240 (A)
Direct Material Price Variance	= Standard Cost of Actual Quantity – Actual Cost
	Or
	= Actual Qty. × (Std. Price – Actual Price)
	= 19,240 kg. × (₹ 30 – ₹ 31)
	= 19,240 (A)
Direct Material Usage Variance	= Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity
	Or
	= Std. Price × (Std. Qty. – Actual Qty.)
	= ₹ 30 × (7,600 units x 2.4 kg – 19,240 kg.)
	= ₹ 30 × (18,240 – 19,240)
	= ₹ 30,000 (A)
Direct Labour Cost Variance	= Standard Cost – Actual Cost
	= Std. Hours × Std. Rate – Actual Hours × Actual Rate
	= (7,610 units × 6 hours) × ₹ 4 – 46,830 hours × ₹ 4.2
	= ₹ 1,82,640 – ₹ 1,96,686
	= ₹ 14,046 (A)
Direct Labour Rate Variance	= Standard Cost of Actual Time – Actual Cost

		Or
	=	Actual Hours × (Std. Rate – Actual Rate)
	=	46,830 hours × (₹ 4 – ₹ 4.20)
	=	₹ 9,366 (A)
Direct Labour Efficiency Variance	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
		Or
	=	Std. Rate × (Std. Hours – Actual Hours)
	=	₹ 4 × (7,610 units × 6 hours – 46,830 hours)
	=	₹ 4,680 (A)
Factory Overhead Cost Variance	=	Absorbed Overheads – Actual Overheads
	=	₹ 4.5 × 7,610 units – ₹ 36,340
	=	₹ 2,095 (A)
Fixed Factory Overhead Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹ 1.5 × 7,610 units – ₹ 11,250
	=	₹ 11,415 – ₹ 11,250
	=	₹ 165 (F)
Fixed Factory Overhead Capacity Variance	=	Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads
		Or
	=	Std. Rate *per hour* × (Actual Hours – Budgeted Hours)
	=	₹ 0.25 × (46,830 hours – 7,500 units × 6 hours)
	=	₹ 457.50 (F)
Fixed Factory Overhead Efficiency Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours
		Or
	=	Std. Rate *per hour* × (Std. Hours for Actual Output – Actual Hours)

$= \left(\frac{₹1.5}{6hrs.}\right) \times$ (7,610 units × 6 hours – 46,830 hours)

= ₹ 292.50 (A)

Variable Factory Overhead Efficiency Variance = Std. Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours

Or

= Std. Rate *per hour* × (Std. Hours for Actual Output – Actual Hours)

$= \left(\frac{₹3.0}{6hrs.}\right) \times$ (7,610 units × 6 hours – 46,830 hours)

= ₹ 585 (A)

WORKING NOTES

1	**Equivalent units regarding Materials**	
		Units
	Production Completed	7,620
	Add: Closing Stock *equivalent units*	100
	Less: Opening Stock *equivalent units*	120
		7,600
2	**Equivalent units regarding Labour and Overheads**	
		Units
	Production Completed	7,620
	Add: Closing Stock *equivalent units*	50
	Less: Opening Stock *equivalent units*	60
		7,610

Problem-13

Alpha Ltd. uses standard costing system for manufacturing its single product 'APS". Standard cost card per unit is as follows:

	(₹)
Selling Price……………………………………………………..	*120*
Direct Material (1 kg per unit)……………………………………	*20*

Direct Labour (6 hrs @ ₹8 per hour)…………………………....	*48*
Variable Overheads………………………………………………	*24*
Contribution	*28*

Actual and budgeted activity levels in units for the month of September are:

	Budget	Actual
Sales………………………………………………….....	*50,000*	*51,200*
Production……………………………………….....…..	*50,000*	*52,000*

Actual sales revenue and variable costs for the month of September are given as under:

Sales………………………………………………………....	*61,33,760*
Direct Material………………………………………………....	*10,65,600*
Direct Labour (3,00,000 hrs)………………………………..	*24,42,000*
Variable Overheads……………………….........................	*12,28,000*

Required

(i) Calculate Direct Labour Rate Variance

(ii) Calculate Direct Labour Efficiency Variance

(iii) Calculate Sales Volume Variance

(iv) Calculate Sales Price Variance

(v) Comment on your findings in (i) and (ii) above.

Solution

(i) Labour Rate Variance = Standard Cost of Actual Time – Actual Cost

= (SR × AH) – (AR × AH)

Or

= (SR – AR) × AH

= (₹8.00 – ₹8.14) × 3,00,000 hrs.

= ₹42,000 (A)

Working

Actual Labour Rate *per hour* $= \frac{\text{Actual Paid}}{\text{Actual Hours}}$

$= \frac{₹\ 24,42,000}{3,00,000\text{ hrs.}}$

		=	₹ 8.14
(ii)	**Labour Efficiency Variance**	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
		=	(SH × SR) – (AH × SR)
			Or
		=	(SH – AH) × SR
		=	(3,12,000 hrs. – 3,00,000 hrs.) × ₹8.00
		=	₹96,000 (F)
	Working		
	Standard Hours	=	Actual Production × Std. hrs. *per unit*
		=	52,000 units × 6 hrs.
		=	3,12,000 hrs.
(iii)	**Sales Volume Variance**	=	Standard Sales – Budgeted Sales
			Or
		=	Budgeted Price × (Actual Quantity – Budgeted Quantity)
		=	₹120 × (51,200 units – 50,000 units)
		=	₹1,44,000 (F)
(iv)	**Sales Price Variance**	=	Actual Sales – Standard Sales
			Or
		=	Actual Quantity × (Actual Price – Budgeted Price)
		=	51,200 units × (₹119.80 – ₹120)
		=	₹10,240 (A)
	Working		
	Actual Sales Price	=	$\frac{\text{Actual Sales}}{\text{Actual Qty.}}$
		=	$\frac{₹\ 61,33,760}{51,200 \text{ units}}$
		=	₹119.80

(v) Comment

Direct Labour Rate Variance

Adverse Labour Rate Variance indicates that the labour rate per hour paid is more than the set standard. The reason may include among other things such as:

(1) While setting standard, the current/ future market conditions like pending labour negotiation/ cases, has not been considered (or predicted) correctly.

(2) The labour may have been told that their wage rate will be raised or bonus will be paid if they work efficiently.

Direct Labour Efficiency Variance

It indicates that the workers has produced actual production quantity in less time than the time allowed. The reason for favourable labour efficiency variance may include among the other things as follows:

(1) While setting standard, workers efficiency could not be estimated properly, this may happen due to non-observance of time and motion study.

(2) The workers may be new in the factory, hence, efficiency could not be predicated properly.

(3) The foreman or personnel manager responsible for labour efficiency, while providing his/ her input at the time of budget/ standard, has adopted conservative approach.

(4) The increase in the labour rate might have encouraged the labours to do work more efficiently.

In this particular case it may have happened that since labour payment has been increased labour efficiency has also been increased. In a nutshell because of additional labour rate (Adverse), labour efficiency has gone up (Favourable)

Missing/Required Information from Given Inputs and Variances

Problem-14

KYC Ltd. uses a standard absorption costing system. The following details have been extracted from its budget for year 2013-14.

Fixed Overhead Cost………………………………... ₹ 7,20,000

Production…………………………………………….36,000 units

In 2013-14 the Fixed Overhead Cost was over-absorbed by ₹3,200 and the Fixed Overhead Expenditure Variance was ₹20,000(F).

Required

What was the actual number of units produced in 2013-14?

Solution

Fixed Overhead Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads
₹20,000 (F)	=	₹7,20,000 – Actual Fixed Production Overheads
Actual Fixed Overheads	=	₹7,00,000
Absorbed Fixed Overheads	=	Actual Fixed Overheads + Over Absorbed Fixed Overheads
	=	₹7,00,000 + ₹3,200
	=	₹7,03,200
Standard Absorption Rate *per unit*	=	₹7,20,000 / 36,000 units
	=	₹20
So, Actual Number of Units	=	₹7,03,200 / ₹20
	=	35,160 units

Problem-15

S. Ltd. operates a system of standard costing in respect of one of its products which is manufactured within a single cost centre, the following information is available:

Standard price of material is ₹ 2 per litre. The standard wage rate is ₹ 6 per hour and 5 hours are allowed to produce one unit. Fixed production overhead is absorbed at the rate of 100% of direct wages cost.

During the month just ended the following occurred -

	₹
Actual Price (paid for material purchased)…………………………..	*1.95 per litre*
Total Direct Wages Cost…………………………………………..	*1,56,000*
Fixed Production Overhead……………………………………....	*1,58,000*

Variance	***Favourable (₹)***	***Adverse (₹)***
Direct Material Price	*8,000*	*-*
Direct Material Usage	*-*	*5,000*
Direct Labour Rate	*-*	*5,760*

Direct Labour Efficiency	*2,760*	*-*
Fixed Production Overhead Expenditure	*-*	*8,000*

Required

Calculate the following for the month-

(i) Budgeted output in units.

(ii) Number of litres purchased.

(iii) Number of litres used above standard allowed.

(iv) Actual units produced.

(v) Actual hours worked.

(vi) Average actual wage rate per hours.

Solution

Budgeted output in units

Fixed Overhead Expenditure Variance = Budgeted Fixed Overheads – Actual Fixed Overheads

⟹ ₹8,000 (A) = Budgeted Output × (₹ 6 × 5 hrs.) – ₹1,58,000

⟹ Budgeted Output = 5,000 units

Number of litres purchased

Material Price Variance = Actual Quantity × (Std. Price – Actual Price)

⟹ ₹8,000 (F) = No. of litres purchased × (₹ 2 – ₹ 1.95)

⟹ No. of litres purchased = 1,60,000 litres

Number of litres used above standard allowed

Material Usage Variance = Standard Price × (Standard Quantity – Actual Quantity)

⟹ ₹5,000 (A) = ₹ 2 × (Standard Quantity – 1,60,000 litres)

⟹ Standard Quantity = 1,57,500 litres

No. of litres above Standard = 1,60,000 litres – 1,57,500 litres

= 2,500 litres

Actual units produced

Labour Cost Variance = Rate Variance + Efficiency Variance

= ₹ 5,760 (A) + ₹ 2,760 (F)

	=	₹ 3,000 (A)
Labour Cost Variance	=	Standard Cost – Actual Cost
⇒ ₹3,000 (A)	=	Actual Output × (₹ 6 × 5 hrs.) – ₹1,56,000
⇒ Actual Output	=	5,100 units

Actual hours worked

Labour Efficiency Variance	=	Standard Rate × (Standard Hours – Actual Hours)
⇒ ₹2,760 (F)	=	₹ 6 x (5,100 units × 5 hrs. – Actual Hours)
⇒ Actual Hours	=	25,040 hours

Average actual wage rate per hours

Labour Rate Variance	=	Actual Hours × (Standard Rate – Actual Rate)
⇒ ₹5,760 (A)	=	25,040 hours × (₹ 6 – Actual Rate)
⇒ Actual Rate	=	₹ 6.23...*per hour*

Problem-16

The details regarding a product manufactured by ZED & Co. for the last one week are as follows:

Standard Cost (for one unit)		***₹***
Direct Materials	*(10 unit @ ₹ 1.50)*	*15*
Direct Wages	*(5 hours @ ₹ 8.00)*	*40*
Production Overheads	*(5 hours @ ₹ 10.00)*	*50*
		105

Actual (for whole activity)	***₹***
Direct Materials	*6,435*
Direct Wages	*16,324*
Direct Materials	
Price	*585 (A)*
Usage	*375 (F)*
Direct Wages	
Rate	*636 (F)*
Usage	*360 (A)*

Production Overheads	
Expenditure	*400 (F)*
Volume	*750 (F)*

Required

(i) Calculate actual output units;

(ii) Calculate actual price of material per unit;

(iii) Calculate actual wage rate per labour hour;

(iv) Calculate the amount of production overhead incurred, and

(v) Calculate the production overhead efficiency variance.

Solution

COMPUTATION OF REQUIREMENTS

Actual output units

Material Cost Variance = Price Variance + Usage Variance

= ₹ 585 (A) + ₹ 375 (F)

= ₹ 210 (A)

Material Cost Variance = Standard Cost of Standard Quantity for Actual Production (refer as Standard Cost) – Actual Cost

⇒ ₹210 (A) = ₹ 15 × Actual Output – ₹ 6,435

⇒ Actual Output = 415 units

Material Usage Variance = Standard Price × (Standard Quantity – Actual Quantity)

⇒ ₹375 (F) = ₹ 1.5 × (415 units × 10 units – Actual Quantity)

⇒ Actual Quantity = 3,900 units

Actual price of material per unit

Actual price of Material *per unit* $= \frac{\text{Actual Cost}}{\text{Actual Quantity}}$

$= \frac{₹6,435}{3,900 \text{ units}}$

= ₹ 1.65

Actual wage rate per labour hour

Labour Rate Variance	=	Actual Hours × (Standard Rate – Actual Rate)
⇒ ₹636 (F)	=	Actual Hours × (₹ 8 – Actual Rate)
⇒ ₹636 (F)	=	Actual Hours × ₹ 8 – Actual Cost
⇒ ₹636 (F)	=	Actual Hours × ₹ 8 – ₹ 16,324
⇒ Actual Hours	=	2,120 Hours
Actual Wage Rate *per hour*	=	$\frac{\text{Actual Wages}}{\text{Actual Hours}}$
	=	$\frac{₹16,324}{2,120 \text{ hours}}$
	=	₹ 7.7 *per hour*

The amount of production overhead incurred

Production Overhead Cost Variance	=	Expenditure Variance + Volume Variance
	=	₹ 400 (F) + ₹ 750 (F)
	=	₹ 1,150 (F)
Production Overhead Cost Variance	=	Absorbed Overheads – Actual Overheads
⇒ ₹ 1,150 (F)	=	₹ 50 × 415 units – Actual Overheads
⇒ Actual Overheads	=	₹ 19,600

The production overhead efficiency variance

Production Overhead Efficiency Variance	=	Absorbed Overheads – Budgeted Overheads for Actual Hours
	=	₹ 10 × (5 Hours × 415 units) – ₹ 10 × 2,120 Hours
	=	₹ 450 (A)

Problem-17

Prince Edward & Co. used a full standard cost system with raw materials inventory carried at Standard. The following data were taken from the records of the company for the year ended 31.12.2013:

	₹
Opening raw materials inventory	*300*
Closing raw materials inventory	*250*
Net purchases	*410*
Material price variance	*10 (A)*
Material usage variance	*20 (A)*
Direct labour cost (Actual)	*900*
Direct labour cost at standard	*840*
Actual overhead cost incurred	*875*
Overheads cost variance	*45 (F)*
Opening work-in-progress inventory	*120*
Closing work-in-progress inventory	*140*
Opening finished goods inventory	*360*
Cost of goods sold reported	*2,240*

Note: "F" denotes favourable and "A" denotes adverse.

Required

Compute-

1. *Raw material Purchases at standard.*
2. *Raw materials consumed at standard.*
3. *Labour cost variance.*
4. *Standard overhead costs.*
5. *Total manufacturing cost at standard.*
6. *Cost of goods manufactured.*
7. *Cost of products sold to customers.*
8. *Closing finished goods inventory.*

Solution

COMPUTATION OF REQUIREMENTS

		₹
1.	**Raw Material Purchases at Standard**	
	Net Purchases *at actual*	410

	Less: Material Price Variance (A)		10
			400
			₹
2.	**Raw Materials Consumed at Standard**		
	Opening Stock at Standard		300
	Add: Purchases at Standard (as per 1)		400
			700
	Less: Closing Stock at Standard		250
			450
			₹
3.	**Labour Cost Variance**		
	Direct Labour Cost at Standard		840
	Less: Actual Direct Labour Cost		900
		Adverse	60
			₹
4.	**Standard Overhead Cost**		
	Actual Overhead Cost		875
	Add: Overhead Cost Variance (Favourable)		45
			920
			₹
5.	**Total Manufacturing Cost at Standard**		
	Standard Raw Material Cost		450
	Standard Direct Labour Cost		840
	Standard Overhead Cost		920
			2,210
			₹
6.	**Cost of Goods Manufactured (at Standard)**		
	Opening WIP (at Standard)		120
	Add: Total Cost of Goods Manufactured (at Standard)		2,210
	Less: Closing WIP (at Standard)		140
			2,190
			₹
7.	**Cost of Products Sold to Customers (at Standard)**		
	Cost of Goods Sold Reported		2,240
	Less: Adverse Cost Variances		

Material Price Variance	10(A)	
Material Usage Variance	20(A)	
Direct Labour Cost Variance	60(A)	90
Add: Favourable Cost Variances		
Overhead Cost Variance		45
		2,195

		₹
8.	**Closing Stock of Finished Goods Inventory at Standard**	
	Opening Finished Goods Inventory (at Standard)	360
	Add: Cost of Goods Manufactured (at Standard)	2,190
	Less: Cost of Products Sold to Customers (at Standard)	2,195
	Closing Finished Goods Inventory (at Standard)	355

Problem-18

The following are the information regarding overheads of a company:

(a) Overheads cost variance = ₹2,800 (A)

(b) Overheads volume variance = ₹2,000 (A)

(c) Budgeted overheads = ₹ 12,000

(d) Actual overhead recovery rate = ₹8 per hour

(e) Budgeted hours for the period = 2,400 hours

Required

Compute the following-

(i) Overheads expenditure variance.

(ii) Actual incurred overheads.

(iii) Actual hours for actual production.

(iv) Overheads capacity variance.

(v) Overheads efficiency variance.

(vi) Standard hours for actual production.

Solution

BASIC WORKINGS

Overheads Cost Variance = ₹ 2,800 (A)

Overheads Volume Variance	=	₹ 2,000 (A)
Budgeted Overheads	=	₹ 12,000
Actual Overhead Recovery Rate	=	₹ 8 per hour
Budgeted Hours *for the period*	=	2,400 hours

COMPUTATION OF REQUIREMENTS

Overheads expenditure variance

Overheads Expenditure Variance = Overheads Cost Variance (–) Overheads Volume Variance

= ₹ 2,800 (A) – ₹ 2,000 (A)

= ₹ 800 (A)

Actual incurred overheads

Overheads Expenditure Variance = Budgeted Overheads (–) Actual Overheads

$\Rightarrow$ ₹ 800(A) = ₹ 12,000 (–) Actual Overheads

Therefore, Actual Overheads = ₹ 12,800

Actual hours for actual production

$$\text{Actual hours for actual production} = \frac{\text{Actual Overheads}}{\text{Actual Overhead Recovery Rate Per Hour}}$$

$$= \frac{₹\,12,800}{₹\,8}$$

= 1,600 hours

Overheads capacity variance

Overheads Capacity Variance = Budgeted Overheads for Actual Hours (–) Budgeted Overheads

= ₹ 5 × 1,600 hrs. – ₹ 12,000

= ₹ 8,000 – ₹ 12,000

= ₹ 4,000 (A)

Overheads efficiency variance

Overheads Efficiency Variance = Absorbed Overheads (–) Budgeted Overheads for Actual Hours

= ₹ 10,000 – ₹ 5 × 1,600 hours

$= ₹\ 2{,}000\ (F)$

Standard hours for actual production

Standard hours for actual output $= \dfrac{\text{Absorbed Overheads}}{\text{Standard Overhead Rate per hour}}$

$= \dfrac{₹\ 10{,}000}{₹\ 5}$

$= 2{,}000$ hours

WORKING NOTE

Overhead Cost Variance = Absorbed Overheads (–) Actual Overheads

$\Rightarrow$ ₹ 2,800 (A) = Absorbed Overheads (–) ₹12,800

$\Rightarrow$ Absorbed Overheads = ₹10,000

Standard Rate *per hour* $= \dfrac{\text{Budgeted Overheads}}{\text{Budgeted Hours}}$

$= \dfrac{₹\ 12{,}000}{2{,}400 \text{ hours}}$

$= ₹\ 5$

Problem-19

Compute the missing data indicated by the question marks from the following:

	Product R	***Product S***
Standard Sales Qty.(Units)	*? ? ?*	*400*
Actual Sales Qty. (Units)	*500*	*? ? ?*
Standard Price/Unit	*₹12*	*₹15*
Actual Price/Unit	*₹15*	*₹20*
Sales Price Variance	*? ? ?*	*? ? ?*
Sales Volume Variance	*₹1,200 (F)*	*? ? ?*
Sales Value Variance	*? ? ?*	*? ? ?*

Sales Mix Variance for both the products together was ₹ 450 (F). 'F' denotes favourable.

Solution

Statement Showing "Standard & Actual Data (incomplete)"

Product	**Standard / Budgeted Data**			**Actual Data**		
	Qty. (units)	**Price (per unit)**	**Amount (₹)**	**Qty. (units)**	**Price (per unit)**	**Amount (₹)**
R	? ??	₹ 12	? ? ?	500	₹ 15	7,500
S	400	₹ 15	6,000	? ? ?	₹ 20	? ? ?
Total	? ? ?		? ??	? ??		? ? ?

Product: R

Sales Price Variance = Actual Qty. × (Actual Price – Budgeted Price)

= 500 units × (₹ 15 – ₹ 12)

= ₹ 1,500 (F)

Sales Volume Variance = Budgeted Price × (Actual Qty. – Budgeted Qty.)

₹1,200 (F) = ₹ 12 × (500 units – Budgeted Qty.)

$\Rightarrow$ Budgeted Qty. = 400 units

Sales Value Variance = Sales Price Variance + Sales Volume Variance

= ₹ 1,500 (F) + ₹ 1,200 (F)

= ₹ 2,700 (F)

The table can now be presented as follows. Assumed **Actual Quantity of S** is **'T' units**.

Product	**Standard / Budgeted Data**			**Actual Data**		
	Qty. (units)	**Price (per unit)**	**Amount (₹)**	**Qty. (units)**	**Price (per unit)**	**Amount (₹)**
R	400	₹ 12	4,800	500	₹ 15	7,500
S	400	₹ 15	6,000	T	₹ 20	20 x T
	800		10,800	500 + T		7,500 + 20T

Sales Mix Variance = Total Actual Qty (units) × (*Average* Budgeted Price *per unit* of Actual Mix – *Average* Budgeted Price *per unit* of Budgeted Mix)

$$\Rightarrow ₹450\ (F) = (500\ units + T\ units) \times \left[\left(\frac{500 units x ₹12 + 'T' units x ₹15}{500\ units + 'T'\ units}\right) - \left(\frac{₹10{,}800}{800 Units}\right)\right]$$

$$\Rightarrow ₹450\ (F) = 6{,}000 + 15T - 13.5 \times (500 + T)$$

$$\Rightarrow T = 800\ units$$

Statement Showing "Standard & Actual Data (Complete)"

Product	Standard / Budgeted Data			Actual Data		
	Qty. (units)	Price (per unit)	Amount (₹)	Qty. (units)	Price (per unit)	Amount (₹)
R	400	₹ 12	4,800	500	₹ 15	7,500
S	400	₹ 15	6,000	800	₹ 20	16,000
	800		10,800	1,300		23,500

Product: S

Sales Price Variance = Actual Qty. × (Actual Price – Budgeted Price)
= 800 units × (₹ 20 – ₹ 15)
= ₹ 4,000 (F)

Sales Volume Variance = Budgeted Price × (Actual Qty. – Budgeted Qty.)
= ₹ 15 × (800 units – 400 units)
= ₹ 6,000 (F)

Sales Value Variance = Sales Price Variance + Sales Volume Variance
= 4,000 (F) + 6,000 (F)
= ₹10,000 (F)

Problem-20

M Star ltd uses standard costing system in manufacturing of its single product 'MGO'. The standard cost per unit of 'MGO' is as follows.

	₹
Direct Material – 2 metres @ ₹ 6 per metre	*12.00*
Direct Labour – 1 hour @ ₹ 4.40 per hour	*4.40*
Variable Overhead – 1 hour @ ₹ 3 per hour	*3.00*
	19.40

During July, 2013, 6,000 units of M were procured and the related data are as under:

Direct material acquired – 19,000 metres @ 5.70 per metre.

Material consumed 12,670 meters.

Direct labour - ? hours @ ₹ ? per hour……………..…………..…….. ₹ 27,950

Variable overheads incurred…………………………..………….……₹ 20,475

The variable overhead efficiency variance is ₹ 1,500 adverse. Variable overheads are based on direct labour hours. There was no stock of raw – material in the beginning.

Required

Compute the missing figures and work out all the relevant variances.

Solution

WORKING NOTE

Standard Cost	₹
Direct Materials (6,000 units × ₹ 12)	72,000
Direct Labour (6,000 units × ₹ 4.40)	26,400
Variable Overheads (6,000 units × ₹ 3)	18,000

Actual Cost	₹
Direct Material (12,670 metres × ₹ 5.70)	72,219
Direct Wages	27,950
Variable Overheads	20,475

WORKING FOR FINDING - MISSING FIGURES

Actual Labour Hours

Variable Overhead Efficiency Variance = Standard Variance Overhead Rate *per hour* × (Std. Hours for Actual Output – Actual Hours)

⇒ ₹ 1,500 (Adverse) = ₹ 3 × (6,000 units × 1 hour – Actual Hours)

⇒ Actual Hours = 6,500 hours

Actual Wage Rate *per hour* $= \frac{\text{Actual Wages Paid}}{\text{Actual Hours}}$

$= \frac{₹27,950}{6,500 \text{ hours}} = ₹\ 4.30$

COMPUTATION OF VARIANCES

Material Variances

1. Material Cost Variance	=	Standard Cost – Actual Cost
	=	₹ 72,000 – 72,219
	=	₹ 219 (A)
2. Material Price Variance	=	Actual Quantity × (Standard Price – Actual Price)
	=	12,670 metres × (₹ 6 – ₹ 5.70)
	=	₹ 3,801 (F)
3. Material Usage Variance	=	Standard Price × (Standard Qty. – Actual Qty.)
	=	₹ 6 × (12,000 metres – 12,670 metres)
	=	₹ 4,020 (A)

Labour Variances

1. Labour Cost Variance	=	Standard Cost – Actual Cost
	=	₹ 26,400 – ₹ 27,950
	=	₹1,550 (A)
2. Labour Rate Variance	=	Actual Hours × (Standard Rate – Actual Rate)
	=	6,500 hours × (₹ 4.40 – ₹ 4.30)
	=	₹ 650 (F)
3. Labour Efficiency Variance	=	Standard Rate × (Standard Hours – Actual Hours)
	=	₹ 4.40 × (6,000 hours – 6,500 hours)
	=	₹ 2,200 (A)

Variable Overhead Variances

1. Total Variable Overhead Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
	=	₹ 18,000 – ₹ 20,475
	=	₹ 2,475 (A)
2. Variable Overhead Efficiency Variance	=	Standard Variable Overhead Rate *per hour* × (Std. Hrs. for Actual Output – Actual Hours)
	=	₹ 3 × (6,000 hours – 6,500 hours)
	=	₹1,500 (A)

3. **Variable Overhead Expenditure Variance**	=	Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
	=	₹ 3 × 6,500 hours – ₹ 20,475
	=	₹ 975 (A)

Problem-21

A company produces a product X, using raw materials A and B. The standard mix of A and B is 1: 1 and the standard loss is 10% of input.

	A	***B***	***Total***
Standard price of raw material (₹/ kg.)	*24*	*30*	
Actual input (kg.)	*?*	*70*	
Actual output (kg.)			*?*
Actual price ₹/ kg.	*30*	*?*	
Standard input quantity (kg.)	*?*	*?*	
Yield variance (sub usage)			*270(A)*
Mix variance			*?*
Usage variance	*?*	*?*	*?*
Price variance	*?*	*?*	*?*
Cost variance	*0*	*?*	*1,300(A)*

Required

Compute the missing information indicated by "?" based on the data given above.

Solution

WORKING FOR FINDING – MISSING FIGURES

Cost Variance $_{A}$ = 0

Cost Variance $_{(A+B)}$ = ₹1,300 (A)

Yield Variance $_{(A+B)}$ = ₹270 (A)

Standard Cost and Actual Cost (Incomplete Information)

Raw Material	Standard Data			Actual Data		
	Qty. (Kg.) [SQ]	**Price (₹) [SP]**	**Amount (₹) [SQ x SP]**	**Qty. (Kg.) [AQ]**	**Price (₹) [AP]**	**Amount (₹) [AQ x AP]**
A	? ??	24	? ? ?	? ? ?	30	? ? ?
B	? ??	30	? ? ?	70	? ? ?	? ? ?
Total	? ? ?		? ??	? ??		? ? ?

Material Cost Variance $_{A}$ = Standard Cost – Actual Cost

$\Rightarrow$ 0 = $(SQ_A \times ₹\ 24 - AQ_A \times ₹\ 30)$

$\Rightarrow SQ_A$ = $1.25\ AQ_A$

Material Yield Variance $_{(A+B)}$ = *Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]

$$\Rightarrow ₹270\ (A) = \left(\frac{₹\ 24 \times SQ_A + ₹\ 30 \times SQ_B}{SQ_A + SQ_B}\right) \times [(SQ_A + SQ_B) - (AQ_A + 70)]$$

$SQ_A = SQ_B$ as Standard Mix is in ratio 1:1

$$\Rightarrow ₹270\ (A) = \left(\frac{₹\ 24 \times SQ_A + ₹\ 30 \times SQ_A}{SQ_A + SQ_A}\right) \times [(SQ_A + SQ_A) - (AQ_A + 70)]$$

$\Rightarrow ₹270\ (A)$ = $27 \times [2 \times SQ_A - (AQ_A + 70)]$

$\Rightarrow ₹270\ (A)$ = $27 \times [2 \times 1.25\ AQ_A - (AQ_A + 70)]$

$\Rightarrow AQ_A$ = 40 Kg.

As SQ_A = $1.25\ AQ_A$

= 1.25×40 Kg.

= 50 Kg.

As SQ_B = SQ_A

= 50 Kg.

Cost Variance $_{(A+B)}$ = Standard Cost – Actual Cost

$\Rightarrow$ 1,300 (A) = (50 Kg. × ₹ 24 + 50 Kg. × ₹ 30) – (40 Kg. × ₹ 30+70 Kg. × AP_B)

$\Rightarrow AP_B$ = ₹ 40

Standard Cost and Actual Cost (Complete Information)

Raw Material	Standard Data			Actual Data			Std. Cost of Actual Qty. (₹) [AQ x SP]
	Qty. (Kg.) [SQ]	Price (₹) [SP]	Amount (₹) [SQ x SP]	Qty. (Kg.) [AQ]	Price (₹) [AP]	Amount (₹) [AQ x AP]	
A	50	24	1,200	40	30	1,200	960
B	50	30	1,500	70	40	2,800	2,100
Total	100		2,700	110		4,000	3,060

COMPUTATION OF VARIANCES

Material Cost Variance = Standard Cost – Actual Cost

= SQ × SP – AQ × AP

(A) = ₹ 1,200 – ₹ 1,200

= ₹ 0

(B) = ₹ 1,500 – ₹ 2,800

= ₹ 1,300 (A)

Total = ₹ 0 + ₹ 1,300 (A)

= ₹ 1,300 (A)

Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

= AQ × SP – AQ × AP

Or

= AQ × (SP – AP)

(A) = 40 Kg. × (₹ 24.00 – ₹ 30.00)

= ₹ 240 (A)

(B) = 70 Kg. × (₹ 30.00 – ₹ 40.00)

= ₹ 700 (A)

Total = ₹ 240 (A) + ₹ 700 (A)

= ₹ 940 (A)

Material Usage Variance = Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity

= SQ × SP – AQ × SP

Or

	=	SP × (SQ – AQ)
(A)	=	₹ 24 × (50 Kg. – 40 Kg.)
	=	₹ 240 (F)
(B)	=	₹ 30 × (50 Kg. – 70 Kg.)
	=	₹ 600 (A)
Total	=	₹ 240 (F) + ₹ 600 (A)
	=	₹ 360 (A)
Material Mix Variance	=	Total Actual Quantity (units) × (*Average* Standard Price *per unit* of Standard Mix – Average Standard Price *per unit* of Actual Mix)
	=	$110 \text{ Kg.} \times \left(\frac{₹\ 2,700}{100 \text{ Kg.}} - \frac{₹\ 3,060}{110 \text{ Kg.}}\right)$
	=	₹ 90 (A)
Material Yield Variance	=	*Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]
	=	$\left(\frac{₹\ 2,700}{100 \text{ Kg.}}\right) \times (100 \text{ Kg.} - 110 \text{ Kg.})$
	=	₹ 270 (A)
Standard Output	=	Standard Input – Standard Loss
	=	100 Kg. – 10 Kg.
	=	90 Kg.
Actual Output	=	90 Kg.

(Actual Output and Standard Output are always equal numerically in any Material Variance Analysis)

Problem-22

Worldwide LTD. is engaged in marketing of wide range of consumer goods. M, N, O and P are the zonal sales officers for your zones. The company fixes annual sales target for them individually.

You are furnished with the following:

(1) The standard costs of sales target in respect of M, N, O and P are ₹ 5,00,000, ₹ 3,75,000, ₹ 4,00,000 and ₹ 4,25,000 respectively.

(2) *M, N, O and P respectively earned ₹ 29,900, ₹ 23,500, ₹ 24,500 and ₹ 25,800 as commission at 5% on actual sales effected by them during the previous year.*

(3) *The relevant variances as computed by a qualified cost accountant are as follows :*

Particulars	*M (₹)*	*N (₹)*	*O (₹)*	*P (₹)*
Sales Price Variance	*4,000 (F)*	*6,000 (A)*	*5,000 (A)*	*2,000 (A)*
Sales Volume Variance	*6,000 (A)*	*26,000 (F)*	*15,000 (F)*	*8,000 (F)*
Sales Margin Mix Variance	*14,000 (A)*	*8,000 (F)*	*17,000 (F)*	*3,000 (A)*

Note: (A) = Adverse variance and (F) = Favourable variance

Required

(i) *Compute the amount of sales target fixed and the actual amount of margin earned in case of each of the zonal sales officer.*

(ii) *Evaluate the overall performance of these zonal sales officers taking three relevant base factors and then recommend whose performance is the best.*

Solution

Statement Showing "Sales Target Fixed & Actual Margin"

(₹)

Particulars	Zonal Sales Officers			
	M	N	O	P
Commissioned Earned	29,900	23,500	24,500	25,800
Actual Sales (Commission Earned / 5%)	5,98,000	4,70,000	4,90,000	5,16,000
Sales Price Variance	4,000(F)	6,000(A)	5,000(A)	2,000(A)
Sales Volume Variance	6,000(A)	26,000(F)	15,000(F)	8,000(F)
Sales Target (Budgeted Sales)	6,00,000	4,50,000	4,80,000	5,10,000
Standard Cost of Sales Target	5,00,000	3,75,000	4,00,000	4,25,000
Budgeted Margin	1,00,000	75,000	80,000	85,000
Sales Margin Mix Variance	14,000(A)	8,000(F)	17,000(F)	3,000(A)
Sales Price Variance	4,000(F)	6,000(A)	5,000(A)	2,000(A)
Actual Margin	90,000	77,000	92,000	80,000

*Note: Since no information has been given about Sales Margin Quantity Variance, therefore for calculating actual margin the same has been assumed to be **zero**.*

Statement Showing "Evaluation of the Performance of Zonal Sales Officers"

Particulars	Zonal Sales Officers			
	M	N	O	P
Efficiency towards the Target Sales				
(a) Whether target achieved	No	Yes	Yes	Yes
(b) Actual Sales to Target Sales Ratio	99.67%	104.44%	102.08%	101.18%
(c) Rank	IV	I	II	III
Margin Approach				
(a) Margin Earned (₹)	90,000	77,000	92,000	80,000
(b) Rank	II	IV	I	III
Margin Vs Sales Ratio				
(a) Budgeted Margin/Sales Target Ratio	16.67%	16.67%	16.67%	16.67%
(b) Actual Margin Vs Actual Sales Ratio	15.05%	16.38%	18.78%	15.50%
(c) Rank	IV	II	I	III

An analysis on performance of four Zonal Sales Officers based on three base factors, the performance of officer O is the best.

Factors Contributing to Change in Profit

Problem-23

The working results of a Jems Ltd. for two corresponding years are shown below:

Particulars	*Amount (₹ in lakhs)*	
	Year 2012	*Year 2013*
Sales	*600*	*770*
Cost of Sales:		
Direct materials	*300*	*324*
Direct wages and variable overheads	*180*	*206*
Fixed overheads	*80*	*150*
Profit	*40*	*90*

In year 2013, there has been an increase in the selling price by 10 per cent. Following are the details of material consumption and utilization off direct labour hours during the two years:

Particulars	*Year 2012*	*Year 2013*
Direct material consumption (M. tons)	*5,00,000*	*5,40,000*
Direct labour hours	*75,00,000*	*80,00,000*

Required

(i) *Taking year 2012 as base year, analyse the variances of year 2013 and also workout the amount which each variance has contributed to change in profit.*

(ii) *Find out the breakeven sales for both years.*

(iii) *Calculate the percentage increase in selling price in the year 2013 that would be needed over the sale value of year 2013 to earn margin of safety of 45 per cent.*

Solution

COMPUTATION OF REQUIREMENTS

(i) Reconciliation Statement Showing "Factors Contributed Change in Profit"

(₹ in lacs)

Particulars	Fav.	Adv.
Increase in Contribution Due to Increase in Volume (*₹ 140 lacs – ₹ 120 lacs*) (*Refer to working note 3*)	20	—
Sales Price Variance (*Refer to working note 3*)	70	—
Material Usage Variance (*Refer to working note 4*)	26	—
Material Price Variance (*Refer to working note 4*)	—	—
Direct Labour Rate Variance (*Refer to working note 4*)	—	14
Direct Labour Efficiency Variance (*Refer to working note 4*)	18	—
Fixed Overhead Expenditure Variance (*Refer to working note 3*)	—	70
Change in Profit	134	84
Change in Profit (Net)	50	

(ii) Break-Even Sales

$$\text{Break-even Sales} = \frac{\text{Fixed cost}}{\text{P/V ratio}}$$

$$\text{Year 2012} = \frac{₹\ 80\text{ lacs}}{\left(\dfrac{₹\ 120\text{ lacs}}{₹\ 600\text{ lacs}}\right)} = ₹\ 400\text{ lacs}$$

Year 2013 $= \dfrac{₹\ 150 \text{ lacs}}{\left(\dfrac{₹\ 240 \text{ lacs}}{₹\ 770 \text{ lacs}}\right)} = ₹\ 481.25 \text{ lacs}$

(iii) Percentage Increase in Selling Price Needed Over the Sales Value of Year 2013 to Earn a Margin of Safety of 45% in Year 2013

Break-even Sales (%) = (100% – 45%) or 55% of Total Sales

Required Contribution $= \dfrac{₹150\text{lacs}}{55} \text{x}100 = ₹\ 272.73 \text{ lacs}$

☞

$$\left[BEP(₹) = \frac{FixedCost(₹)}{PVR\%}\right]$$

Or

$$\left[\frac{BEP(₹)}{Sales(₹)} = \frac{FixedCost(₹)}{PVR\%\ xSales(₹)}\right]$$

Or

$$\left[\frac{BEP(₹)}{Sales(₹)} x100 = \frac{FixedCost(₹)}{PVR\%\ xSales(₹)} x100\right]$$

Or

$$\left[BEP(\%) = \frac{FixedCost(₹)}{Contribution(₹)} x100\right]$$

Or

$$\left[Contribution(₹) = \frac{FixedCost(₹)}{BEP(\%)} x100\right]$$

Present Contribution = ₹ 240 lacs

Increase in Selling Price required = ₹ 32.72 lacs (₹ 272.73 lacs – ₹ 240 lacs)

Percentage increase in Selling Price over the Sales Value of Year 2013 $= \dfrac{₹\,32.72\text{lacs}}{₹\,770\text{lacs}} \times 100 = 4.25\%$

WORKING NOTES

1. Budgeted Sales in Year 2013

If Actual Sales in Year 2013 is ₹ 110 then Budgeted Sales is ₹ 100.

If Actual Sales in Year 2013 is ₹ 1 then Budgeted Sales = $\dfrac{₹\ 100}{₹110}$

If Actual Sales in Year 2013 are ₹ 770,00,000 then Budgeted Sales are

$$= \frac{₹100}{₹110} \times ₹7,70,00,000 = ₹700 \text{ lacs}$$

2. Budgeted Figures of Direct Material; Direct Wages; and Variable Overhead Worked Out on the Basis of % of Sales in Year 2013

Direct Material % to Sales (in Year 2012) $= \frac{\text{Direct Material}}{\text{Sales}} = \frac{300}{600} \times 100 = 50\%$

Budgeted figure of Direct Material (in Year 2013) = 50% × ₹ 700 lacs = 350 lacs

Direct Wages and Variable Overhead (% to sales in Year 2012) $= \frac{\text{Direct Wages and Variable Overhead}}{\text{Sales}}$

$$= \frac{180}{600} \times 100 = 30\%$$

Budgeted figure of Direct Wages and Variable Overhead (in Year 2013) = 30% × 700 lacs = 210 lacs

3. Statement of Figures Extracted from Working Results of Company

(Figure in lacs of ₹)

Particulars	**Year 2012 [Actual] (a)**	**Year 2013 [Budgeted] (b)**	**Year 2013 [Actual] (c)**	**Total [Variance] (d) = (c) – (b)**
Sales : (A) (**Refer to working note 1*)	600	700*	770	70 (F)
Direct Material...(a) (**Refer to working note 2*)	300	350*	324	26 (F)
Direct Wages and Variable Overhead...(b) (**Refer to working note 2*)	180	210*	206	4 (F)
Total Variable Costs: (B) = (a + b)	480	560	530	30(F)
Contribution (C) = (A) – (B)	120	140	240	100 (F)
Less : Fixed Cost	80	80	150	70 (A)
Profit	40	60	90	30(F)

4. **Data for Material Variances (i)**

Standard Cost for Actual Output			Actual Cost		
Quantity of Material (m/t)	**Rate per m/t (₹)**	**Amount (₹)**	**Quantity of Material (m/t)**	**Rate per m/t (₹)**	**Amount (₹)**
5,83,333.. $\left[\frac{₹350\ \text{lacs}}{₹60^*}\right]$	60*	350 lacs	5,40,000	60	324 lacs

** ₹ 300 lacs / 5 lacs m/t*

Material Price Variance = (Standard Rate – Actual Rate) × Actual Quantity
= Nil

Material Usage Variance = (Standard Quantity – Actual Quantity) × Standard Rate per m/t
= (5,83,333.. – 5,40,000) × ₹ 60
= ₹26 lacs (F)

Data for Labour Variances/ Overhead Variances (ii)

Standard Cost for Actual Output			Actual Cost		
Labour Hours	**Rate per hour (₹)**	**Amount (₹)**	**Labour Hours**	**Rate per hour (₹)**	**Amount (₹)**
87,50,000 $\left[\frac{₹210\ \text{lacs}}{₹2.40}\right]$	2.40*	210 lacs	80,00,000	2.575	206 lacs

** ₹ 180 lacs / 75 lacs hours*

Rate Variance = (Standard Rate – Actual Rate) × Actual Labour Hours
= (₹ 2.40 – ₹ 2.575) × 80,00,000
= ₹14 lacs (A)

Efficiency Variance = (Standard Labour Hours – Actual Labour Hours) × Standard Rate per Hour
= (87,50,000 – 80,00,000) × ₹ 2.40
= ₹ 18 lacs (F)

Problem-24

RST Ltd. has provided the following summarized results for two years:

	Year ended (₹ In lacs)	
	31-03-2013	***31-3-2014***
Sales	*3,000*	*3,277.50*
Material	*2,000*	*2,357.50*
Variable overheads	*500*	*525.00*
Fixed overheads	*300*	*367.50*
Profit	*200*	*27.50*

During the year ended 31-3-2014 sale price has increased by 15% whereas material and overhead prices have increased by 15% and 5% respectively.

Required

(i) Analyse the variances of revenue and each element of cost over the year in order to bring out the reasons for the change in profit.

(ii) Present a profit reconciliation statement starting from profits in 2012-13 showing the factors responsible for the change in profits in 2013-14.

Solution

Statement Showing "Reconciliation Between

Budgeted Profit [F.Y. 2012-13] & Actual Profit [F.Y. 2013-14]"

Particulars	**(₹ in lacs)**	**(₹ in lacs)**
Budgeted Profit		200.00
Sales Margin Variances:		
Price	427.50 (F)	
Volume	10.00 (A)	417.50 (F)
Direct Material Variances:		
Price	307.50 (A)	
Usage	150.00 (A)	457.50 (A)
Variable Overheads Variances:		
Expenditure	25.00 (A)	
Efficiency	25.00 (A)	50.00 (A)

Fixed Overheads Variances:		
Expenditure	67.50 (A)	
Volume	15.00 (A)	82.50 (A)
Actual Profit		27.50

COMPUTATION OF VARIANCES (₹ In Lacs)

Sales Variances

Price Variance = Actual Sales – Standard Sales

= ₹3,277.50 – ₹2,850.00

= ₹427.50 (F)

Volume Variance = Standard Sales – Budgeted Sales

= ₹2,850.00 – ₹3,000.00

= ₹150 (A)

Sales Margin Price Variance = Sales Price Variance

= ₹427.50 (F)

Sales Margin Volume Variance = Sales Volume Variance × Budgeted Net Profit Ratio

$$= ₹150\ (A) \times \left(\frac{₹200}{₹3{,}000}\right)$$

= ₹10 (A)

Material Variances

Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

= ₹2,050.00 – ₹2,357.50

= ₹307.50 (A)

Material Usage Variance = Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity

= ₹1,900 – ₹2,050

= ₹150 (A)

Variable Overhead Variances

Expenditure Variance = Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads

Or

	= Std. Rate *per unit* × Expected Output for Actual Hours Worked – Actual Variable Overheads
	= ₹500 – ₹525
	= ₹25 (A)
Efficiency Variances	= Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours
	Or
	= Std. Rate *per unit* × Actual Output – Std. Rate *per unit* × Expected Output for Actual Hours Worked
	= ₹475 – ₹500
	= ₹25 (A)
Fixed Overhead Variances	
Expenditure Variance	= Budgeted Fixed Overheads – Actual Fixed Overheads.
	= ₹300.00 – ₹367.50
	= ₹67.50 (A)
Volume Variance	= Absorbed Fixed Overheads – Budgeted Fixed Overheads
	= ₹285 – ₹300
	= ₹15 (A)

WORKING NOTES (₹ in lacs)

Note-1

Sales in F.Y. 2013-2014	3,277.50
Less: Increase due to *price rise* [₹3,277.50 lacs × 15/115]	427.50
Sales in F.Y. 2013-2014 at F.Y. 2012-2013 Prices **[Standard Sales]**	2,850.00
Sales in F.Y. 2012-2013	3,000.00
Fall in Sales in F.Y. 2013-2014 [₹3,000 lacs – ₹2,850 lacs]	150.00
Percentage fall	5%

Note-2

Material Cost In F.Y. 2012-2013	2,000.00
Less: 5% for Decrease in Volume	100.00
'Standard Material Usage' at F.Y. 2012-13 Prices **(Standard Cost of Standard Quantity for Actual output)**	1,900.00
Actual Material Cost F.Y. 2013-2014	2,357.50

Less: 15% Increase in Prices [₹2,357.50 lakhs × 15/115]	307.50
Actual Materials Used, at F.Y. 2012-2013 Prices **(Standard Cost of Actual Quantity)**	2,050.00

Note-3

Variable Overheads Cost in F.Y. 2012-13	500.00
Less: 5% due to fall in Volume of Sales in F.Y. 2013-14	25.00
"Standard Overheads for Production" in F.Y. 2013-14	475.00
Actual Variable Overheads Incurred in F.Y. 2013-14	525.00
Less: 5% for Increase in Price [₹525 lacs × 5 / 105]	25.00
Amount Spent in F.Y. 2013-14 at F.Y. 2012-13 Prices **(Budgeted Variable Overheads for Actual Hours)**	500.00

Note-4

Fixed Overheads Cost in F.Y. 2012-13	300.00
Less: 5% due to fall in Volume of Sales in F.Y. 2013-14	15.00
"Standard Overheads for Production" in F.Y. 2013-14. **(Absorbed Fixed Overheads)**	285.00

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This problem can also be solve by **'Contribution'** approach.

Problem-25

The summarised results of a company for the two years ended 31st December 2013 and 2012 are given below:-

Particulars	***2013 ₹' lakhs***	***2012 ₹' lakhs***
Sales	*770*	*600*
Direct Materials	*324*	*300*
Direct Wages	*137*	*120*
Variables Overheads	*69*	*60*
Fixed Overheads	*150*	*80*
Profit	*90*	*40*

As a result of re-organisation of production methods and extensive advertisement campaign used, the company was able to secure an increase in the selling price by 10% during the year 2013 as compared to the previous year.

In the year 2012, the company consumed 1,20,000 kgs. of raw materials and used 24,00,000 hours of direct labour. In the year 2013, the corresponding figures were 1,35,000 kgs. of raw materials and 26,00,000 hours of direct labour.

Required

Use the information given for the year 2012 as the base year information to analyse the results of the year 2013 and to show in a form suitable to the management the amount each factor has contributed by way of price, usage and volume to the change in profit in 2013.

Solution

STATEMENT SHOWING "Causes of Change in Profit in 2013"

	₹' lakhs	₹' lakhs
Profit Earned in 2012		40
Add: Increase in Profit *due to*:		
Sales Price Variance	70.00 (F)	
Sales Margin Volume Variance [₹100 × 20%]	20.00 (F)	90
Add: Savings in Material Cost *due to*:		
Material Price Variance	13.50 (F)	
Material Usage Variance	12.50 (F)	26
Add: Net Savings in Wages		
Labour Rate Variance	7.00 (A)	
Labour Efficiency Variance	10.00 (F)	3
Add: Net Savings in Variable Overheads *due to*:		
Expenditure Variance	4.00 (A)	
Efficiency Variance	5.00 (F)	1
Less: Decrease in Profit *due to*:		
Increase in Fixed Overheads		70
Profit in 2013		90

WORKING NOTES

(1) Sales

Sales in 2013 Price $\left(₹770\ \text{lakhs} \times \dfrac{100\%}{110\%}\right)$	₹700 lakhs
Increase in Sales Volume (16.67% or 1/6th over that in 2012) *Or* Say Sales Volume Variance	₹100 lakhs
Sales Price Variance (₹770 lakhs – ₹ 700 lakhs)	₹70 lakhs

(2) Material

Material Price *per Kg.* in 2012 $\left(\dfrac{₹300\ \text{lakhs}}{1.20\ \text{lakhs kgs.}}\right)$	₹250
Material Price *per Kg.* in 2013 $\left(\dfrac{₹324\ \text{lakhs}}{1.35\ \text{lakhs kgs.}}\right)$	₹240
Saving in Material Price *per Kg.*	₹10
Increase in *expected* Material Consumption In 2013 (1/6 of 1,20,000 Kgs.)	20,000 Kgs.
Total *expected* Consumption in 2013 (1,20,000 Kgs.+ 20,000 Kgs.)	1,40,000 Kgs.
Actual Consumption in 2012	1,35,000 Kgs.
Saving in Materials	5,000 Kgs.
Material Price Variance (1,35,000 × ₹10)	₹13,50,000 (F)
Material Usage variance (5,000Kgs. × ₹250)	₹12,50,000 (F)

(3) Wages

Labour *hour rate* in 2012 $\left(\dfrac{₹120\ \text{lakhs}}{24\ \text{lakh hrs.}}\right)$	₹5
Labour *hour rate* in 2013 $\left(\dfrac{₹137\ \text{lakhs}}{26\ \text{lakh hrs.}}\right)$	₹5.2692..
Increase in *expected* Labour due to Volume increase in 2013 (1/6 of 24lakh hrs.)	4,00,000 hrs.
Total *expected* Hours required in 2013 (24,00,000 hrs.+ 1/6 of 24,00,000 hrs.)	28,00,000 hrs.
Actual Labour Hours *used* in 2013	26,00,000 hrs.
Saving in Labour Hours	2,00,000 hrs.

	Labour Rate Variance [26,00,000 hrs.× (₹ 5 – ₹ 5.2692...)]	₹7,00,000(A)
	Labour Efficiency Variance (2,00,000 hrs. × ₹ 5)	₹10,00,000 (F)
(4)	**Variable Overheads (V.O.)**	
	Variable Overhead *hour rate* in 2012 $\left(\frac{₹60\text{ lakhs}}{24\text{ lakh hrs.}}\right)$	₹2.5
	Labour *hour rate* in 2013 $\left(\frac{₹69\text{ lakhs}}{26\text{ lakh hrs.}}\right)$	₹2.6538..
	Increase in *expected* V.O. due to Volume increase in 2013 (1/6 of 24lakh hrs.)	4,00,000 hrs.
	Total *expected* Hours required in 2013 (24,00,000 hrs.+ 1/6 of 24,00,000 hrs.)	28,00,000 hrs.
	Actual Variable Overheads Hours *used* in 2013	26,00,000 hrs.
	Saving in Variable Overheads Hours	2,00,000 hrs.
	V.O. Expenditure Variance [26,00,000 hrs.× (₹ 2.5 – ₹ 2.6538...)]	₹4,00,000(A)
	V.O. Efficiency Variance (2,00,000 hrs. × ₹ 2.5)	₹5,00,000(F)
	(Assumed *Variable Overheads* are related to direct labour hours)	
(5)	**Fixed Overheads**	
	Increase in 2013 over 2012 (₹150 lakhs – ₹ 80 lakhs)	₹ 70 lakhs
(6)	**P/V Ratio in 2012**	
	$\left[\frac{₹(80+40)\text{ lakhs}}{₹600\text{ lakhs}}\right]\text{x}100$	20%

Computation of Variances and Reconciliation of Budgeted/ Standard Profit with Actual Profit

Problem-26

ZCL Ltd. produces one standard product X and operates standard costing and budgetary control system. During the month of February the following information were available:

(i) Direct Materials:

100 tonnes of material A at ₹ 155 per tonne were issued for production. The standard price of A is ₹ 150 per tonne and standard production from each tonne of material A consumed is 50 units.

(ii) *Direct Labour:*

Skilled and semi-skilled workers are employed in the factory. The budgeted labour-mix is as follows:

Skilled……………………… 6,000 hours at ₹ 1.50 per hour…………………………..₹ 9,000

Semi-Skilled………………10,000 hours at ₹ 1.00 per hour…………………………₹10,000

At the end of February an analysis of wages showed the following:

Skilled……………………....6,600 hours at ₹1.60 per hour…………………….......₹ 10,560

Semi-Skilled……………….11,000 hours at ₹ 0.80 per hour…………………………₹ 8,800

Failure of power, machine breakdown, etc. resulted in 120 idle hours in respect of skilled workers.

(iii) *Variable Overhead:*

The standard variable overhead rate per unit has been set at ₹ 2. Actual variable overhead for the month was ₹ 11,500.

(iv) *Fixed Overhead:*

Budgeted Overhead……………………………………………………...........₹2,18,750 p.a.

Budgeted Production for the year…………………………………….............62,500 units

Budgeted number of weeks in the year…………………...............................50 weeks

Actual production (February)…………………………………….....................6,000 units

Actual overhead (February)…………………………………............................₹ 22,000

(v) *Sales:*

Product	**Budget**			**Actual**		
	Quantity	**Price (₹)**	**Value (₹)**	**Quantity**	**Price (₹)**	**Value (₹)**
X	5,000	20	1,00,000	4,600	21	96,600

Required

Calculate the necessary variances and prepare a summary thereof with reconciliation statement.

Solution

BASIC WORKINGS

Standard Output (100 tonnes x 50 units) = 5,000 units

Actual Output = 6,000 units

COMPUTATION OF VARIANCES

Direct Material Variances

Material Cost Variance	=	Standard Cost – Actual cost
	=	120 tonnes × ₹150 – 100 tonnes × ₹155
	=	₹18,000 – ₹15,500
	=	₹ 2,500 (F)
Material Price Variance	=	Actual Quantity × (Standard Price – Actual Price)
	=	100 tonnes × (₹150 – ₹155)
	=	₹ 500 (A)
Material Usage Variance	=	Standard Price × (Standard Quantity – Actual Quantity)
	=	₹ 150 × (120 tonnes – 100 tonnes)
	=	₹ 3,000 (F)

Verification

Material Cost Variance	=	Material Price Variance + Material Usage Variance
	=	₹ 500 (A) + ₹ 3,000 (F)
	=	₹ 2,500 (F)

Direct Labour Variances

Category	Standard Cost (6,000 units)			Actual (6,000 units)		
	Hrs.	Rate	Amt.	Hrs.	Rate	Amt.
Skilled	7,200	1.50	10,800	6,600	1.60	10,560
Semi-Skilled	12,000	1.00	12,000	11,000	0.80	8,800
Total	19,200		22,800	17,600		19,360

Labour Rate Variance	=	Actual Hours × (Standard Rate - Actual Rate)
Skilled	=	6,600 hours × (₹1.50 – ₹1.60)
	=	₹660 (A)
Semi-Skilled	=	11,000 hours × (₹1.00 – ₹0.80)
	=	₹2,200 (F)
Total	=	₹660 (A) + ₹2,200 (F)
	=	₹1,540 (F)

Labour Efficiency Variance	= Standard Rate × (Standard Hours – Actual Hours)
Skilled	= ₹1.50 × (7,200 hours – 6,600 hours)
	= 900 (F)
Semi-Skilled	= ₹1.00 × (12,000 hours – 11,000 hours)
	= 1,000 (F)
Total	= 900 (F) + 1,000 (F)
	= 1,900 (F)
Labour Cost Variance	= Labour Rate Variance + Labour Efficiency Variance
	= 1,540 (F) + 1,900 (F) = ₹ 3,440 (F)

Verification

Labour Cost Variance	= Standard Cost – Actual Cost
	= ₹ 22,800 – ₹19,360 = ₹ 3,440 (F)

Labour Efficiency Variance may be segregated into:

(i) Idle Time Variance

(ii) Net Efficiency Variance

Or

(i) Idle Time Variance

(ii) Mix Variance

(i) Yield Variances

Idle Time Variance	= Standard Rate *per hour* × Actual Idle hours
	= ₹1.50 × 120 hours
	= ₹ 180 (A)
Net Efficiency Variance	= Standard Rate × (Standard Hours – Actual Hours Worked)
Skilled	= ₹1.50 × (7,200 hours – 6,480 hours)
	= ₹1,080 (F)
Semi-Skilled	= ₹1.00 × (12,000 hours –11,000 hours)
	= ₹1,000 (F)
Total	= ₹1,080 (F) + ₹1,000 (F)
	= ₹ 2,080 (F)

Verification

Labour Efficiency Variance	=	Idle Time Variance + Net Efficiency Variance
	=	₹ 180 (A) + ₹ 2,080 (F)
	=	₹ 1,900 (F)
Labour Mix Variance	=	Total Actual Time *Worked* (hours) × {*Average* Standard Rate *per hour* of Standard Gang Less *Average* Standard Rate *per hour* of Actual Gang@}
		@*on the basis of hours worked*
	=	17,480 hours × $\left(\frac{₹22,800}{19,200 \text{ hrs.}} - \frac{₹1.5 \text{ x } 6,480 \text{ hrs.} + ₹1.0 \text{ x } 11,000\text{hrs.}}{17,480 \text{ hrs.}}\right)$
	=	₹ 37.50 (F)
Labour Yield Variance	=	*Average* Standard Rate *per hour* of Standard Gang × {Total Standard Time (hours) Less Total Actual Time *Worked* (hours)}
	=	$\left(\frac{₹\ 22,800}{19,200 \text{ hrs.}}\right) \text{x} \left(19,200 \text{ hrs.} - 17,480 \text{ hrs.}\right)$
	=	₹2,042.50 (F)

Verification

Labour Efficiency Variance	=	Idle Time Variance + Mix Variance + Yield Variance
	=	₹ 180 (A) + ₹ 37.50 (F) + 2,042.50 (F)
	=	₹ 1,900 (F)

Variable Overhead Variances

Cost Variance	=	Standard Variable Overheads for Output – Actual Overheads
	=	₹ 12,000 – 11,500
	=	₹ 500 (F)

Fixed Overhead Variances

Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
	=	6,000 units × ₹ 3.50 – ₹ 22,000
	=	₹21,000 – ₹22,000
	=	₹1,000 (A)

Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads.
	=	5,000 units × ₹3.50 – ₹22,000
	=	₹17,500 – ₹22,000
	=	₹4,500 (A)
Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹21,000 – ₹17,500
	=	₹3,500 (F)
Verification		
Cost Variance	=	Expenditure Variance + Volume variance
	=	4,500 (A) + 3,500 (F)
	=	₹ 1,000 (A)
Efficiency Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours
	=	₹ 21,000 – ₹ 3.50 × $\frac{5{,}000\text{units}}{16{,}000\text{hrs.}}$ x17,480hrs.
	=	₹ 1,881.25 (F)
Capacity Variance	=	Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads
	=	₹ 3.50 × $\frac{5{,}000\text{units}}{16{,}000\text{hrs.}}$ x17,480hrs. – ₹17,500
	=	₹ 1,618.75 (F)
Verification		
Volume Variance	=	Efficiency Variance + Capacity variance
	=	₹ 1,881.25 (F) + ₹ 1,618.75 (F)
	=	₹ 3,500 (F)
Sales Variances		
Sales Value Variance	=	Actual Sales – Budgeted Sales
	=	₹96,600 – ₹1,00,000
	=	₹3,400 (A)

Sales Price Variance = Actual Sales – Standard Sales

= ₹96,600 – 4,600 units × ₹20

= 4,600 (F)

Sales Volume Variance = Standard Sales – Budgeted Sales

= ₹92,000 – ₹1,00,000

= ₹ 8,000 (A)

SUMMARY OF VARIANCES

Particulars	**(₹)**	**(₹)**	**(₹)**
Direct Material Cost Variance			
Price Variance		500 (A)	
Usage Variance		3,000 (F)	2,500 (F)
Direct Labour Cost Variance			
Rate Variance		1,540 (F)	
Net Efficiency Variance			
Mix Variance	37.50 (F)		
Yield Variance	2,042.50 (F)	2,080 (F)	
Idle Time Variance		180 (A)	3,440 (F)
Variable Overhead Cost Variance			500 (F)
Fixed Overhead Cost Variance			
Expenditure Variance		4,500 (A)	
Volume Variance			
Capacity Variance	1,881.25 (F)		
Efficiency Variance	1,618.75 (F)	3,500 (F)	1,000 (A)
Sales Value Variances			
Price Variance		4,600 (F)	
Volume Variance		8,000 (A)	3,400 (A)
Sales Margin Variances			
Price Variance		4,600 (F)	
Volume Variance $\left[₹8{,}000(A) \times \frac{(₹20 - ₹12.30)}{₹20}\right]$		3,080 (A)	1,520 (F)

STANDARD COST *per unit*

	₹
Direct Material	3.00
Direct Labour	3.80
Variable Overheads	2.00
Fixed Overheads	3.50
Standard Cost	12.30

RECONCILIATION - BUDGETED AND ACTUAL PROFIT

	₹
Budgeted Profit {5,000 units × (₹20 – ₹12.30)}	38,500
Add: Sales Margin Price Variance (F)	4,600
Less: Sales Margin Volume Variance (A)	3,080
Add: Total Cost Variance (F) [₹2,500(F)+₹3,440(F)+₹500(F)+₹1,000(A)]	5,440
Actual Net Profit	45,460

VERIFICATION

	₹
Actual Sales	96,600
Less: Actual Cost	
Materials	15,500
Labour	19,360
Variable Overhead	11,500
Fixed Overhead	22,000
Add: Closing Stock of Finished Goods at *Standard Cost* [1,400 units x ₹12.30]	17,220
Actual Net Profit	45,460

Problem-27

Safron products Ltd. produces and sells a single product. Standard cost card per unit of the product is as follows:

	₹
Direct Material, A 10 kg @ ₹ 5 per kg	*50.00*
B 5 kg @ ₹ 6 per kg	*30.00*
Direct Wages, 5 hours @ ₹ 5 per hour	*25.00*

Variable Production Overheads, 5 hours @ 12 per hour	*60.00*
Fixed Production Overheads	*25.00*
Total Standard Cost	*190.00*
Standard Gross Profit	*35.00*
Standard Selling Price	*225.00*

A fixed production overhead has been absorbed on the expected annual output of 25,200 units produced evenly throughout the year. During the month of December, 2013, the following were the actual results for an actual production of 2,000 units:

	₹
Sales, 2,000 units @ ₹ 225	*4,50,000*
Direct Materials, A 18,900 kg	*99,225*
B 10,750 kg	*61,275*
Direct Wages, 10,500 hours (actually worked 10,300 hours)	*50,400*
Variable Production Overheads	*1,15,000*
Fixed Production Overheads	*56,600*
Gross Profit	*67,500*

The material price variance is extracted at the time of receipt of materials. Material purchase were a 20,000 kg. @ ₹ 5.25 per kg; B 11,500 kg @ ₹ 5.70 per kg.

Required

(i) *Calculate all Variances.*

(ii) *Prepare a reconciliation statement showing Standard Gross Profit, Variances and Actual*
Gross Profit.

(iii) *Explain the reason for the difference in Actual Gross Profit given in the Problem and calculated in (ii) above.*

Solution

COMPUTATION OF VARIANCES

Direct Material Variances

Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

(At the time of receipt)

= PQ × SP – PQ × AP

Or

= PQ × (SP – AP)

(A) = 20,000 Kg. × (₹ 5.00 – ₹ 5.25)

= ₹ 5,000 (A)

(B) = 11,500 Kg. × (₹ 6.00 – ₹ 5.70)

= ₹ 3,450 (F)

Total = ₹ 5,000 (A) + ₹ 3,450 (F)

= ₹ 1,550 (A)

Material Usage Variance = Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity

= SQ × SP – AQ × SP

Or

= SP × (SQ – AQ)

(A) = ₹ 5 × (2,000 units × 10 Kg. – 18,900 Kg.)

= ₹ 5,500 (F)

(B) = ₹ 6 × (2,000 units × 5 Kg. – 10,750 Kg.)

= ₹ 4,500 (A)

Total = ₹ 5,500 (F) + ₹ 4,500 (A)

= ₹ 1,000 (F)

Material Mix Variance = Total Actual Quantity (units) × (*Average* Standard Price *per unit* of Standard Mix – Average Standard Price *per unit* of Actual Mix)

= 29,650 Kg. ×

$$\left(\frac{(₹50 + ₹30) \text{ x } 2{,}000 \text{ units}}{2{,}000\text{units x } (10 \text{ Kg.} + 5 \text{ Kg.})} - \frac{₹5 \text{ x } 18{,}900 \text{ Kg.} + ₹6 \text{ x } 10{,}750 \text{ Kg.}}{18{,}900 \text{ Kg.} + 10{,}750 \text{ Kg.}}\right)$$

= ₹ 866.66… (A)

Material Yield Variance = *Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]

$$= \left\{\frac{(₹50 + ₹30) \text{ x } 2{,}000 \text{ units}}{2{,}000 \text{ units x } (10 \text{ Kg.} + 5 \text{ Kg.})}\right\} \times$$

[(10Kg. + 5Kg.) × 2,000 units – (18,900 Kg. + 10,750 Kg.)]

= ₹ 1,866.66…. (F)

Direct Labour Variances

Labour Rate Variance = Standard Cost of Actual Time – Actual Cost

= SR × AH* – AR × AH*

Or

= (SR – AR) × AH*

$$= \left(₹5 - \frac{₹50{,}400}{10{,}500 \text{hours}}\right) \text{x} 10{,}500 \text{ hours}$$

= ₹2,100(F)

AH refers to Actual Hours Paid*

Labour Efficiency Variance = Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time

= (SH × SR) – ($AH^{\#}$ × SR)

Or

= (SH – $AH^{\#}$) × SR

= ₹5.00 × (2,000 units × 5 hours – 10,300 hours)

= ₹ 1,500 (A)

Idle Time Variance = Standard Rate per Hour x Actual Idle Hours

= (AH^{*} × SR) – ($AH^{\#}$ × SR)

Or

= (AH^{*} – $AH^{\#}$) × SR

= ₹5.00 × (10,500 hours – 10,300 hours)

= ₹ 1,000 (A)

$AH^{\#}$ refers to Actual Hours Worked

Variable Overhead Variances

Cost Variance = Standard Variable Overheads for Production – Actual Variable Overheads

	=	2,000 units × ₹ 60 – ₹ 1,15,000
	=	₹ 5,000 (F)
Expenditure Variance	=	Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
	=	10,300 hours × ₹ 12 – ₹ 1,15,000
	=	₹ 8,600 (F)
Efficiency Variances	=	Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours
	=	2,000 units × ₹ 60 – 10,300 hours × ₹ 12
	=	₹ 3,600 (A)

Fixed Overhead Variances

Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
	=	2,000 units × ₹ 25.00 – ₹ 56,600
	=	₹50,000 – ₹56,600
	=	₹6,600 (A)
Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads.
	=	2,100 units × ₹25.00 – ₹56,600
	=	₹52,500 – ₹56,600
	=	₹4,100 (A)
Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹50,000 – ₹52,500
	=	₹2,500 (A)

RECONCILIATION STATEMENT

Particulars	**(₹)**	**(₹)**	**(₹)**
Standard Profit (₹35 x 2,000 units)			70,000
Variances	***Favourable***	***Adverse***	
Material:			
Price (at the time of receipt)	----	1,550	
Mix	----	866.66...	
Yield	1,866.66...	----	(550)

Labour:			
Rate	2,100	----	
Efficiency	----	1,500	
Idle time	----	1,000	(400)
Variable Overheads:			
Expenditure	8,600	----	
Efficiency	----	3,600	5,000
Fixed Overheads:			
Expenditure	----	4,100	
Volume	----	2,500	(6,600)
Gross Profit			67,450

REASON FOR THE DIFFERENCE IN ACTUAL GROSS PROFIT

Actual Gross Profit given in the problem is ₹ 67,500 while calculated Gross Profit in statement is ₹ 67,450. The difference amount is due to Material Price Variance that is calculated at the time of *receipt of material* instead of *consumption of material*.

Material Price Variance	=	Standard Cost of Actual Quantity – Actual Cost
	=	AQ × SP – AQ × AP
		Or
	=	AQ × (SP – AP)
(A)	=	18,900 Kg. × (₹ 5.00 – ₹ 5.25)
	=	₹4,725 (A)
(B)	=	10,750 Kg. × (₹ 6.00 – ₹ 5.70)
	=	₹3,225 (F)
Total	=	₹4,725 (A) + ₹ 3,225 (F)
	=	₹1,500 (A)

Over Recovery in the reconciliation statement is ₹50 (₹1,550 – ₹1,500), should be added in Gross Profit ₹67,500 (₹67,450 + ₹50).

Problem-28

You are appointed Accountant of Exe Ltd. Given below is the Company's Operating Report for March, 2013.

Particulars	**Standard and Variances (₹)**	**Actual (₹)**
Sales Budgeted	*18,000*	
Variance due to		
Volume of Orders	*1,000*	
Selling Price	*400*	*19,400*
Profit- Budgeted		*3,800*
Sales Variances-		
Volume	*240*	
Price	*400*	*640*
Labour Variances-		
Rate	*(250)*	
Efficiency	*(100)*	*(350)*
Material Variances-		
Price	*150*	
Usage	*(60)*	*90*
Overhead Variances-		
Expenditure-Fixed	*100*	
-Variable	*(250)*	
Efficiency	*200*	
Capacity	*100*	*150*
Operating Profit		*4,330*

Your assistant provides the following information about sales and costs for April, 2013:

Sales	**Budgeted Units**	**Sales Value (₹)**	**Actual Units**	**Sales Value (₹)**
Product A	*250*	*10,000*	*280*	*10,800*
Product B	*200*	*6,000*	*190*	*5,500*
Product C	*150*	*3,000*	*180*	*3,500*

Product	Standard Selling Price per unit	Standard Product Cost per unit
A	40	31
B	30	25
C	20	15

Labour:	
Standard Labour Cost (per hour)	*₹ 0.90*
Budgeted Hours	*4,000*
Standard Hours (produced)	*4,500*
Actual Clocked Hours	*4,400*
Actual Labour Cost	*₹ 4,260*

Materials:	
Standard Cost of Material (actually used)	*₹ 5,230*
Standard Cost of Material (allowed)	*₹ 5,330*
Actual Cost of Material (used)	*₹ 5,430*

Overheads:	
Budget Rate of Overhead Recovery (per labour hour)	
Fixed	*₹ 0.50*
Variable	*₹ 1.00*
Actual Overhead Costs	
Fixed	*₹ 2,000*
Variable	*₹ 4,300*

Required

Prepare the Operating Statement for April, 2013 in the same form as for March, 2013.

Solution

OPERATING STATEMENT FOR APRIL, 2013

Particulars	**Standard and Variances (₹)**	**Actual (₹)**
Sales Budgeted	19,000	
Variance due to		
Volume of Orders	1,500	
Selling Price	(700)	19,800
Profit- Budgeted*		4,000
Sales Variances-		
Volume	370	
Price	(700)	(330)
Labour Variances-		
Rate	(300)	
Efficiency	90	(210)
Material Variances-		
Price	(200)	
Usage	100	(100)
Overhead Variances-		
Expenditure - Variable	100	
Efficiency - Fixed	50	
- Variable	100	
Capacity	200	450
Operating Profit		3,810

(*) Budgeted Profit [(₹40 − ₹31) × 250 units + (₹30−₹25) × 200 units + (₹20 − ₹15) × 150 units]

WORKING NOTES

1. **Sales Variances**

Value Variance = Actual Sales – Budgeted Sales

= ₹ 19,800 – ₹ 19,000

	=	₹ 800 (F)
Price Variance	=	Actual Sales – Standard Sales
		Or
	=	Actual Quantity × (Actual Price – Budgeted Price)
A	=	₹ 10,800 – 280 units × ₹ 40
	=	400 (A)
B	=	₹ 5,500 – 190 units × ₹ 30
	=	200 (A)
C	=	₹ 3,500 – 180 units × ₹ 20
	=	100 (A)
Total	=	400 (A) + 200 (A) + 100 (A)
	=	700 (A)
Volume Variance	=	Standard Sales – Budgeted Sales
		Or
	=	Budgeted Price × (Actual Quantity – Budgeted Quantity)
A	=	280 units × ₹ 40 – ₹ 10,000
	=	1,200 (F)
B	=	190 units × ₹ 30 – ₹ 6,000
	=	300 (A)
C	=	180 units × ₹ 20 – ₹ 3,000
	=	600 (F)
Total	=	1,200 (F) + 300 (A) + 600 (F)
	=	1,500 (F)
Margin Volume Variance	=	Standard Margin – Budgeted Margin
		Or
	=	Budgeted Margin × (Actual Quantity – Budgeted Quantity)
A	=	₹9 × (280 units – 250 units)
	=	270 (F)
B	=	₹5 × (190 units – 200 units)
	=	50 (A)

C	=	₹ 5 × (180 units – 150 units)
	=	150 (F)
Total	=	270 (F) + 50 (A) + 150 (F)
	=	370 (F)

2. Labour Variances

Cost Variance	=	Standard Cost* – Actual Cost
	=	₹ 0.90 × 4,500 hours – ₹ 4,260
	=	₹ 4,050 – ₹ 4,260
	=	₹ 210 (A)
		**Standard Cost refers to 'Standard Cost of Standard Time for Actual Output'*
Rate Variance	=	Standard Cost of Actual Time – Actual Cost
	=	4,400 hours × ₹ 0.90 – 4,260
	=	₹ 3,960 – ₹ 4,260
	=	₹ 300 (A)
Efficiency Variance	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
	=	₹ 0.90 × 4,500 hours – 4,400 hours × ₹ 0.90
	=	₹ 90 (F)

3. Material Variances

Cost Variance	=	Standard Cost* – Actual Cost
	=	₹ 5,330 – ₹ 5,430
	=	₹ 100 (A)
		**Standard Cost refers to 'Standard Cost of Standard Quantity of Actual Output'*
Price Variance	=	Standard Cost of Actual Quantity – Actual Cost
	=	₹ 5,230 – ₹ 5,430
	=	200 (A)
Usage Variance	=	Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity
	=	₹ 5,330 – ₹ 5,230
	=	₹ 100 (F)

4. Variable Overhead Cost Variances

Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
	=	₹1 × 4,500 hours – ₹4,300
	=	₹ 200 (F)
Expenditure Variance	=	Budgeted Overheads for Actual Hours – Actual Overheads
	=	4,400 hours × ₹ 1 – ₹ 4,300
	=	₹ 100 (F)
Efficiency Variance	=	Standard Variable Overheads for Production – Budgeted Overheads for Actual Hours
	=	₹ 4,500 – ₹4,400
	=	₹ 100 (F)

5. Fixed Overhead Variances

Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
	=	4,500 hours × ₹ 0.50 – ₹ 2,000
	=	₹ 2,250 – ₹ 2,000
	=	₹ 250 (F)
Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads
	=	4,000 hours × ₹ 0.50 – ₹ 2,000
	=	Nil
Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹ 2,250 – ₹ 2,000 = ₹ 250 (F)
Capacity Variance	=	Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads
	=	4,400 hours × ₹ 0.50 – 4,000 hours × ₹ 0.50
	=	₹ 200 (F)
Efficiency Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours
	=	4,500 hours × ₹ 0.50 – 4,400 hours × ₹ 0.50
	=	₹ 50 (F)

Problem-29

Standard Cost Card of a product is as under:

	₹
Direct Materials	
A 2 Kg. @ ₹ 3 per Kg.	*6.00*
B 1 Kg. @ ₹ 4 per Kg.	*4.00*
Direct Wages 5 hours @ ₹ 4 per hour	*20.00*
Variable Overheads 5 hours @ ₹ 1 per hour	*5.00*
Fixed Overheads 5 hours @ ₹ 2 per hour	*10.00*
Standard Cost	*45.00*
Standard Profit	*5.00*
Standard Selling Price	*50.00*

Budgeted Output is 8,000 units per month.

In October 2013, the company produced and sold 6,000 units. The actual sales value was ₹ 3,05,000. Direct materials consumed was: Material A: 14,850 kg. valued at ₹ 43,065 and Material B 7,260 kg. valued at ₹ 29,750. The total direct labour hours worked was 32,000 and the wages paid therefore amounted to ₹ 1,27,500. The direct labour hours actually booked on production was 31,800. Overheads recorded were: Fixed ₹ 80,600 and Variable ₹ 30,000. Closing work-in-progress was 600 units in respect of which materials A and B were fully issued and labour and overheads were 50% complete.

OPERATING STATEMENT

	₹
Budgeted Profit	
Sales Variances	
Price	
Volume	
Direct Material Variances	
Price (Material A)	
Price (Material B)	
Yield	
Mix	
Direct Wages Variances	

Rate

Efficiency

Idle Time

Variable Overheads Variances

Expenditure

Efficiency

Fixed Overheads Variances

Expenditure

Efficiency

Capacity

Annual Profit

Required

Analyse the variance and present an operating statement showing the reconciliation between budgeted and actual profits for the month in the above format.

Solution

BASIC CALCULATIONS

Equivalent Production in Units

Particulars	**Direct Materials**		**Labour & Overhead**	
Units Completed	100%	6,000	100%	6,000
Work-in-Progress	100%	600	50%	300
Total Equivalent Units		6,600		6,300

Standard and Actual Cost of Material

Material	**Standard Cost of 6,600 units**			**Actual Cost of 6,600 units**			
	Qty. (Kg.) [SQ]	**Rate (₹) [SP]**	**Amt (₹) [SQ x SP]**	**Qty. (Kg.) [AQ]**	**Rate (₹) [AP]**	**Amt (₹) [AQ x AP]**	**Amt (₹) [AQ x SP]**
A	13,200	3	39,600	14,850	2.90*	43,065	44,550
B	6,600	4	26,400	7,260	4.09....*	29,750	29,040
	19,800		66,000	22,110		72,815	73,590

**Actual Cost/Actual Quantity*

COMPUTATION OF VARIANCES

Direct Material Variances

Material Cost Variance	=	Standard Cost – Actual Cost
	=	SQ × SP – AQ × AP
(A)	=	₹ 39,600 – ₹ 43,065
	=	₹ 3,465 (A)
(B)	=	₹ 26,400 – ₹ 29,750
	=	₹ 3,350 (A)
Total	=	₹ 3,465 (A) + ₹ 3,350 (A)
	=	₹ 6,815 (A)
Material Price Variance	=	Standard Cost of Actual Quantity – Actual Cost
	=	AQ × SP – AQ × AP
		Or
	=	AQ × (SP – AP)
(A)	=	14,850 Kg. × (₹ 3.00 – ₹ 2.90)
	=	₹ 1,485 (F)
(B)	=	7,260 Kg. × (₹ 4.00 – ₹ 4.09.....)
	=	₹ 710 (A)
Total	=	₹ 1,485 (F) + ₹ 710 (A)
	=	₹ 775 (F)
Material Usage Variance	=	Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity
	=	SQ × SP – AQ × SP
		Or
	=	SP × (SQ – AQ)
(A)	=	₹ 3 × (13,200 Kg. – 14,850 Kg.)
	=	₹ 4,950 (A)
(B)	=	₹ 4 × (6,600 Kg. – 7,260 Kg.)
	=	₹ 2,640 (A)

Total	=	₹ 2,640 (A) + ₹ 4,950 (A)
	=	₹ 7,590 (A)
Material Mix Variance	=	Total Actual Quantity (units) × (*Average* Standard Price *per unit* of Standard Mix – Average Standard Price *per unit* of Actual Mix)
	=	$22{,}110 \text{ Kg.} \times \left(\frac{₹\ 66{,}000}{19{,}800 \text{ Kg.}} - \frac{₹\ 73{,}590}{22{,}110 \text{ Kg.}}\right)$
	=	₹ 110 (F)
Material Yield Variance	=	*Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]
	=	$\left(\frac{₹\ 66{,}000}{19{,}800 \text{ Kg.}}\right) \times (19{,}800 \text{ Kg.} - 22{,}110 \text{ Kg.})$
	=	₹ 7,700 (A)

Direct Labour Variances

Labour Cost Variance	=	Standard Cost – Actual Cost
	=	SH × SR – AH* × AR
	=	(6,300 units × 5 hours) × ₹ 4 – ₹1,27,500
	=	₹ 1,500 (A)
Labour Rate Variance	=	Standard Cost of Actual Time – Actual Cost
	=	SR × AH* – AR × AH*
		Or
	=	(SR – AR) × AH*
	=	$\left(₹4 - \frac{₹1{,}27{,}500}{32{,}000 \text{hours}}\right) \text{x} 32{,}000 \text{ hours}$
	=	₹500 (F)
		AH refers to Actual Hours Paid*
Labour Efficiency Variance	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
	=	$(SH \times SR) - (AH^{\#} \times SR)$
		Or
	=	$(SH - AH^{\#}) \times SR$

	=	₹4.00 × (6,300 units × 5 hours – 31,800 hours)
	=	₹ 1,200 (A)
Idle Time Variance	=	Standard Rate per Hour × Actual Idle Hours
	=	(AH* × SR) – (AH# × SR)
		Or
	=	(AH* – AH#) × SR
	=	₹4.00 × (32,000 hours – 31,800 hours)
	=	₹ 800 (A)
		AH# refers to Actual Hours Worked

Variable Overhead Variances

Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
	=	6,300 units × ₹ 5 – ₹ 30,000
	=	₹ 1,500 (F)
Expenditure Variance	=	Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
	=	31,800 hours × ₹ 1 – ₹ 30,000
	=	₹ 1,800 (F)
Efficiency Variances	=	Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours
	=	6,300 units × ₹ 5 – 31,800 hours x ₹ 1
	=	₹ 300 (A)

Fixed Overhead Variances

Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
	=	6,300 units × ₹ 10.00 – ₹ 80,600
	=	₹63,000 – ₹80,600
	=	₹17,600 (A)
Expenditure Variance	=	Budgeted Fixed Overheads – Actual Fixed Overheads.
	=	8,000 units × ₹10.00 – ₹80,600
	=	₹80,000 – ₹80,600
	=	₹600 (A)

Volume Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
	=	₹63,000 – ₹80,000
	=	₹17,000 (A)
Efficiency Variance	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours
	=	₹ 63,000 – ₹ 2.00 × 31,800 hours
	=	₹ 600 (A)
Capacity Variance	=	Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads
	=	₹ 2.00 × 31,800 hours – ₹80,000
	=	₹ 16,400 (A)

Sales Variances

Value Variance	=	Actual Sales – Budgeted Sales
	=	AP × AQ – BP × BQ
	=	₹ 3,05,000 – ₹50 × 8,000 units
	=	₹ 95,000 (A)
Price Variance	=	Actual Sales – Standard Sales
	=	AP × AQ – BP × AQ
		Or
	=	AQ × (AP – BP)
	=	₹3,05,000 – 6,000 units × ₹50
	=	5,000 (F)
Volume Variance	=	Standard Sales – Budgeted Sales
	=	BP × AQ – BP × BQ
		Or
	=	BP × (AQ – BQ)
	=	₹50 × (6,000 units – 8,000 units)
	=	₹ 1,00,000 (A)

Sales Margin Variances

Sales Margin Price Variance	=	Sales Price Variance
	=	5,000 (F)
Sales Volume Variance	=	Sales Volume Variance × Budgeted Net Profit Ratio
	=	1,00,000 (A) × $\left(\frac{₹5}{₹50} x100\right)$
	=	₹ 10,000 (A)
Margin Variance	=	Sales Margin Price Variance + Sales Margin Volume Variance
	=	₹5,000 (F) + ₹10,000 (A)
	=	₹ 5,000 (A)

☞

> **Sales Price Variance** is equal to **Sales Margin Price Variance.** This is because, for the actual quantity sold, standard cost remaining constant, change in selling price will have equal impact or turnover and profit.
>
> **Sales Margin Volume Variance** is **equal** to **Sales Volume Variance × Budgeted Net Profit Ratio**

OPERATING STATEMENT

Reconciliation between Budgeted and Actual Profit for the Month

Particulars	**(₹)**	**(₹)**
Budgeted Profit (8,000 units x ₹ 5)		40,000
Sales Variance:		
Price	5,000 (F)	
Volume	10,000 (A)	5,000 (A)
Direct Material Variance:		
Price	775 (F)	
Yield	7,700 (A)	
Mix	110 (F)	6,815 (A)
Direct Wages Variance:		
Rate	500 (F)	

Efficiency	1,200 (A)	
Idle time	800 (A)	1,500 (A)
Variable Overheads Variance:		
Expense	1,800 (F)	
Efficiency	300 (A)	1,500 (F)
Fixed Overheads Variance:		
Expense	600 (A)	
Efficiency	600 (A)	
Capacity	16,400 (A)	17,600 (A)
Actual Profit		10,585

VERIFICATION

	₹
Actual Sales	3,05,000
Less: Actual Cost	
Materials (₹43,065+₹29,750)	72,815
Labour	1,27,500
Variable Overhead	30,000
Fixed Overhead	80,600
Add: Closing Stock of WIP at *Standard Cost*	16,500
Actual Net Profit	10,585

VALUATION OF CLOSING STOCK (at Standard Cost)

		₹
Material A 600 units	@ ₹ 6.00	3,600
Material B 600 units	@ ₹ 4.00	2,400
Labour 300 units	@ ₹ 20.00	6,000
Fixed Overheads 300 units	@ ₹ 10.00	3,000
Variable Overheads 300 units	@ ₹ 5.00	1,500
		16,500

Problem-30

Fo -Tan Ltd. operating on a standard costing system, for a given four week period budgeted *for sales of 10,000 units at ₹ 50 per unit, actual sales were 9,000 units at ₹ 51.25 per unit. Costs relating to that period were as follows:*

	Standard (₹)	*Actual (₹)*
Materials	*2,50,000*	*2,57,400*
Wages	*75,000*	*70,875*
Fixed Overhead	*20,000*	*18,810*
Variable Overhead	*10,000*	*9,250*
Semi-Variable Overhead	*2,700*	*2,430*
Hours	*50,000*	*40,500*

(i) The standard material content of each unit is estimated at 25 Kg. at ₹ 1 per Kg. actual figures was 26 Kg. at ₹ 1.10 per Kg.

(ii) The standard wages per unit are 5 hours at ₹ 1.50 per unit, actual wages were 4.5 hours at ₹ 1.75.

(iii) Semi-variable overhead consists of five-ninths fixed expenses and four-ninths variable.

(iv) There were no opening stocks and the whole production for the period was sold.

(v) The four week period was a normal period.

Required

(a) Compute the variance in sales, materials, labour and overhead due to all possible causes, and

(b) With the help of such a computation draw-

- *a statement reconciling the actual profit for the period with the standard profit.*
- *a statement reconciling the actual profit for the period with the budgeted profit.*

Solution

COMPUTATION OF VARIANCES

1. Sales Variances

Sales Value Variance = Actual Sales – Budgeted Sales

= ₹ 51.25 × 9,000 units – ₹ 50 × 10,000 units

= ₹ 38,750 (A)

Sales Price Variance = Actual Sales – Standard Sales

Or

= Actual Quantity × (Actual Price – Budgeted Price)

= 9,000 units × (₹ 51.25 – ₹ 50)

= 11,250 (F)

Sales Volume Variance = Standard Sales – Budgeted Sales

Or

= Budgeted Price × (Actual Quantity – Budgeted Quantity)

= ₹ 50 × (9,000 units – 10,000 units)

= 50,000 (A)

Sales Margin Price Variance = Sales Price Variance

= ₹11,250 (F)

Sales Margin Volume Variance = Sales Volume Variance × Budgeted Net Profit Ratio

$$= 50{,}000\ (A) \times \left(\frac{₹14.23}{₹50.00} x100\right)\%$$

= ₹14,230 (A)

Sales Margin Variance = Sales Margin Price Variance + Sales Margin Volume Variance

= ₹11,250 (F) + ₹14,230 (A)

= ₹2,980 (A)

Sales Price Variance is equal to **Sales Margin Price Variance**. This is because, for the actual quantity sold, standard cost remaining constant, change in selling price will have equal impact or turnover and profit.

Sales Margin Volume Variance is **equal** to **Sales Volume Variance × Budgeted Net Profit Ratio**

2. Material Variances

Cost Variance = Standard Cost* – Actual Cost

= ₹ 1 × 25 Kg. × 9,000 units – ₹ 2,57,400

= ₹32,400 (A)

**Standard Cost refers to 'Standard Cost of Standard Quantity of Actual Output'*

Price Variance = Standard Cost of Actual Quantity – Actual Cost

= SP × AQ – AP × AQ

Or

= AQ × (SP – AP)

$$= \left(\frac{₹2,57,400}{₹1.10}\right) \times (₹\ 1.00 - ₹\ 1.10)$$

= 23,400 (A)

Usage Variance = Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity

= (SQ × SP) – (AQ × SP)

Or

= (SQ – AQ) × SP

$$= \left[9{,}000\text{ units x }25\text{ Kg.} - \left(\frac{₹2,57,400}{₹1.10}\right)\right] \times ₹\ 1.00$$

= ₹ 9,000 (A)

3. Labour Variances

Cost Variance = Standard Cost* – Actual Cost

= SH × SR – AH × AR

= ₹ 1.50 × (5 hours × 9,000 units) – ₹ 70,875

= ₹ 67,500 – ₹ 70,875

= ₹ 3,375 (A)

**Standard Cost refers to 'Standard Cost of Standard Time for Actual Output'*

Rate Variance = Standard Cost of Actual Time – Actual Cost

= SR × AH – AR × AH

Or

= (SR – AR) × AH

= (₹ 1.50 – ₹ 1.75) × 40,500 hours

= ₹ 10,125 (A)

Efficiency Variance = Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time

= (SH × SR) – (AH × SR)

Or

= (SH – AH) × SR

= (45,000 hours – 40,500 hours) × ₹ 1.50

= ₹ 6,750 (F)

4. Variable Overhead Cost Variances

Cost Variance = Standard Variable Overheads for Production – Actual Variable Overheads

= ₹1.12 × 9,000 units – ₹10,330

= ₹ 250 (A)

Expenditure Variance = Budgeted Overheads for Actual Hours – Actual Overheads

= 40,500 hours × ₹ 0.224 – ₹ 10,330

= ₹ 1,258 (A)

Efficiency Variance = Standard Variable Overheads for Production – Budgeted Overheads for Actual Hours

= ₹1.12 × 9,000 units – 40,500 hours × ₹ 0.224

= ₹ 1,008 (F)

5. Fixed Overhead Variances

Cost Variance = Absorbed Fixed Overheads – Actual Fixed Overheads

= 9,000 units × ₹ 2.15 – ₹ 20,160

= ₹ 19,350 – ₹ 20,160

= ₹ 810 (A)

Expenditure Variance = Budgeted Fixed Overheads – Actual Fixed Overheads

= ₹ 21,500 – ₹ 20,160

= ₹ 1,340 (F)

Volume Variance = Absorbed Fixed Overheads – Budgeted Fixed Overheads

= ₹ 19,350 – ₹ 21,500

= ₹ 2,150 (A)

Capacity Variance = Budgeted Fixed Overheads for Actual Hours – Budgeted Fixed Overheads

= 40,500 hours × ₹ 0.43 – ₹ 21,500

= ₹ 4,085 (A)

Efficiency Variance = Absorbed Fixed Overheads – Budgeted Fixed Overheads for Actual Hours

= ₹ 19,350 – 40,500 hours × ₹ 0.43

= ₹ 1,935 (F)

RECONCILIATION STATEMENT

(Standard and Actual Profit)

Particulars	**(₹)**	**(₹)**
Profit- Standard		1,28,070
Sales Margin Variances		
Volume	N.A.	
Price	11,250 (F)	11,250
Direct Material Variances		
Price	23,400 (A)	
Usage	9,000 (A)	(32,400)
Direct Labour Variances		
Labour Rate	10,125 (A)	
Labour Efficiency	6,750 (F)	(3,375)
Variable Overhead Variances		
Expenditure	1,258 (A)	
Efficiency	1,008 (F)	(250)
Fixed Overhead Variances		
Expenditure	1,340 (F)	
Capacity	4,085 (A)	
Efficiency	1,935 (F)	(810)
Actual Profit		1,02,485

RECONCILIATION STATEMENT

(Budgeted & Actual Profit)

Particulars	(₹)	(₹)
Budgeted Profit (10,000 units x ₹ 14.23)		1,42,300
Sales Margin Variances		
Volume	14,230 (A)	
Price	11,250 (F)	(2,980)
Direct Material Variances		
Price	23,400 (A)	
Usage	9,000 (A)	(32,400)
Direct Labour Variances		
Labour Rate	10,125 (A)	
Labour Efficiency	6,750 (F)	(3,375)
Variable Overhead Variances		
Expenditure	1,258 (A)	
Efficiency	1,008 (F)	(250)
Fixed Overhead Variances		
Expenditure	1,340 (F)	
Capacity	4,085 (A)	
Efficiency	1,935 (F)	(810)
Actual Profit		1,02,485

WORKING NOTES

1. Standard Variable Overheads = ₹ 10,000 + ₹ 2,700 × 4/9

 = ₹ 11,200

2. Std. Variable Overhead Rate *per unit* = $\frac{₹11,200}{10,000 \text{units}}$

 = ₹ 1.12

3. Std. Variable Overheads Rate *per hour* = $\frac{₹11,200}{50,000 \text{hours}}$

 = ₹ 0.224

4.	Actual Variable Overheads	= ₹ 9,250 + ₹ 2,430 × 4/9
		= ₹ 10,330
5.	Budgeted Fixed Overheads	= ₹ 20,000 + 5/9 × ₹ 2,700
		= ₹ 21,500
6.	Standard Fixed Overheads Rate *per unit*	= $\frac{₹21,500}{10,000 \text{units}}$
		= ₹ 2.15
7.	Std. Fixed Overheads Rate *per hour*	= $\frac{₹21,500}{50,000 \text{hours}}$
		= ₹ 0.43
8.	Actual Fixed Overheads	= ₹ 18,810 + ₹ 2,430 × 5/9
		= ₹ 20,160
9.	Standard Hrs. for *actual production*	= 9,000 units × $\frac{50,000 \text{hours}}{10,000 \text{units}}$
		= 45,000 hours
10.	Standard Cost *per unit*	= $\frac{₹3,57,700}{10,000 \text{units}}$
		= ₹35.77
11.	Budgeted Margin *per unit*	= ₹50 – ₹35.77
		= ₹14.23
12.	Standard Profit/Margin	= Actual Qty. Sold × Budgeted Margin *per unit*
		= 9,000 units × ₹ 14.23
		= ₹1,28,070
13.	Computation of Actual Profit	
	Actual Sales (9,000 units x ₹ 51.25)	= ₹ 4,61,250
	Actual Cost of Sales	= ₹ 3,58,765
	Actual Profit	= Actual Sales – Actual Cost of Sales
		= ₹ 4,61,250 – ₹ 3,58,765
		= ₹1,02,485

Problem-31

BOM & Co. operate a system of standard costs. For the four weeks ended 31st March, 2013 the following was their Profit and Loss Account:

Particulars	₹	Particulars	₹
Material Consumed	1,89,000	Transfer to Sales Deptt. 3,500 units of finished articles at. ₹ 140 each	4,90,000
Direct Wages	22,100		
Fixed Expenses	1,88,000		
Variable Expenses	62,000		
Profit	28,900		
	4,90,000		4,90,000

The following further information is given:

(a) *There was no opening or closing work-in-progress. The articles manufactured are identical and get transferred to sales department after manufacture.*

(b) *Materials were drawn for 3,600 units at ₹ 52.50 per unit.*

(c) *For the four week period, the standard production capacity is 4,800 units, and the break-up of the standard selling price is given below:*

	₹
Material	50
Direct Wages	6
Fixed Expenses	40
Variable Expenses	20
Standard Cost of Sale	116
Standard Profit	24
Standard Selling Price	140

(d) *The standard wages per article is based on 9,600 hours worked for the four-week period at a rate of ₹ 3.00 per hour. 6,400 hours were actually worked during the four-week period and, in addition, wages for 400 hours were paid to compensate for idle time due to breakdown of a machine, and the overall wage rate was ₹ 3.25.*

Required

Present a Trading and Profit and Loss account indicating the comparison between standards and actual and analyse the variances.

Solution

COMPARISON BETWEEN STANDARD AND ACTUAL

Trading and Profit and Loss Account
for 4 weeks ended 31st March, 2013

Particulars	Std. 3,500 units	Actual 3,500 units	Variance	Particulars	Std. 3,500 units	Actual 3,500 units	Variance
	₹	₹	₹		₹	₹	₹
Material	1,75,000	1,89,000	14,000(A)	Transfer to Sales Dept. at ₹140 each	4,90,000	4,90,000	-
Direct Wages	21,000	22,100	1,100(A)				
Variable Exp.	70,000	62,000	8,000(F)				
Fixed Exp.	1,40,000	1,88,000	48,000(A)				
Profit	84,000	28,900	55,100(A)				
	4,90,000	4,90,000			4,90,000	4,90,000	

COMPUTATION OF VARIANCES

1. Direct Material Variances

Material Price Variance = Actual Quantity × (Standard Price – Actual Price)
= 3,600 units × (₹ 50.00 – ₹ 52.50)
= ₹ 9,000 (A)

Material Usage Variance = Standard Price × (Standard Quantity – Actual Quantity)
= ₹ 50 × (3,500 units – 3,600 units)
= ₹ 5,000 (A)

Material Cost Variance = ₹ 9,000 (A) + ₹ 5,000 (A)
= ₹14,000 (A)

2. Direct Labour Cost Variance

Labour Rate Variance = Actual Hours × (Standard Rate – Actual Rate)
= 6,800 hours × (₹ 3.00 – ₹ 3.25)
= ₹ 1,700 (A)

	Labour Efficiency Variance	=	Standard Rate × (Standard Hours – Actual Hours)
		=	₹ 3 × (3,500 units × 2 hours – 6,400 hours)
		=	₹ 1,800 (F)
	Idle Time Variance	=	Standard Rate × Idle Hours
		=	₹ 3 × 400
		=	₹ 1,200 (A)
	Labour Cost Variance	=	₹ 1,700 (A) + ₹ 1,800 (F) + ₹ 1,200 (A)
		=	₹ 1,100 (A)
3.	**Variable Expense Variance**		
		=	Standard Variable Expenses – Actual Variable Expenses
		=	3,500 units × ₹ 20 – ₹ 62,000
		=	₹ 8,000 (F)
4.	**Fixed Expenses Variances**		
	Expenditure Variance	=	Budgeted Fixed Expenses – Actual Fixed Expenses
		=	4,800 units × ₹ 40 – ₹ 1,88,000
		=	₹ 4,000 (F)
	Volume Variance	=	Absorbed Fixed Expenses – Budgeted Fixed Expenses
		=	₹ 40 × 3,500 units – ₹ 40 × 4,800 units
		=	₹ 52,000 (A)
	Capacity Variance	=	Std. Rate *per hour* × (Actual Hours – Budgeted Hours)
		=	₹ 20 × (6,400 hours – 9,600 hours)
		=	₹ 64,000 (A)
	Efficiency Variance	=	Std. Rate *per hour* × (Std. Hours for Actual Output – Actual Hours)
		=	₹ 20 × (7,000 hours – 6,400 hours)
		=	₹ 12,000 (F)
	Fixed Expense Variance *(Total)*	=	₹ 4,000 (F) + ₹ 64,000 (A) + ₹ 12,000 (F)
		=	₹ 48,000 (A)
5.	**Total Cost Variance**	=	Direct Material Cost Variance + Direct Labour Cost Variance + Variable Expenses Variance + Fixed Expenses Variance

	=	₹ 14,000 (A) +1,100 (A) + ₹ 8,000 (F) + ₹ 48,000 (A)
	=	₹ 55,100 (A)
6. Profit Variance	=	Standard Profit – Actual Profit
	=	₹ 84,000 – ₹ 28,900
	=	₹ 55,100 (A)

Reconciliation of Budgeted/Standard Profit with Actual Profit with Given Variances

Problem-32

Tsim Sha Tsui Ltd. adopts a standard costing system. The standard output for a period is 20,000 units and the standard cost and profit per unit is as under:

	(₹)
Direct Material (3 units @ ₹ 1.50)	4.50
Direct Labour (3 hrs. @ ₹ 1.00)	3.00
Direct Expenses	0.50
Factory Overheads	
Variable	0.25
Fixed	0.30
Administration Overheads	0.30
Total Cost	8.85
Profit	1.15
Selling Price (Fixed by Govt.)	10.00

The actual production and sales for a period was 14,400 units. There has been no price revision by the Govt. during the period.

The following are the variances worked out at the end of the period:

		Favourable(₹)	Adverse(₹)
Direct Material			
	Price	----	4,250
	Usage	1,050	----
Direct Labour			
	Rate	----	4,000
	Efficiency	3,200	----

Factory Overheads			
	Variable-Expenditure	*400*	*----*
	Fixed-Expenditure	*400*	*----*
	Fixed-Volume	*----*	*1,680*
Administrative Overheads			
	Expenditure	*----*	*400*
	Volume	*----*	*1680*

Required

(a) *Ascertain the details of actual costs and prepare a Profit and Loss Statement for the period showing the actual profit/loss. Show workings clearly.*

(b) *Reconcile the Actual Profit with Standard Profit.*

Solution

WORKING NOTE

		₹
(1)	Material Cost as per Standard (14,400 units x ₹4.50)	64,800
	Add: Price Variance (A)	4,250
	Less: Usage Variance (F)	1,050
	Actual Material cost	68,000
(2)	Labour Cost as per Standard (14,400 units x ₹3.00)	43,200
	Add: Rate Variance (A)	4,000
	Less: Efficiency Variance (F)	3,200
	Actual Labour Cost	44,000
(3)	Factory Overheads as per Standard: Variable	3,600
	Factory Overheads as per Standard: Fixed	4,320
	Total Factory Overheads	7,920
	Add: Fixed Overheads Volume Variance (A)	1,680
	Less: Fixed Overheads Expenditure Variance (F)	400

	Less: Variable Overheads Expenditure Variance (F)	400
	Actual Factory Overheads	8,800
(4)	Administration Overheads as per Standard	4,320
	Add: Expenditure Variance (A)	400
	Add: Volume Variance (A)	1,680
	Actual Administration Overheads	6,400

PROFIT & LOSS STATEMENT SHOWING THE ACTUAL PFORIT FOR THE PERIOD

	₹
Sales 14,400 units @ ₹ 10 each	1,44,000
Less: Cost of Sales:	
Material Cost (W.N.1)	68,000
Labour Cost (W.N.2)	44,000
Direct Expenses	7,200
Factory Overheads (W.N.3)	8,800
Administration Overheads (WN 4)	6,400
Actual Profit	9,600

RECONCILIATION STATEMENT OF THE ACTUAL PROFIT WITH STANDARD PROFIT

	Variances		
	Favourable	Adverse	
	(₹)	(₹)	(₹)
Standard Profit (on 14,400 units @ ₹ 1.15 per unit)			16,560
Direct Material Variances:			
Price	----	4,250	
Usage	1,050	----	(3,200)
Direct Labour Variances:			
Rate	----	4,000	
Efficiency	3,200	----	(800)
Factory Overheads Variances:			
Expenditure	800	----	

Volume	----	1,680	(880)
Administration Overheads Variances:			
Expenditure	----	400	
Volume	----	1,680	(2,080)
Actual Profit			9,600

Problem-33

The budget output of a single product manufacturing company for 2013-14 was 5,000 units. The financial results in respect of the actual output of 4,800 units achieved during the year were as under:–

	₹
Direct Material	*29,700*
Direct Wages	*44,700*
Variable Overheads	*72,750*
Fixed Overheads	*39,000*
Profit	*36,600*
Sales	*2,22,750*

The standard direct wage rate is ₹ 4.50 per hour and the standard variable overhead rate is ₹ 7.50 per hour.

The cost accounts recorded the following variances for the year:–

Variances	***Favourable (₹)***	***Adverse (₹)***
Material Price	—	*300*
Material Usage	—	*600*
Wage Rate	*750*	—
Labour Efficiency	—	*2,250*
Variable Overhead Expense	*3,000*	—
Variable Overhead Efficiency	—	*3,750*
Fixed Overhead Expense	—	*1,500*
Selling Price	*6,750*	—

Required

(i) *Prepare a statement showing the original budget.*

(ii) *Prepare the standard product cost sheet per unit.*

(iii) *Prepare a statement showing the reconciliation of originally budgeted profit and the actual profit.*

Solution

WORKING NOTE

		₹
(a)	Actual Sales	2,22,750
	Less: Price Variance (F)	6,750
	Standard Sales	2,16,000
	Units Sold	4,800

Std. Price *per unit*: $\frac{₹2,16,000}{4,800 \text{units}} = ₹45$

		₹
(b)	Actual Cost of Material	29,700
	Less: Price Variance (A)	300
	Less: Usage Variance (A)	600
	Standard Cost	28,800
	Units Produced	4,800

Standard Material Cost *per unit*: $\frac{₹28,800}{4,800 \text{units}} = ₹6$

		₹
(c)	Direct Wages Spent	44,700
	Add: Wage Rate Variance (F)	750
	Less: Efficiency Variance (A)	2,250
	Standard Wages	43,200

Standard Wage Rate *per unit*: $\frac{₹43,200}{4,800 \text{units}} = ₹9$

		₹
(d)	Standard Direct Wage Rate *per hour*	4.50
	Hence Standard Time *per unit*: ₹9 / ₹4.50 = 2 hours	

		₹
(e)	Variable Overheads:	
	Standard Rate *per hour*	7.50

Variable Overhead Rate *per unit*: 2 hours × ₹7.50 = ₹15

		₹
(f)	Fixed Overheads Spent (Actual Fixed Overheads)	39,000
	Less: Fixed Overheads Expense Variance (A)	1,500
	Budgeted Overheads	37,500

Standard Fixed Overhead Rate *per unit*: $\frac{₹37,500}{5,000 \text{units}} = ₹7.5$

(g)	Fixed Overheads Recovered/Absorbed: (4,800 units × ₹7.50)	₹36,000
(h)	Fixed Overhead Volume Variance: (₹ 36,000 – ₹ 37,500)	₹1,500(A)
(i)	Budgeted Sales: (5,000 units × ₹ 45)	₹2,25,000
(j)	Standard Sales: (4,800 units × ₹ 45)	₹2,16,000
(k)	Actual Sales:	₹2,22,750
(l)	Sales Volume Variance: (₹2,16,000 – ₹2,25,000)	₹9,000(A)
(m)	Sales Price Variance: (₹2,22,750 – ₹2,16,000)	₹6,750(F)

STATEMENT SHOWING THE ORIGINAL BUDGET

		₹
Budgeted Sales	(5,000 units × ₹ 45)	2,25,000
Less:		
Direct Materials	(5,000 units × ₹ 6)	30,000
Direct Wages	(5,000 units × ₹ 9)	45,000
Variable Overheads	(5,000 units × ₹ 15)	75,000
Fixed Overheads	(5,000 units × ₹ 7.50)	37,500
Budgeted Profit		37,500

STANDARD PRODUCT COST SHEET PER UNIT

	₹
Direct Materials	6.00
Direct Wages	9.00
Prime Cost	15.00
Variable Overheads	15.00
Fixed Overheads	7.50
Total Cost	37.50
Profit	7.50
Selling Price	45.00

STATEMENT SHOWING RECONCILIATION OF ORIGINALLY BUDGETED PROFIT AND THE ACTUAL PROFIT

		₹
Budget Profit		37,500
Less: Sales Margin Volume Variance (A): [₹ 9,000 (A) × $16^2/_3$ %*]		1,500
Add: Sales Price Variance (F)		6,750
		42,750
Add: Favourable Cost Variances:	₹	
Wage Rate	750	
Variable Overhead Expense	3,000	3,750
		46,500
Less: Adverse Cost Variances:	₹	
Material Price	300	
Material Usage	600	
Labour Efficiency	2,250	
Variable Overhead Efficiency	3,750	
Fixed Overhead Volume Variance [Refer W.N. (h)]	1,500	
Fixed Overhead Expense	1,500	9,900
Actual Profit		36,600

* Budgeted Net Profit Ratio= $\frac{₹7.5}{₹45} x100 = 16\frac{2}{3}\%$

☞

Sales Price Variance is equal to **Sales Margin Price Variance**. This is because, for the actual quantity sold, standard cost remaining constant, change in selling price will have equal impact or turnover and profit.

Sales Margin Volume Variance is *equal to* Sales Volume Variance × Budgeted Net Profit Ratio

Sales Volume Variance × Budgeted Net Profit Ratio	=	Budgeted Price × (Actual Qty. – Budgeted Qty.) × Budgeted Net Profit Ratio
	=	Budgeted Price × $\left(\frac{\text{Budgeted Margin}}{\text{Budgeted Price}}\right)$ × (Actual Qty. – Budgeted Qty.)
	=	Budgeted Margin x (Actual Qty. – Budgeted Qty.)
	=	Sales Margin Volume Variance

Problem-34

Jagan Manufacturing Company has furnished the following financial data relating to the actual output of 9,600 units produced in the last quarter:

		₹
Sales		4,45,500
Costs:		
Direct Materials	59,400	
Direct Wages	89,400	
Variable Overheads	1,45,500	
Fixed Overheads	78,000	3,72,300
Profit		73,200

The standard wage rate is ₹ 4.50 per hour and the standard variable overhead rate is ₹ 7.50 per hour. The company uses a JIT system and the budgeted production and sales quantity is 10,000 units.

The following are the variances from standard costs recorded during the last quarter:

		₹
Direct Materials	Price Variance	600 (A)
	Usage Variance	1,200 (A)
Direct Wages	Rate Variance	1,500 (F)
	Efficiency Variance	4,500 (A)
Variable Overheads	Expense Variance	6,000 (F)
	Efficiency Variance	7,500 (A)
Fixed Overheads	Expense Variance	3,000 (A)
Sales	Price Variance	13,500 (F)

Required

(i) Prepare the Original budget and Standard cost sheet per unit of output;

(ii) Produce a statement reconciling the budgeted profit with actual profit.

Solution

WORKING NOTE

Direct Material

Material Cost Variance	=	Material Price Variance + Material Usage Variance
	=	₹ 600 (A) + ₹ 1,200 (A)
	=	₹ 1,800 (A)
Material Cost Variance	=	Standard Cost* – Actual Cost
⇒ ₹ 1,800 (A)	=	Standard Cost – ₹ 59,400
⇒Standard Cost	=	₹ 57,600
		(*) Standard Cost refers to *Standard Cost of Standard Quantity for Actual Output*
Material Price Variance	=	Standard Cost of Actual Quantity – Actual Cost
⇒ ₹ 600 (A)	=	Standard Cost of Actual Quantity – ₹ 59,400
⇒ Standard Cost of Actual Quantity	=	₹ 58,800
Standard Cost *per unit*	=	$\left(\frac{₹57{,}600}{9{,}600\text{ units}}\right)$
	=	₹ 6

Direct Labour

Labour Cost Variance	=	Standard Cost* – Actual Cost
⇒ ₹ 3,000 (A)	=	Standard Cost – ₹ 89,400
⇒ Standard Cost	=	₹ 86,400
		(*) Standard Cost refers to *Standard Cost of Standard Time for Actual Output/Production*
Labour Rate Variance	=	Standard Cost of Actual Time – Actual Cost
⇒ ₹ 1,500 (F)	=	Standard Cost of Actual Time – ₹ 89,400
⇒ Standard Cost of Actual Time	=	₹ 90,900

Standard Cost *per unit* = $\left(\frac{₹86,400}{9,600 \text{ units}}\right)$

= ₹ 9

Standard Rate *per hour* = ₹ 4.50

Standard Time *per unit* = $\left(\frac{₹9.00}{₹4.50}\right)$

= 2 hrs.

Variable Overheads

Standard Rate *per hour* = ₹ 7.50

Standard Rate *per unit* = ₹ 7.50 × 2 hrs.

= ₹ 15.00

Fixed Overheads

Expenditure Variance = Budgeted Fixed Overheads – Actual Fixed Overheads

⇛ ₹ 3,000 (A) = Budgeted Fixed Overheads – ₹ 78,000

⇛ Budgeted Fixed Overheads = ₹ 75,000

Standard Rate *per unit* = $\left(\frac{₹75,000}{10,000 \text{ units}}\right)$

= ₹ 7.50

Volume Variance = Absorbed Fixed Overheads – Budgeted Fixed Overheads

= ₹ 7.50 × 9,600 units – ₹ 75,000

= ₹ 3,000 (A)

Sales Variances (Turnover Based)

Price Variance = Actual Sales – Standard Sales

⇛ ₹ 13,500 (F) = ₹ 4,45,500 – Standard Sales

⇛ Standard Sales = ₹ 4,32,000

Budgeted Price *per unit* = $\left(\frac{\text{Standard Sales}}{\text{Actual Quantity}}\right)$

$$= \left(\frac{₹4,32,000}{9,600\,\text{units}}\right)$$

$= ₹\,45$

Volume Variance = Standard Sales – Budgeted Sales

= ₹4,32,000 – ₹ 45 × 10,000 units

= ₹18,000 (A)

Sales Variances (Margin Based)

Sales Margin Price Variance

= Sales Price Variance

= 13,500 (F)

ORIGINAL BUDGET AND STANDARD COST SHEET

Particulars (Budgeted units - 10,000 units)	Budget (₹)	Standard Cost Per Unit (₹)
Sales ...(A)	4,50,000	45.00
Direct Materials @ ₹ 6 per unit	60,000	6.00
Direct Wages @ ₹ 9 per unit	90,000	9.00
Variable Overheads @ ₹ 15 per unit	1,50,000	15.00
Fixed overheads @ ₹ 7.50 per unit	75,000	7.50
Total Cost ...(B)	3,75,000	37.50
Budgeted Profit ...(A-B)	75,000	7.50

Sales Margin Volume Variance = Sales Volume Variance × Budgeted Net Profit Ratio

$$= 18,000\ (A) \times \left(\frac{₹7.5}{₹45} x100\right)$$

= ₹ 3,000 (A)

STATEMENT OF RECONCILIATION (Budgeted and Actual Profit)

	₹
Budgeted Profit	75,000
Less: Sales Margin Volume Variance	3,000 (A)
Standard Profit	72,000

Add: Sales Price Variance	13,500	(F)
Less: Material Usage Variance	1,200	(A)
Less: Material Price Variance	600	(A)
Less: Labour Efficiency Variance	4,500	(A)
Add: Labour Rate Variance	1,500	(F)
Less: Variable Overhead Efficiency Variance	7,500	(A)
Add: Variable Overhead Expense Variance	6,000	(F)
Less: Fixed Overhead Volume Variance	3,000	(A)
Less: Fixed Overhead Expense Variance	3,000	(A)
Actual Profit	73,200	

Reconciliation of Budgeted Profit with Actual Profit with Given Budgeted Profit & Loss Account and Actual Profit & Loss Account

Problem-35

The following information is available from the record of Prince Ltd. which produces only one product:

Budgeted Income Statement: January 2013

	(₹)	(₹)	(₹)
Sales Revenue			
(20,000 units at ₹ 5)			*1,00,000*
Production Costs			
(Budgeted Production 20,000 units)			
Direct Materials			
A (10,000 Kg. @ ₹ 0.30)	*3,000*		
B (10,000 Kg. @ ₹ 0.70)	*7,000*	*10,000*	
Direct Labour			
Skilled (9,000 Hrs. @ ₹ 3.00)	*27,000*		
Un–Skilled (5,200 Hrs. @ ₹ 2.50)	*13,000*	*40,000*	
Production Overhead			
Fixed	*20,000*		
Variable (20,000 units @ ₹ 0.50)	*10,000*	*30,000*	
		80,000	

Add: Opening Stock			
(1,000 units @ ₹ 4.00)		*4,000*	
Less: Closing Stock			
(1,000 units @ ₹ 4.00)		*4,000*	*80,000*
Budgeted Profit			*20,000*

During January 2013 production and sales were both above budget and the following income statement was prepared:

Income Statement January 2013

	(₹)	(₹)	(₹)
Sales Revenue			
(14,000 units at ₹ 5)		*70,000*	
(8,000 units at ₹4.75)		*38,000*	*1,08,000*
Production Costs			
(Actual Production 24,000 units)			
Direct Materials			
A (16,000 Kg. @ ₹ 0.20)	*3,200*		
B (10,000 Kg. @ ₹ 0.80)	*8,000*	*11,200*	
Direct Labour			
Skilled (13,000 Hrs. @ ₹ 2.95)	*38,350*		
Un–Skilled (6,300 Hrs. ₹ 2.60)	*16,380*	*54,730*	
Production Overhead			
Fixed	*18,020*		
Variable (24,000 units @ ₹ 0.625)	*15,000*	*33,020*	
		98,950	
Add: Opening Stock			
(1,000 units @ ₹4)		*4,000*	
Less: Closing Stock			
(3,000 units @ ₹ 4)		*12,000*	*90,950*
Actual Profit			*17,050*

During the period 1,000 abnormal idle hours for skilled labour due to machine break – down was reported. In the above statement stock is valued at standard cost of ₹ 4 per unit.

Required

Prepare a standard costing statement analysing the differences between the budget and the actual performance. In your analysis include calculations of the sales volume and sales price variance; direct material price, mix, yield and usage variances; direct labour rate, idle time and efficiency variances; variable overhead cost variance; fixed overhead expenditure and volume variances.

Solution

RECONCILIATION OF ACTUAL & BUDGETED PROFIT

	Reference of Working Note	Variance Favourable	Adverse	Amount
		₹	₹	₹
Budgeted Profit				20,000
Sales Margin Volume Variance	1	2,000	--	
Sales Margin Price Variance	2	--	2,000	
Material:				
- Price	3	600	--	
- Mix	4	1,200	--	
- Yield	5	--	1,000	
Labour:				
- Rate	6	20	--	
- Efficiency	7	--	3,750	
- Idle Time	8	--	3,000	
Variable Overhead:				
- Cost	9	--	3,000	
Fixed Overhead:				
- Expenditure	10	1,980	--	
- Volume	11	4,000	--	
		9,800	12,750	(2,950)
Actual Profit				17,050

WORKING NOTE

1. **Sales Margin Volume Variance** = Standard Margin – Budgeted Margin

= (BM × AQ) – (BM × BQ)

Or

= (AQ – BQ) × BM

= (22,000 units – 20,000 units) × ₹1

= ₹2,000 (F)

2. **Sales Margin Price Variance** = Sales Price Variance

= Actual Sales – Standard Sales

= (AP × AQ) – (BP × AQ)

Or

= (AP – BP) × AQ

= 14,000 units × (₹ 5 – ₹ 5) + 8,000 units × (₹ 4.75 – ₹ 5)

= ₹2,000 (A)

☞

> **Sales Price Variance** is equal to **Sales Margin Price Variance.** This is because, for the actual quantity sold, standard cost remaining constant, change in selling price will have equal impact or turnover and profit.

3. **Material Price Variance** = Standard Cost of Actual Quantity – Actual Cost

= (SP × AQ) – (AP × AQ)

Or

= (SP – AP) × AQ

A: = (₹0.30 – ₹0.20) × 16,000 Kg.

= ₹1,600 (F)

B: = (₹0.70 – ₹0.80) × 10,000 Kg.

= ₹1,000 (A)

Total = ₹1,600 (F) + ₹ 1,000 (A)

= ₹600 (F)

4. **Material Mix Variance** = Total Actual Quantity (units) × (*Average* Standard *per unit* of Standard Mix – Average Standard Price *per unit* of Actual Mix)

= 26,000 Kg. ×

$$\left\{\left(\frac{₹\,10{,}000}{20{,}000\text{Kg.}}\right)-\left(\frac{₹\,0.30 \times ₹\,16{,}000+₹\,0.70 \times ₹10{,}000}{26{,}000\text{Kg.}}\right)\right\}$$

= ₹1,200 (F)

5. **Material Yield Variance** = *Average* Standard Price *per unit* of Standard Mix × [Total Standard Quantity (units) – Total Actual Quantity (units)]

$$= \left(\frac{₹10{,}000}{20{,}000\text{Kg.}}\right) \text{x}$$

$$\left(\frac{20{,}000\text{Kg.}}{20{,}000\text{units}} \text{x} 24{,}000\text{units} - 26{,}000\text{Kg.}\right)$$

= ₹1,000 (A)

6. Labour Rate Variance = Standard Cost of Actual Time – Actual Cost

= (SR × AH*) – (AR × AH*)

Or

= (SR – AR) × AH*

Skilled labour = (₹3 – ₹2.95) × 13,000 hrs.

= ₹ 650 (F)

Un–Skilled Labour = (₹2.50 – ₹2.60) × 6,300 hrs

. = ₹630 (A)

Total = ₹20 (F)

7. Labour Efficiency Variance = Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time

= (SH × SR) – (AH# × SR)

Or

= (SH – AH#) × SR

Skilled Labour = (10,800 hrs.[1] – 12,000 hrs.) × ₹3

= ₹3,600 (A)

([1]) $24{,}000\text{units} \text{x} \frac{9{,}000\text{hours}}{20{,}000\text{units}}$

Un–Skilled Labour = (6,240 hrs[2] – 6,300 hrs.) × ₹ 2.50

. = ₹150 (A)

([2]) $24{,}000\text{units} \text{x} \frac{5{,}200\text{hours}}{20{,}000\text{units}}$

Total = ₹3,750 (A)

8. Idle Time Variance = Standard Rate per Hour × Actual Idle Hours

= (AH* × SR) – (AH# × SR)

Or

= (AH* – AH#) × SR

	Skilled Labour	=	(13,000 hrs. – 12,000 hrs.) × ₹ 3
		=	₹ 3,000 (A)
			Note
			AH* refers to Actual Hours *paid for;*
			AH# refers to Actual Hours *worked*
9.	**Variable Overhead Cost Variance**	=	Standard Variable Overheads for Production – Actual Variable Overheads
		=	24,000 units × ₹0.50 – ₹15,000
		=	₹3,000 (A)
10.	**Fixed Overhead Expenditure Variance**	=	Budgeted Fixed Overheads – Actual Fixed Overheads
		=	₹20,000 – ₹18,020
		=	₹1,980 (F)
11.	**Fixed Overhead Volume Variance**	=	Absorbed Fixed Overheads – Budgeted Fixed Overheads
		=	24,000 units × ₹1 – ₹20,000
		=	₹ 4,000 (F)

Information Required, Given Reconciliation between Budgeted/ Standard Profit with Actual Profit

Problem-36

The following profit reconciliation statement has been prepared by the Cost Accountant of GHI Ltd. for March, 2013:

₹

Budget Profit	*3,60,000*	
Sales Price Variance	*76,500*	*(F)*
Sales Volume Profit Variance	*63,000*	*(A)*
Material Price Variance	*23,820*	*(A)*
Material Usage Variance	*4,800*	*(F)*
Labour Rate Variance	*1,17,600*	*(F)*

Labour Efficiency Variance	*48,000 (A)*
Variable Overhead Expenditure Variance	*12,000 (F)*
Variable Overhead Efficiency Variance	*18,000 (A)*
Fixed Overhead Volume Variance	*2,94,000 (A)*
Fixed Overhead Expenditure Variance	*6,000 (F)*
Actual Profit	*1,30,080*

Budgeted production and sales volumes for March, 2013 were equal and the level of finished goods stock was unchanged, but the stock of raw materials decreased by 6,400 kg (valued at standard price) during the month.

The standard cost card is as under:

	₹
Material 4 kg @ ₹ 3.00	*12.00*
Labour 4 hours @ ₹ 48.00	*192.00*
Variable Overhead 4 hours @ ₹ 18.00	*72.00*
Fixed Overheads 4 hours @ ₹ 42.00	*168.00*
Standard Cost	*444.00*
Standard Profit	*36.00*
Standard Selling Price	*480.00*

Required

(i) Calculate actual quantity of material purchased

(ii) Calculate actual production and sales volume

(iii) Calculate actual number of hours worked

(iv) Calculate actual variable and fixed overhead cost incurred.

Solution

COMPUTATION OF REQUIREMENTS

Actual Production & Sales Volume

Fixed Overhead Volume Variance = Standard Fixed Overhead Rate per Unit × (Actual Output – Budgeted Output*)

⇒ ₹ 2,94,000 (A) = ₹ 168 × (Actual Output – 10,000 units)

$\Rightarrow$ Actual Output = 8,250 units

*Budgeted Output = $\frac{\text{Budgeted Profit}}{\text{Budgeted Profit per unit}}$

= $\frac{₹\ 3,60,000}{₹\ 36}$

= 10,000 units

Alternative

Sales Margin Volume Variance = Standard Margin – Budgeted Margin

= Budgeted Margin × Actual Qty. – Budgeted Margin x Budgeted Qty

Or

. = Budgeted Margin × (Actual Qty. – Budgeted Qty.)

$\Rightarrow$ ₹ 63,000(A) = ₹ 36 × (Actual Qty. – 10,000 units)

$\Rightarrow$ Actual Qty. = 8,250 units

Actual Quantity of Material Purchased

Material Usage Variance = Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity

= Standard Qty. × Standard Price – Actual Qty. × Standard Price

Or

= Standard Price × (Standard Qty. – Actual Qty.)

$\Rightarrow$ ₹ 4,800 (F) = ₹ 3 × (8,250 units × 4 Kg – Actual Qty.)

$\Rightarrow$ Actual Qty. = 31,400 Kg.

Actual Quantity Purchased = Actual Qty. Consumed – Decrease in Stock

= 31,400 Kg. – 6,400 Kg.

= 25,000 Kg.

Actual Hours Worked

Labour Efficiency Variance = Standard Cost of Standard Time for Actual Output – Standard Cost for Actual Time

= Standard Hours × Standard Rate – Actual Hours × Standard Rate

		Or
	=	Standard Rate × (Standard Hours – Actual Hours)
⇒ ₹ 48,000 (A)	=	₹ 48 × (8,250 units × 4 Hrs. – Actual Hours)
⇒ Actual Hours	=	34,000 Hrs.

Actual Fixed Overhead and Actual Variable Overhead Incurred

Variable Overhead Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
		Or
	=	(Standard/Budgeted Variable Overhead per unit × Actual Production in Units) – (Actual Variable Overheads)
⇒ ₹ 12,000 (F) + ₹ 18,000 (A)	=	₹ 72 × 8,250 units – Actual Variable Overheads
⇒ Actual Variable Overheads	=	₹ 6,00,000
Fixed Overhead Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
		Or
	=	(Standard Fixed Overhead Rate per Unit × Actual Production in units) – (Actual Fixed Overheads)
⇒ ₹ 6,000 (F) + ₹ 2,94,000 (A)	=	₹ 168 × 8,250 units – Actual Variable Overheads
⇒ Actual Fixed Overheads	=	₹ 16,74,000

Problem-37

The following is the Operating Statement of a company for April 2013:

				(₹)
Budgeted Profit				*1,00,000*
Variances:		***Favourable (₹)***	***Adverse (₹)***	
Sales	*Volume*	*----*	*4,000*	
	Price	*9,600*	*----*	
Direct Material	*Price*	*----*	*4,960*	
	Usage	*----*	*6,400*	
Direct Labour	*Rate*	*----*	*3,600*	
	Efficiency	*3,600*	*----*	
Fixed Overheads	*Efficiency*	*2,400*	*----*	

	Capacity	*----*	*4,000*	
	Expense	*1,400*	*----*	*5,960 (A)*
Actual Profit				*94,040*

Additional information is as under:

Budget for the year………………………………………………..1,20,000 units

Budgeted fixed overheads……………….…………………… ₹ 4,80,000 per annum

Standard cost of one unit of product is:

Direct Materials…………………………………………………..5 Kg. @ ₹ 4 per Kg.

Direct Labour……………………………………………………..2 hours @ ₹ 3 per hour

Fixed overheads are absorbed on direct labour hour basis.

Profit………………………………………………………………25% on sales

Required

Prepare the Annual Financial Profit / Loss Statement for April, 2013 in the following format:

Account	***Qty./ Hours***	***Rate / Price (₹)***	***Actual Value (₹)***
Sales	---	---	---
Direct Materials	---	---	---
Direct Labour	---	---	---
Fixed Overheads	---	---	---
Total Costs	---	---	---
Profit	---	---	---

Solution

WORKING NOTES

1. (a) Budgeted Fixed Overhead (per unit): $= \dfrac{\text{Budgeted Fixed Overheads p.a.}}{\text{Budgeted Output for the year}}$

$= \dfrac{₹4,80,000}{1,20,000 \text{ units}}$

$=$ ₹4 (per unit)

(b) Budgeted Fixed Overhead Hour: $= \dfrac{\text{Budgeted Fixed Overheads per unit}}{\text{Standard Labour Hours per unit}}$

$$= \frac{₹4}{2\text{ hours}}$$

= ₹2 per hour

2. Statement showing Standard Cost and Budged Selling Price

(a)	**Standard Cost (per unit)**	(₹)
	Direct Material (5 kg. × ₹ 4/- per kg.)	20
	Direct Labour (2 hours × ₹ 3/- per hour)	6
	Fixed Overhead (2 hours × ₹ 2)	4
	Total Standard Cost (per unit)	30
(b)	**Budgeted Selling Price (per unit)**	
	Standard Cost (per unit)	30
	Standard Profit (per unit) (25% on Sales or 33-1/3% of Standard Cost)	10
	Budgeted Selling Price (per unit)	40

3. (a) Actual Output (units) for April, 2013

Fixed Overhead Volume Variance = Efficiency Variance + Capacity Variance
= ₹2,400 (F) + ₹4,000 (A)
= ₹1,600 (A)

Fixed Overhead Volume Variance = Absorbed Overheads – Budgeted Overheads
= (Standard Hours for Actual Output – Budgeted Hours) × Standard Fixed Overhead Rate *per hour*

⇛ (–) ₹ 1,600 = (2 hrs × Actual Output – 10,000 units × 2 hrs) × ₹ 2

⇛Actual Output = 9,600 units

(b) Actual Fixed Overhead Expenses

Fixed Overhead Expenses Variance = Budgeted Fixed Overheads – Actual Fixed Overheads

$\Rightarrow$ ₹ 1,400 (F) = ₹40,000 – Actual Fixed Overheads

$\Rightarrow$ Actual Fixed Overheads = ₹38,600

4. (a) Actual Sales Quantity (units)

Sales Margin Volume Variance = Budgeted Margin *per unit* × $\begin{pmatrix}\text{Actual Sales} & - & \text{Budgeted} \\ \text{Quantity units} & & \text{Quantity units}\end{pmatrix}$

$\Rightarrow$ ₹ 4,000 (A) = ₹10 × (Actual Sales Quantity – 10,000 units)

$\Rightarrow$ Actual Sales Quantity = 9,600 units

(b) Actual Selling Price (per unit)

Sales Price Variance = $\begin{pmatrix}\text{Actual Selling} & - & \text{Budgeted Selling} \\ \text{Price per unit} & & \text{Price per unit}\end{pmatrix}$ x Actual Sales *units*

$\Rightarrow$ ₹ 9,600 (F) = (Actual Selling Price *per unit* – ₹40) × 9,600 units

$\Rightarrow$ Actual Selling Price *per unit* = ₹41

5. (a) Actual Quantity of Material Consumed

Material Usage Variance = $\begin{pmatrix}\text{Standard} & - & \text{Actual} \\ \text{Quantity} & & \text{Quantity}\end{pmatrix}$ x $\begin{matrix}\text{Standard Price} \\ \text{per unit}\end{matrix}$

$\Rightarrow$ ₹ 6,400 (A) = (9,600 units × 5 kg. – Actual Quantity) × ₹4

$\Rightarrow$ Actual Quantity = 49,600 Kg.

(b) Actual Price *per kg*

Material Price Variance = (Standard Price *per kg.* – Actual Price *per kg.*) × Actual Quantity of Material Consumed

$\Rightarrow$ 4,960 (A) = (₹4 – Actual Price *per kg.*) × 49,600 Kg.

$\Rightarrow$ Actual Price *per kg* = ₹ 4.10

6. (a) Actual Direct Labour Hours Used

Labour Efficiency Variance = (Standard Hours – Actual Hours) × Standard Rate per hour

$\Rightarrow$ ₹ 3,600 (F) = (9,600 units × 2 hrs – Actual Hours) × ₹3

$\Rightarrow$Actual Direct Labour Hours = 18,000 hours

(b) Actual Direct Labour Hour Rate

Labour Rate Variance = $\left(\begin{array}{c}\text{Standard} \\ \text{Rate per hour}\end{array} - \begin{array}{c}\text{Actual} \\ \text{Rate per hour}\end{array}\right) \times$

Actual Direct Labour Hours

$\Rightarrow$ ₹3,600 (A) = (₹3 per hour – Actual Rate *per hour*) × 18,000 hours

$\Rightarrow$ Actual Direct Labour Hour Rate = ₹3.20 per hour

ANNUAL FINANCIAL PROFIT /LOSS STATEMENT
(FOR APRIL, 2013)

Particulars	Qty./ Hours	Rate/Price (₹)	Actual Value (₹)
(a)	(b)	(c)	(d)=(b)×(c)
Sales: (A) [Refer to working note 4]	9,600 units	41	3,93,600
Direct Materials: [Refer to working note 5]	49,600 kgs.	4.10 per kg.	2,03,360
Direct Labour: [Refer to working note 6]	18,000 hours	3.20 per hour	57,600
Fixed Overheads: [Refer to working note 6 (a) and 3 (b)] *(₹ 38,600/18,000 hours)* *(absorbed on direct labour hour basis)*	18,000 hours	2.144.. per hour	38,600
Total Costs: (B)			2,99,560
Profit: [(A) – (B)]			94,040

Problem-38

The following profit reconciliation statement has been prepared by the Cost Accountant of RSQ Ltd. for March, 2012:

	₹	
Budget Profit	*2,40,000*	
Sales Price Variance	*51,000*	*(F)*
Sales Volume Profit Variance	*42,000*	*(A)*
Material Price Variance	*15,880*	*(A)*
Material Usage Variance	*3,200*	*(F)*
Labour Rate Variance	*78,400*	*(F)*
Labour Efficiency Variance	*32,000*	*(A)*
Variable Overhead Expenditure Variance	*8,000*	*(F)*
Variable Overhead Efficiency Variance	*12,000*	*(A)*
Fixed Overhead Volume Variance	*1,96,000*	*(A)*
Fixed Overhead Expenditure Variance	*4,000*	*(F)*
Actual Profit	*86,720*	

Budgeted production and sales volumes for March, 2012 were equal and the level of finished goods stock was unchanged, but the stock of raw materials decreased by 6,400 kg (valued at standard price) during the month.

The standard cost card is as under:

	₹
Material 4 kg @ ₹ 2.00	*8.00*
Labour 4 hours @ ₹ 32.00	*128.00*
Variable Overhead 4 hours @ ₹ 12.00	*48.00*
Fixed Overheads 4 hours @ ₹ 28.00	*112.00*
Standard Cost	*296.00*
Standard Profit	*24.00*
Standard Selling Price	*320.00*

Required

(i) *Calculate actual quantity of material purchased*

(ii) *Calculate actual production and sales volume*

(iii) *Calculate actual number of hours worked*

(iv) *Calculate actual variable and fixed overhead cost incurred.*

Solution

COMPUTATION OF REQUIREMENTS

Actual Production & Sales Volume

Fixed Overhead Volume Variance = Standard Fixed Overhead Rate per Unit × (Actual Output – Budgeted Output*)

⇒ ₹ 1,96,000 (A) = ₹ 112 × (Actual Output – 10,000 units)

⇒ Actual Output = 8,250 units

*Budgeted Output = $\frac{\text{Budgeted Profit}}{\text{Budgeted Profit per unit}}$

= $\frac{₹\,2,40,000}{₹\,24}$

= 10,000 units

Alternative

Sales Margin Volume Variance = Standard Margin – Budgeted Margin

= Budgeted Margin × Actual Qty. – Budgeted Margin × Budgeted Qty.

Or

= Budgeted Margin × (Actual Qty. – Budgeted Qty.)

⇒ ₹ 42,000(A) = ₹ 24 × (Actual Qty. – 10,000 units)

⇒ Actual Qty. = 8,250 units

Actual Quantity of Material Purchased

Material Usage Variance = Standard Cost of Standard Quantity for Actual Output – Standard Cost of Actual Quantity

= Standard Qty. × Standard Price – Actual Qty. × Standard Price

Or

= Standard Price × (Standard Qty. – Actual Qty.)

⇒ ₹ 3,200 (F) = ₹ 2 × (8,250 units × 4 Kg – Actual Qty.)

⇒ Actual Qty. = 31,400 Kg.

Actual Quantity Purchased	=	Actual Qty. Consumed – Decrease in Stock
	=	31,400 Kg. – 6,400 Kg.
	=	25,000 Kg.

Actual Hours Worked

Labour Efficiency Variance	=	Standard Cost of Standard Time for Actual Output – Standard Cost for Actual Time
	=	Standard Hours × Standard Rate – Actual Hours × Standard Rate
		Or
	=	Standard Rate × (Standard Hours – Actual Hours)
⇛ ₹ 32,000 (A)	=	₹ 32 × (8,250 units × 4 Hrs. – Actual Hours)
⇛ Actual Hours	=	34,000 Hrs.

Actual Fixed Overhead and Actual Variable Overhead Incurred

Variable Overhead Cost Variance	=	Standard Variable Overheads for Production – Actual Variable Overheads
		Or
	=	(Standard Variable Overhead Rate per unit × Actual Production in Units) – (Actual Variable Overheads)
⇛ ₹ 8,000 (F) + ₹ 12,000 (A)	=	₹ 48 × 8,250 units – Actual Variable Overheads
⇛ Actual Variable Overheads	=	₹ 4,00,000
Fixed Overhead Cost Variance	=	Absorbed Fixed Overheads – Actual Fixed Overheads
		Or
	=	(Standard Fixed Overhead Rate per Unit × Actual Production in units) – (Actual Fixed Overheads)
⇛ ₹ 4,000 (F) + ₹ 1,96,000 (A)	=	₹112 × 8,250 units – Actual Variable Overheads
⇛ Actual Fixed Overheads	=	₹11,16,000

Standard - Marginal Costing

Problem-39

A company following standard marginal costing system has the following interim trading statement for the quarter ending 30th June, 2013, which reveals a loss of ₹ 17,000, detailed below:

	₹
Sales	*4,99,200*
Closing Stock (at prime cost)	*18,000*
Direct Material	*1,68,000*
Direct Labour	*1,05,000*
Variable Overhead	*42,000*
Fixed Overhead	*1,20,000*
Fixed Administration Overhead	*40,000*
Variable Distribution Overhead	*19,200*
Fixed Selling Overhead	*40,000*
Loss	*17,000*

Additional information is as follows:

(i) Sales for the quarter were 1,200 units. Production was 1,400 units, of which 100 units were scrapped after complete manufacture. The factory capacity is estimated at 2,000 units.

(ii) Because of low production, labour efficiency during the quarter is estimated to be 20% below normal level.

Required

Analyse the above and report to the management giving the reasons for the loss.

Solution

WORKING NOTE

Details	Working	Amount (₹)
Selling Price	$\frac{₹4,99,200}{1,200\text{units}}$	416
Raw Materials	$\frac{₹1,68,000}{1,400\text{units}}$	120

Labour **Equivalent units* *(1,400 units / 80%)*	$\frac{₹1,05,000}{1,750 units*}$	60
Variable Overheads	$\frac{₹42,000}{1,400 units}$	30
Manufacturing Cost (Variable)		210
Distribution Overheads	$\frac{₹19,200}{1,200 units}$	16
Total Variable Cost		226
Contribution		190
Fixed Cost Factory Administration Selling	 ₹ 1,20,000 ₹ 40,000 ₹ 40,000	 2,00,000

STANDARD PROFIT for 1,200 Units Sold

Details	*Working*	*Amount (₹)*
Contribution	1,200 units × ₹ 190	2,28,000
Less: Fixed Costs		2,00,000
Profit		28,000

RECONCILIATION BETWEEN BUDGETED AND ACTUAL PROFIT

Details	*Working*	*Amount (₹)*
Budgeted Profit	(2,000 units × ₹ 190 – ₹ 2,00,000)	1,80,000
Less: Volume variance	(800 units× ₹190)	1,52,000
Standard Profit		28,000
Factors causing loss:		
Units Scrapped	(100 units × ₹210)	21,000
Labour Inefficiency	(350 units × ₹60)	21,000
Undervaluation of Closing Stock	{100 units × (₹210 – ₹180)}	3,000
Actual Profit		(-)17,000

Problem-40

The following figures are available. Find out the missing figures, giving appropriate formulae:

	₹
Budgeted profit	*15,000*
Less: Adverse variances:	
Contribution price variance	*10,600*
Direct materials variance	*1,000*
Fixed overhead variance	*600*
Add: Favourable variances:	
Contribution quantity variance	*1,800*
Direct wages variance	*600*
Variable overhead variance	*1,800*
Actual profit	*7,000*

There is no inventory. Production units equals to Sales units for both actual and budget.

Standard selling price	*₹ 18 / unit*
Standard variable cost	*₹ 15 / unit*
Budgeted sales	*10,000 units*
Actual selling price	*₹ 17 / unit*

Standard material cost per unit………………………………….. ₹ 1 (which is 5 kg. @ ₹ 20 Paise/kg.)

Material usage variance………………………………………….. ₹ 400 (A)

Actual labour hours @ actual rate………………………………₹ 63,000

Actual labour hours @ standard rate……………………………₹ 61,950

Variable overhead standard rate……………………………....₹ 2

Standard hours of production…………………………………….4 per unit

Variable overhead at standard rate……………………………...₹ 84,800

Variable overhead expenditure variance……………………….. ₹ 400 (A)

Budgeted fixed overhead…………………………………………₹ 15,000

Required

Find out the following-

(i) Actual sales units

(ii) Actual sales rupees

(iii) *Actual quantity of raw materials used*

(iv) *Labour efficiency variance*

(v) *Actual variable overhead in rupees*

(vi) *Variable overhead efficiency variance*

(vii) *Actual fixed overheads*

(viii) *Operating profit variance.*

Solution

COMPUTATION OF REQUIREMENTS

Computation of Actual Sales (units)		
Budgeted Contribution (₹15,000 + ₹15,000)		₹ 30,000
Add: Contribution Quantity Variance		₹ 1,800
Total Standard Contribution		₹ 31,800
Standard Contribution *per unit*		₹ 3
Actual Sales Volume (₹ 31,800 / ₹ 3)		10,600 units
Computation of Actual Sales (₹) :		
Actual Sales Value (10,600 units × ₹ 17)		₹1,80,200
Computation of Actual Quantity of Raw Materials (used)		
Standard Consumption (10,600 units × 5 kg.)		53,000 kgs.
Add: Material Usage Variance [400 (A) / ₹ 0.20]		2,000 kgs.
Actual Consumption		55,000 kgs.
Computation of Labour Efficiency Variance		
Standard Labour Cost *for Standard Hours*	(₹63,000 + ₹600)	₹ 63,600
Standard Labour Cost for Actual Hours		₹ 61,950
Labour Efficiency Variance		₹ 1,650 (F)
Computation of Actual Variable Overhead (₹)		
Standard Variable Overheads *for Output*		₹ 84,800
Less: Variable Overhead Variance		₹1,800
Actual Variable Overhead		₹ 83,000

Computation of Variable Overhead Efficiency Variance

Workings

Actual Output		10,600 units
Standard Hours for Actual Output	(10,600 units × 4 hrs.)	42,400 hours
Standard Labour Cost *for Standard Hours*		₹ 63,600
Standard Labour Rate *per hour*	(₹ 63,600 / 42,400 hours)	₹1.5
Actual Hours	(₹61,950 / ₹1.5)	41,300 hours
Variable Overhead Efficiency Variance [(42,400 hours - 41,300 hours) x ₹2]		₹ 2,200 (F)
Computation of Actual Fixed Overheads		
Actual Fixed Overheads (₹15,000 + ₹600)		₹ 15,600
Computation of Operating Profit Variance		
Operating Profit Variance:		
If budgeted profit is considered (₹15,000 – ₹ 7,000)		₹ 8,000 (A)
If standard profit is considered (₹16,800 – ₹ 7,000)		₹ 9,800 (A)

VERIFICATION

	₹
Actual Sales (10,600 units x ₹17)	1,80,200
Less: Actual Cost	
Materials (₹0.20x 5Kg. x10,600 units + ₹1,000)	11,600
Labour	63,000
Variable Overhead	83,000
Fixed Overhead	15,600
Actual Net Profit	7,000

☞

Sales Contribution Volume Variance Volume	= Sales Margin Volume Variance + Fixed Overhead Variance
	Or
	= Budgeted Margin *per unit* × (Actual Qty. – Budgeted Qty.) + Standard Fixed Overhead Rate per Unit × (Actual Output – Budgeted Output)

	Or
	= (Actual Qty. – Budgeted Qty.) × [Budgeted Margin *per unit* + Standard Fixed Overhead Rate per Unit]
	Or
	= (Actual Qty. – Budgeted Qty.) × [Standard Contribution per Unit]
Note: Production units equals to Sales units for both actual and budget.	

☞

Reconciliation between Budgeted Profit & Actual Profit-I	₹
Budgeted Profit	✓
Add / Less: Impact of Variances	
Contribution Price Variance / Sales Price Variance / Sales Margin Price Variance	✓
Contribution Volume Variance	✓
Direct Material Cost Variance	✓
Direct Wages Cost Variance	✓
Fixed Overhead Expenditure Variance	✓
Variable Overheads Cost Variance	✓
Actual Profit	✓

☞

Reconciliation between Budgeted Profit & Actual Profit-II	₹
Budgeted Profit	✓
Add/Less: Impact of Variances	
Contribution Price Variance / Sales Price Variance / Sales Margin Price Variance	✓
Margin Volume Variance	✓
Direct Material Cost Variance	✓
Direct Wages Cost Variance	✓
Fixed Overhead Cost Variance	✓
Variable Overheads Cost Variance	✓
Actual Profit	✓

Problem-41

Young Chin Limited uses standard and marginal costing system. It provides the following details for the year 2012-13 relating to its production, cost and sales:

Particulars	*Budget*	*Actual*
Sales units	*24,000*	*25,600*
Sales value (₹)	*6,000*	*6,784*
Materials (₹)	*960*	*1,080*
Labour (₹)	*1,440*	*1,664*
Variable overheads (₹)	*2,400*	*2,592*

The sales budget is based on the expectation of the company's estimate of market share of 12%. The entire industry's sales of the same product for the year 2012-13 is 2,40,000 units. Further details are as follows:

Particulars	*Standard (In ₹)*	*Actual (In ₹)*
Material price per kg.	*8.00*	*7.50*
Labour rate per hour	*6.00*	*6.40*

Required

(a) Prepare a statement reconciling the budgeted contribution with actual contribution on the basis of important material variances, labour variances, variable overhead variances and sales variances.

(b) Compute market size variance and market share variance also.

Solution

COMPUTATION OF VARIANCES

Sales Variances - Turnover Based

Workings

Budgeted Sales	₹ 6,000
Budgeted Sales Quantity (units)	24,000
Budgeted Selling Price (₹ 6,000 / 24,000 units)	₹ 0.25
Actual Industry Sales (units)	2,40,000
Budgeted Market Share	12%
Market Share Required (units) (2,40,000 units × 12%)	28,800

Variances

Value Variance = Actual Sales – Budgeted Sales

	=	AP × AQ – BP × BQ
	=	₹ 6,784 – ₹6,000
	=	₹ 784 (F)
Price Variance	=	Actual Sales – Standard Sales
	=	AP × AQ – BP × AQ
		Or
	=	AQ × (AP – BP)
	=	$25{,}600 \text{ units} \times \left\{\left(\frac{₹6{,}784}{25{,}600\text{units}}\right)-\left(\frac{₹6{,}000}{24{,}000\text{units}}\right)\right\}$
	=	384 (F)
Volume Variance	=	Standard Sales – Budgeted Sales
	=	BP × AQ – BP × BQ
		Or
	=	BP × (AQ – BQ)
	=	$\left(\frac{₹6{,}000}{24{,}000\text{units}}\right)$ × (25,600 units – 24,000 units)
	=	₹400 (F)
Market Size Variance	=	(Required Sales Quantity *in units* –Total Budgeted Quantity *in units*) × Average Budgeted Price *per unit*
	=	(28,800 units – 24,000 units) × ₹ 0.25
	=	₹1,200 (F)
Market Share Variance	=	(Total Actual Quantity *in units* – Required Sales Quantity *in units*) × Average Budgeted Price *per unit*
	=	(25,600 units – 28,800 units) × ₹ 0.25
	=	₹800 (A)

Sales Variances - Contribution Based

Workings

Budgeted Contribution:

Sales	₹ 6,000
Less: Variable Costs	₹ 4,800

Contribution	₹ 1,200
Budgeted Units	24,000
Contribution / unit (₹1,200 / 24,000 units)	₹ 0.05

Variances

Sales Contribution Price Variance

= Sales Price Variance

= 384 (F)

Sales Contribution Volume Variance = Sales Volume Variance x Budgeted Profit Volume Ratio

$$= 400\ (F) \times \left(\frac{₹1,200}{₹6,000} x100\right)$$

= ₹ 80 (F)

Market Size Variance = (Required Sales Quantity *in units* –Total Budgeted Quantity *in units*) × Average Budgeted Contribution *per unit*

= (28,800 units – 24,000 units) × ₹ 0.05

= ₹240 (F)

Market Share Variance = (Total Actual Quantity *in units* – Required Sales Quantity *in units*) × Average Budgeted Contribution *per unit*

= (25,600 units – 28,800 units) × ₹ 0.05

= ₹160 (A)

Contribution Variance = Sales Contribution Price Variance + Sales Contribution Volume Variance

= ₹384 (F) + ₹80 (F)

= ₹464 (F)

Direct Materials Variance

Workings

Budgeted Material Cost	₹ 960
Budgeted Units	24,000
Budgeted Material Cost per 100 units (₹960 / 24,000units × 100)	₹ 4
Standard Price of Material *per Kg*	₹ 8
Standard Requirement of Materials per 100 units of output (₹4 / ₹8)	0.50 Kg

Actual Output (units)	25,600
Standard Requirement for Actual Output {(25,600 units × 0.50 Kg) / 100 units}	128 Kg
Actual Material Cost	₹ 1,080
Actual Price *per Kg*	₹ 7.50
Actual Quantity of Materials Consumed (₹1,080 / ₹7.50)	144 Kg

Variances

Material Price Variance = Standard Cost of Actual Quantity – Actual Cost

Or

= Actual Qty. × (Std. Price – Actual Price)

= 144 Kg. × (₹ 8 – ₹ 7.50)

= 72 (F)

Material Usage Variance = Standard Cost of Standard Quantity for Actual Production – Standard Cost of Actual Quantity

Or

= Std. Price × (Std. Qty. – Actual Qty.)

= ₹ 8 × (128 Kg. – 144 Kg.)

= ₹ 128 (A)

Direct Labour Variances

Workings

Budgeted Labour Cost	₹ 1,440
Budgeted Units	24,000
Budgeted Labour Cost per 100 units (₹1,440 / 24,000 units ×100units)	₹ 6
Standard Labour Rate *per hour*	₹ 6
Standard Requirement of Labour Hours per 100 units of output (₹6 / ₹6)	1 hr
Actual Output (units)	25,600
Standard Hours Required for Actual Output (25,600 units × 1 hr /100 units)	256 hrs
Actual Labour Cost	₹ 1,664
Actual Direct Labour Rate *per hour*	₹ 6.40
Actual Hours Worked (₹1,664 / ₹6.40)	260 hrs
Budgeted Direct Labour Hours (₹1,440 / ₹6)	240 hrs

Variances

Labour Rate Variance	=	Standard Cost of Actual Time – Actual Cost
		Or
	=	Actual Hours × (Std. Rate – Actual Rate)
	=	260 hours × (₹ 6.00 – ₹ 6.40)
	=	₹104 (A)
Labour Efficiency Variance	=	Standard Cost of Standard Time for Actual Production – Standard Cost of Actual Time
		Or
	=	Std. Rate × (Std. Hours – Actual Hours)
	=	₹ 6 × (256 hours – 260 hours)
	=	₹ 24 (A)

Variable Overheads Variances

Workings

Budgeted Variable Overheads	₹ 2,400
Budgeted Labour Hours	240
Standard Variable Overhead Rate per direct labour hour (₹ 2,400 / ₹ 240)	₹ 10
Actual Hours	260 hrs
Standard Hours Required for Actual Output	256 hrs

Variances

Expenditure Variance	=	Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
	=	260 hours × ₹ 10 – ₹ 2,592
	=	₹ 8 (F)
Efficiency Variances	=	Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours
	=	256 hours × ₹ 10 – 260 hours × ₹ 10
	=	40 (A)

CONTRIBUTION ANALYSIS

	Budget	Actual
	₹	₹
Sales	6,000	6,784
Variable Cost	4,800	5,336
Contribution	1,200	1,448

RECONCILIATION

Budgeted and Actual Contribution

	₹
Budgeted Contribution	1,200
Add: Sales Contribution Volume Variance	80 (F)
Standard Contribution	1,280
Add: Sales Price Variance	384 (F)
Less: Material Usage Variance	128 (A)
Add: Material Price Variance	72 (F)
Less: Labour Efficiency Variance	24 (A)
Less: Labour Rate Variance	104 (A)
Less: Variable Overhead Efficiency Variance	40 (A)
Add: Variable Overhead Expense Variance	8 (F)
Actual Contribution	1,448

Single Plan/Partial Plan

Problem-42

Under the single plan, record the journal entries giving appropriate narration, with indication of amounts of debits or credits alongside the entries, for the following transactions using the respective control A/c.

(i) *Material price variance (on purchase of materials)*

(ii) *Material usage variance (on consumption)*

(iii) *Labour rate variance.*

Solution

JOURNAL ENTRIES IN SINGLE PLAN

S. No.	Journal Entries	Debit Amount (₹)	Credit Amount (₹)
(i)	Dr. Material Control A/c	√	
	Dr. or Cr. Material Price Variance A/c	√	
	Cr. Creditors A/c		√
	(Being recording of Price Variance during Purchase of Materials)		
(ii)	Dr. WIP Control A/c	√	
	Dr. or Cr. Material Usage Variance A/c	√	
	Cr. Material Control A/c		√
	(Being recording of Usage Variance at Standard Cost of excess / under utilized Quantity)		
(iii)	Dr. Wages Control A/c	√	
	Dr. or Cr. Labour Rate Variance A/c	√	
	Cr. Cash		√
	(Being recording of Wages at Standard Rate)		

Incomplete Ledger, Computation of Variances

Problem-43

Transparent Ltd. manufactures paint. It uses a standard costing system and the variances are reported to the management on fortnightly basis. A fire destroyed some important records of the company. You have been able to collect the following information from the spoilt papers/records and as a 'result of consultation with accounting personnel in respect of a fortnight:

(a) *The paint requires two types of raw material RM_1 and RM_2. The standard quantity of RM_2 in final product is 5 litres and standard cost thereof is ₹ 36 per litre.*

(b) *The company purchased 200 Kg. of RM_1 and 550 litres of RM_2 during that fortnight.*

(c) *The standard wage rate is ₹ 24 per labour hour. Actual labour hours were 460 during the fortnight.*

(d) Variances as disclosed from some spilled paper are :

(i)	*Price Variance (RM_2)*	--	*₹ 1,320 (A)*
(ii)	*Usage Variance (RM_1)*	--	*₹ 240 (F)*
(iii)	*Labour Efficiency Variance*	--	*₹ 1,440 (A)*

(e) Some incomplete ledger entries for that fortnight reveal

	₹		₹
	(1) Sundry Creditors		
		Purchase of Raw Material	*25,440*
	(2) RM_2		
Opening Balance	*3,600*	*Closing Balance*	*8,280*
	(3) RM_1		
Opening Balance	*0*		*3,600*
		Closing Balance	*1,200*
	(4) Works – in – Progress		
Opening Balance	*0*		
RM_2	*14,400*	*Closing Balance*	*0*
	(5) Wages		
Paid & Outstanding	*10,350*		

Required

Compute the meaningful variances to be presented before management. (Key computations should from part of the answer).

Solution

COMPUTATION OF KEY INFORMATION

1. **Actual Output of Paint**

$$= \frac{\text{Total Standard Cost of } RM_2 \text{ in Final Product}}{\text{Standard Cost of } RM_2 \text{ in One Unit of Final Product}}$$

$$= \frac{₹14,400}{₹180^*}$$

= 80 units of Paint

** Standard Cost of RM_2 in One Unit of Final Product*

= 5 litres × ₹ 36

= ₹180

2. **Actual Cost *per litre* of RM_2**

Purchase Price Variance (RM_2)

= Standard Cost of Actual Quantity – Actual Cost

= Purchase Quantity × (Standard Price – Actual Price)

1,320 (A) = 550 litres × (₹36 – Actual Price)

⇒ –1,320 = 550 × (36 – Actual Price)

⇒ Actual Price = ₹38.40 per litre

3. **Actual Quantity of RM_2 Utilised**

Total Quantity of RM_2 Purchased	550 litres
Add: Opening Balance (₹3,600/₹36)	100 litres
Less: Closing Balance (₹8,280/₹36)	230 litres
	420 litres

4. **Standard Quantity of RM_2 for Actual Output**

$$= \frac{\text{Standard Cost of } RM_2 \text{ issued to production}}{\text{Standard Cost of } RM_2 \text{ per litre}}$$

$$= \frac{₹14,400}{₹36}$$

= 400liters

5. **Standard Cost *per Kg.* of RM_1**

Standard Quantity of RM_1	₹
Issued to Production at Standard Cost	3,600
Balance at Standard Cost	1,200
Total	4,800

The above total is equal to total purchase or total standard cost of 200 kg.

Standard Cost *per Kg.* of RM_1 = $\frac{\text{Total Standard Cost of 200 Kg.}}{\text{200 Kg.}}$

= $\frac{₹4,800}{\text{200 Kg.}}$

= ₹24

6. **Actual Quantity of RM_1 issued to production**

= $\frac{₹3,600}{₹24}$

= 150 Kg.

7. **Standard Quantity of RM_1 for actual output**

Material Usage Variance = Standard Price × (Standard Quantity – Actual Quantity)

⇒ ₹240 (F) = ₹24 × (Standard Quantity – 150 Kg.)

⇒ Std. Quantity = 160 Kg.

8. **Actual Cost *per Kg* of RM_1**

	₹
Total Purchase Cost of Raw materials (RM_1 + RM_2)	25,440
Less: Actual Cost of 550 litres of RM_2 @ ₹ 38.40 per litre	21,120
Total Purchase Cost of 200 Kg of RM_1	4,320

Actual Cost *per Kg.* of RM_1 = $\frac{\text{Total Purchase Cost of 200 Kg. of } RM_1}{\text{200 Kg.}}$

= $\frac{₹4,320}{\text{200 Kg.}}$

= ₹21.60

9. **Standard and Actual Cost of Material**

Raw Material	Standard			Actual		
	Qty. [SQ]	Price [SP] (₹)	Amount [SQ x SP] (₹)	Qty. [AQ]	Price [AP] (₹)	Amount [AQ x AP] (₹)
RM_1	160Kg.	24	3,840	150Kg.	21.60	3,240
RM_2	400lt.	36	14,400	420lt	38.40	16,128
			18,240			19,368

10. **Actual Wage Rate *per hour***

$$= \frac{\text{Wages Paid \& Outstanding}}{\text{Actual Labour Hours}}$$

$$= \frac{₹10,350}{460\text{Hrs.}}$$

$$= ₹22.50$$

11. **Standard Labour Hours *for actual output***

Labour Efficiency Variance = Std. Wage Rate × (Std. Hours – Actual Hours)

1,440 (A) = ₹24 × (Std. Hours – 460 Hours)

⇒ Std. Hours = 400 Hours

12. **Standard & Actual Cost of Labour**

Standard			Actual		
Hours	**Wage Rate per hour (₹)**	**Amount (₹)**	**Hours**	**Wage Rate per hour (₹)**	**Amount (₹)**
400	24	9,600	460	22.50	10,350

COMPUTATION OF VARIANCES

Material Cost Variance = Std. Cost – Actual Cost

= ₹ 18,240 – ₹ 19,368

= ₹ 1,128 (A)

Material Price Variance RM_1 = Actual Quantity × (Std. Price – Actual Price)

= 150 Kg × (₹ 24 – ₹ 21.60)

= ₹ 360 (F)

Material Price Variance RM_2 = 420 litres × (₹ 36 – ₹ 38.40)

= 1,008 (A)

Material Usage VarianceRM_2 = Std. Price × (Std. Quantity – Actual Quantity)

= ₹ 36 × (400 litres – 420 litres)

= ₹ 720 (A)

Labour Cost Variance = Standard Cost – Actual Cost

= ₹ 9,600 – ₹ 10,350

= ₹ 750 (A)

Labour Rate Variance	=	Actual Hours × (Std. Rate – Actual Rate)
	=	460 Hours × (₹ 24 – ₹ 22.50)
	=	₹ 690 (F)

Verification

Material Cost Variance	=	Material Price Variance + Material Usage Variance
	=	₹ 360 (F) + ₹ 240 (F) + ₹ 1,008 (A) + ₹720 (A)
	=	₹ 1,128 (A)
Labour Cost Variance	=	Labour Rate Variance + Labour Efficiency Variance
	=	₹ 690 (F) + ₹ 1,440 (A)
	=	₹ 750 (A)

Planning & Operational Variances, Controllable and Non Controllable Variances

Problem-44

C Preserves produces Jams, Marmalade and Preserves. All the products are produced in a similar fashion; the fruits are cooked at low temperature in a vacuum process and then blended with glucose syrup with added citric acid and pectin to help setting.

Margins are tight and the firm operates, a system of standard costing for each batch of Jam.

The standard cost data for a batch of raspberry jam are-

Fruits extract	*400 kgs @ ₹ 16 per kg.*
Glucose syrup	*700 kgs @ ₹ 10 per kg.*
Pectin	*99 kgs. @ ₹ 33.2 per kg.*
Citric acid	*1 kg at ₹ 200 per kg.*
Labour	*18 hours @ ₹ 32.50 per hour*
Standard processing loss 3%	

The climate conditions proved disastrous for the raspberry crop. As a consequence, normal prices in the trade were ₹ 19 per kg for fruits extract although good buying could achieve some savings. The impact of exchange rates for imported sugar plus the minimum price fixed for sugarcane, caused the price of syrup to increase by 20%.

The retail results for the batch were –

Fruit extract	*428 kgs at ₹ 18 per kg.*
Glucose syrup	*742 kgs at ₹ 12 per kg.*

Pectin	*125 kgs at ₹ 32.8 per kg.*
Citric acid	*1 kg at ₹ 95 per kg.*
Labour	*20 hrs. at ₹ 30 per hour*

Actual output was 1,164 kgs of raspberry jam.

Required

(i) Calculate the ingredients planning variances that are deemed uncontrollable.

(ii) Calculate the ingredients operating variances that are deemed controllable.

(iii) Calculate the mixture and yield variances.

(iv) Calculate the total variances for the batch.

Solution

BASIC WORKINGS

Statement Showing "Original Standard, Revised Standard and Actual Data"

Ingred.	*Original Standards*		*Revised Standards*		*Actual*	
Fruit	400 Kgs × ₹16.00	₹6,400.00	400 Kgs × ₹19.00	₹7,600.00	428 Kgs × ₹18.00	₹7,704.00
Glucose	700 Kgs × ₹10.00	₹7,000.00	700 Kgs × ₹12.00	₹8,400.00	742Kgs × ₹12.00	₹ 8,904.00
Pectin	99 Kgs × ₹33.20	₹3,286.80	99 Kgs × ₹33.20	₹3,286.80	125Kgs × ₹32.80	₹ 4,100.00
Citric acid	1 Kg × ₹ 200.00	₹200.00	1 Kg × ₹200.00	₹200.00	1 Kg × ₹95.00	₹ 95.00
Total		₹16,886.80		₹19,486.80		₹20,803.00
Labour		₹ 585.00		₹ 585.00		₹ 600.00
Input	1,200 Kgs	₹17,471.80	1,200 Kgs	₹20,071.80	1,296 Kgs	₹ 21,403
Loss	36 Kgs		36 Kgs		132 Kgs	
Output	1,164 Kgs	₹17,471.80	1,164 Kgs	₹20,071.80	1,164 Kgs	₹ 21,403.00

COMPUTATION OF VARIANCES

(i) Planning Variances

* Fruit extract (₹ 6,400.00 *less* ₹ 7,600.00)	₹ 1,200.00 (A)
Glucose syrup (₹ 7,000.00 *less* ₹ 8,400.00)	₹ 1,400.00 (A)
Total	₹ 2,600.00 (A)

* *(Std. Qty. × Std Price. less Std. Qty. × Revised Std. Price)*

(ii) Ingredients Operating Variances

Total (₹ 19,486.80 *less* ₹ 20,803.00) = ₹ 1,316.20 (A)

Ingredients Price Variance:

(Revised Material Price less Actual Material Price) × *(Actual Qty. Consumed)*

		Variance in ₹
Fruit extract	(₹ 19.00 – ₹ 18.00) × 428.00 Kgs	428.00 (F)
Glucose syrup	(₹ 12.00 – ₹ 12.00) × 742.00 Kgs	Nil
Pectin	(₹ 33.20 – ₹ 32.80) × 125.00 Kgs.	50.00 (F)
Citric acid	(₹ 200.00 – ₹ 95.00) × 1.00 Kg.	105.00 (F)
		583.00 (F)

Ingredients Usage Variance:

(Std. Qty. on Actual Production less Actual Qty on Actual Production) × *Revised Std. Price*

		Variance in ₹
Fruit extract	(400.00 Kgs.– 428.00 Kgs.) × ₹ 19.00	532.00 (A)
Glucose syrup	(700.00 Kgs.– 742.00 Kgs.) × ₹ 12.00	504.00 (A)
Pectin	(99.00 Kgs. – 125.00 Kgs.) × ₹ 33.20	863.20 (A)
Citric acid	(1.00 Kg. – 1.00 Kg.) × ₹ 200.00	Nil
		1,899.20 (A)

Labour Operating Variance:

(Standard Cost – Actual Cost)

₹ 585 – ₹ 600 = ₹ 15 (A)

(iii) Mix Variance

(Actual Usage in Std. Mix less Actual Usage in Actual Mix) × *Revised Std. Price*

		Variance in ₹
Fruit extract	(432.00 Kgs. – 428.00 Kgs.) × ₹ 19.00	76.00 (F)
Glucose syrup	(756.00 Kgs. – 742.00 Kgs.) × ₹ 12.00	168.00 (F)
Pectin	(106.92 Kgs. – 125.00 Kgs.) × ₹ 33.20	600.30 (A)
Citric acid	(1.08 Kgs. – 1.00 Kgs.) × ₹ 200.00	16.00 (F)
		340.30 (A)

Yield Variance:

(Actual Yield – Std. Yield from Actual Input) × Std. Cost per unit of Output

$= (1{,}164 \text{ Kgs.} - 1{,}296 \text{ Kgs.} \times 0.97) \times \dfrac{₹19{,}486.80}{1{,}164\text{Kgs.}}$

= 1,558.90 (A)

(iv) Total Variance

Planning Variance + Usage Variance + Price Variance + Labour Operating Variance

2,600.00 (A) + 1,899.20 (A) + 583.00 (F) + 15.00 (A) = 3,931.20 (A)

Problem-45

Managing Director of Petro-KL Ltd (PTKLL) thinks that Standard Costing has little to offer in the reporting of material variances due to frequently change in price of materials.

PTKLL can utilize one of two equally suitable raw materials and always plan to utilize the raw material which will lead to cheapest total production costs. However PTKLL is frequently trapped by price changes and the material actually used often provides, after the event, to have been more expensive than the alternative which was originally rejected.

During last accounting period, to produce a unit of 'P' PTKLL could use either 2.50 Kg of 'PG' or 2.50 kg of 'PD'. PTKLL planned to use 'PG' as it appeared it would be cheaper of the two and plans were based on a cost of 'PG' of ₹ 1.50 per Kg. Due to market movements the actual prices changed and if PTKLL had purchased efficiently the cost would have been:

'PG' ₹ 2.25 per Kg;

'PD' ₹ 2.00 per Kg

Production of 'P' was 1,000 units and usage of 'PG' amounted to 2,700 Kg at a total cost of ₹ 6,480/-

Required

Analyze the material variance for 'P' by:

(i) Traditional Variance Analysis; and

(ii) An approach which distinguishes between Planning and Operational Variances.

Solution

COMPUTATION OF VARIANCES

Traditional Variance (Actual Vs Original Budget)

Usage Variance	=	(Standard Quantity – Actual Quantity) × Standard Price
	=	(2,500 Kg – 2,700 Kg) × ₹ 1.50
	=	₹ 300 (A)
Price Variance	=	(Standard Price – Actual Price) × Actual Quantity
	=	(₹ 1.50 – ₹ 2.40) × 2,700 Kg
	=	₹ 2,430 (A)
Total Variance	=	₹ 300 (A) + ₹ 2,430 (A) = ₹ 2,730 (A)

Operational Variance (Actual Vs Revised)

Usage Variance	=	(2,500 Kg – 2,700 Kg) × ₹ 2.25
	=	₹ 450 (A)
Price Variance	=	(₹ 2.25 – ₹ 2.40) × 2,700 Kg
	=	₹ 405 (A)
Total Variance	=	₹ 450 (A) + ₹ 405 (A) = ₹ 855 (A)

Planning Variance (Revised Vs Original Budget)

Controllable Variance	=	(₹ 2.00 – ₹ 2.25) × 2,500 Kg
	=	625 (A)
Uncontrollable Variance	=	(₹ 1.50 – ₹ 2.00) × 2,500 Kg
	=	1,250 (A)
Total Variance	=	₹ 625 (A) + ₹ 1,250 (A) = ₹ 1,875 (A)
Traditional Variance	**=**	**Operational Variance + Planning Variance**
	=	855 (A) + 1,875 (A) = 2,730 (A)

☞

A **Planning Variance** simply compares a revised standard to the original standard. An **Operational Variance** simply compares the actual results against the revised amount. **Controllable Variances** are those variances which arises due to inefficiency of a cost centre /department. **Uncontrollable Variances** are those variances which arises due to factors beyond the control of the management or concerned department of the organization.

Problem-46

Osaka Manufacturing Co. (OMC) is a leading consumer goods company. The budgeted and actual data of OMC for the year 2013-14 are as follows:-

Particulars	*Budget*	*Actual*	*Variance*
Sales / Production (units)	*2,00,000*	*1,65,000*	*(35,000)*
Sales (₹)	*21,00,000*	*16,92,900*	*(4,07,100)*
Less: Variable Costs (₹)	*12,66,000*	*10,74,150*	*1,91,850*
Less: Fixed Costs (₹)	*3,15,000*	*3,30,000*	*(15,000)*
Profit	*5,19,000*	*2,88,750*	*(2,30,250)*

The budgeted data shown in the table is based on the assumption that total market size would be 4,00,000 units but it turned out to be 3,75,000 units.

Required

Prepare a statement showing reconciliation of budget profit to actual profit through marginal costing approach for the year 2013-14 in as much detail as possible.

Solution

STATEMENT OF RECONCILIATION - BUDGETED VS ACTUAL PROFIT

Particulars	**₹**
Budgeted Profit	5,19,000
Less: Sales Volume Contribution Planning Variance (Adverse)	52,125
Less: Sales Volume Contribution Operational Variance (Adverse)	93,825
Less: Sales Price Variance (Adverse)	39,600
Less: Variable Cost Variance (Adverse)	29,700
Less: Fixed Cost Variance (Adverse)	15,000
Actual Profit	2,88,750

WORKINGS

Basic Workings

Budgeted Market Share (in %) $= \dfrac{2,00,000\text{units}}{4,00,000\text{units}} = 50\%$

Actual Market Share (in %) $= \dfrac{1,65,000\text{units}}{3,75,000\text{units}} = 44\%$

Budgeted Contribution = ₹21,00,000 – ₹12,66,000

= ₹8,34,000

Average Budgeted Contribution (*per unit)* = $\frac{₹8,34,000}{₹2,00,000}$ = ₹4.17

Budgeted Sales Price *per unit* = $\frac{₹21,00,000}{₹2,00,000}$ = ₹10.50

Actual Sales Price *per unit* = $\frac{₹16,92,900}{₹1,65,000}$ = ₹10.26

Standard Variable Cost *per unit* = $\frac{₹12,66,000}{₹2,00,000}$ = ₹6.33

Actual Variable Cost *per unit* = $\frac{₹10,74,150}{₹1,65,000}$ = ₹6.51

CALCULATION OF VARIANCES

Sales Variances:……….

Volume Contribution Planning* Sales = Budgeted Market Share % × (Actual Industry Sales Quantity *in units* – Budgeted Industry Quantity *in units*) × (Average Budgeted Contribution *per unit*)

= 50% × (3,75,000 units – 4,00,000 units) × ₹4.17

= 52,125 (A)

(*) *Market Size Variance*

Volume Contribution Operational** = (Actual Market Share % – Budgeted Market Share %) × (Actual Industry Sales Quantity *in units*) × (Average Budgeted Contribution *per unit*)

= (44% – 50 %) × 3,75,000 units × ₹4.17

= 93,825 (A)

(**) *Market Share Variance*

Price = Actual Sales – Standard Sales

= Actual Sales Quantity × (Actual Price – Budgeted Price)

	=	1,65,000 units × (₹10.26 – ₹10.50) = 39,600 (A)
Variable Cost Variances:……….		
Cost	=	Standard Cost for Production – Actual Cost
	=	Actual Production × (Standard Cost *per unit* – Actual Cost *per unit*)
	=	1,65,000 units × (₹6.33 – ₹6.51) = ₹29,700(A)
Fixed Cost Variances:……….		
Expenditure	=	Budgeted Fixed Cost – Actual Fixed Cost
	=	₹3,15,000 – ₹3,30,000 = ₹15,000 (A)

☞

Fixed Overhead Volume Variance ***does not*** arise in a Marginal Costing system

SECTION - C

Interpretation of Variances

Problem-1

Natural Spices manufactures and distributes high-quality spices to gourmet food shops and top quality restaurants. Gourmet and high-end restaurants pride themselves on using the freshest, highest-quality ingredients.

Natural Spices has set up five state of the art plants for meeting the ever growing demand. The firm procures raw material directly from the centers of produce to maintain uniform taste and quality. The raw material is first cleaned, dried and tested with the help of special machines. It is then carefully grounded into the finished product passing through various stages and packaged at the firm's ultraclean factory before being dispatched to customers.

The following variances pertain to last week of operations, arose as a consequence of management's decision to lower prices to increase volume.

Sales Volume Variance	*18,000 (F)*
Sales Price Variance	*14,000 (A)*
Purchase Price Variance	*10,000 (F)*
Labour Efficiency Variance	*11,200 (F)*
Fixed Cost Expenditure Variance	*4,400 (F)*

Required

(i) *Identify the 'Critical Success Factors' for Natural Spices.*

(ii) *Evaluate the management's decision with the 'Overall Corporate Strategy' and 'Critical Success Factors'.*

Solution

(i) Gourmet and high-end restaurants recognises Natural Spices on the basis of its *high quality* of spices. Therefore, quality is most critical success factor of Natural Spices. There are other factors which cannot be ignore such as price, delivery options, attractive packing etc. But all are secondary to the quality.

(ii) Deliberate action of cutting price to increase sales volume indicates that firm is intending to expand its market to retail market and street shops which is price sensitive.

Purchase Price Variance is clearly indicating that firm has purchased raw material at lower price which may be due to buying of lower quality of material. Similarly positive *Efficiency Variance* is indicating cost cutting and stretching resources.

It appears that firm is intending to expand its market to retail market and street shops by not only reducing the price but also compromising its quality which is opposing its current strategy of *high quality*.

Management should monitor the trends of variances on regular basis and take appropriate action in case of evidence of permanent decline in quality. Here, customer feedback is also very important.

6 Costing of Service Sector

Basic Concepts

Costing of Service Sector	This is a method of ascertaining costs of providing or operating a service. This method of costing is applied by those undertakings which provide services rather than production of commodities.
Costing Methods Used in Service Sector	Costing Methods used in Service Sector are: (i) Job Costing Method (ii) Process Costing Method (iii) Hybrid Costing Method
Customer Costing in Service Sector	The central theme of this approach is customer satisfaction. For customer costing purpose, the costs are divided into following categories. These are: (i) Customer Specific Costs (ii) Customer-Line Categories (iii) Company Costs
Job Costing in Service Sector	The two significant costs which are incurred in Service Sectors are: (i) Direct Labour (ii) Service Overheads
Process Costing in Service Sector	In this method the cost of service is obtained by assigning costs to masses of similar units and then computing unit cost on an average basis.
Hybrid Costing in Service Sector	This method of service costing combines elements of both Job Costing and Process Costing method.

SECTION - A

Method/ Characteristics

Question-1

Discuss briefly any two methods of costing in the service sector and give examples.

Answer

Methods of Costing in the service sector are as follows:

(i) **Job costing method**: In job costing method the cost of a particular service is obtained by assigning costs to a distinct identifiable service. In service sector like Accounting firm, Advertising campaigns etc. job costing method is used. For assigning indirect costs (overheads) models such as Activity Based Costing may be used.

(ii) **Process costing method:** In process costing system the cost of a service is obtained by assigning costs to masses of similar unit and then computing unit cost on an average basis. Retail banking, Postal delivery, Credit card etc. uses process costing method.

(iii) **Hybrid costing method:** Many companies uses a method of costing which is neither job costing nor process costing method. They in fact uses a hybrid costing method which combines elements of both job costing and process costing methods.

Question-2

Explain the main characteristics of Service sector costing.

Answer

Main Characteristics of Service Sector are as below:

(i) **Activities are Labour Intensive:** The activities of service sector generally are labour intensive. The direct material cost is either small or non-existent.

(ii) **Cost-unit is usually *difficult to define*:** The selection of cost units usually, for service sector is difficult to ascertain as compared to the selection of cost unit for manufacturing sector. The following table provides some examples of the cost units for service sector.

- Hospital – Patient Per Day, Room Per Day
- Accounting Firm – Charged Out Client Hours

- Transport – Passenger Km., Tonne-Km.
- Machine Maintenance – Maintenance Hours *provided to user department*
- Computer Department – Computer Time *provided to user department*

(iii) **Product Costs in Service Sector:** Costs are classified as product or period costs in manufacturing sector for various reasons viz.

- To determine the unit manufacturing costs so that inventories can be valued and the selling prices be determined & verified.
- To report production costs on income statement.
- To analyse costs for control purposes.

The only difference between manufacturing and service sector is that in service sector there is no physical product that can be stored, assembled and valued.

Question-3

State the unique characteristics features which are to be taken into consideration in measurement of performance in service sector.

Answer

The unique characteristic features in performance measurement in service sector are:

(i) Most services are intangible.

(ii) Service outputs vary from day to day.

(iii) The production and consumption of many services are inseparable.

(iv) Services are perishable and cannot be stored.

Question-4

"Customer profile is important in charging cost." Explain this statement in the light of customer costing in service sector.

Answer

Customer Costing in the Service Sector: The customer costing is a new approach to management. The central theme of this approach is customer satisfaction. In some service industries, such as public relations, the specific output of industry may be difficult to identify and even more difficult to quantify. Further there are multiple customers, identifying support activities i.e. common costs with particular customer may be more problematic. In such cases it is important to cost customer. An ABC analysis of customers profitability provides valuable information to help management in pricing customer. Consider a banking sector. A bank's activities for customer will include the following types of activities. These are:

(i) Stopping a Cheque

(ii) Withdrawal of Cash

(iii) Updation of Pass Book

(iv) Issue of Duplicate Pass Book

(v) Returning a Cheque because of Insufficient Funds

(vi) Clearing of a Customer Cheque

Different customers or categories of customers use different amount of these activities and so customer profiles can be built up and customer can be charged according to the cost to serve them.

Customer profile is important in analyzing cost under the following categories-

(i) **Customer Specific Costs:** These are the direct and indirect cost of providing service to customer plus customer related cost assigned to each customer. For example: cost of express courier service to a client who requests over-night delivery of some agreement.

(ii) **Customer – Line Categories:** These are the costs which are broken into broad categories of customers and not individual customers.

(iii) **Company Costs:** These are those costs which are not allocated to either customer line or individual customers but charge to company. The example is the cost of advertisement to promote sale of service.

SECTION - B

Utility Service Agency

Problem-1

A public company responsible for the supply of domestic gas has been approached by several prospective customers in a rural area adjacent to a high-pressure main. As a condition of its license to operate as a utility, the company is obliged to respond positively to current needs provided the financial viability of the company is not put at risk. New customers are charged ₹ 250 each for connection to the system.

Once a meter is installed, a standing charge of ₹ 10 per quarter is billed. Charges for gas are levied at ₹ 400 per 1,000 metered units.

A postal survey of the area containing, according to the rating authority, 5,000 domestic units, elicited a 40% response rate. 95% of those who responded confirmed that they wished to become gas users and expressed their willingness to pay the connection charge.

Although it is recognized that a small percentage of those willing to pay for connection may not actually choose to use gas, it is expected that the average household will burn 50 metered units per month. There will be some seasonal differences.

The company's marginal cost of capital is 17% pa and supplies of bulk gas cost the company ₹ 0.065 per metered unit.

Required

Determine what the maximum capital project cost can be to allow the company to provide the service required if wastage of 15% has to be allowed.

Solution

Working Notes

1.	No. of Customer	=	1,900 (5,000 × 40% × 95%)
2.	Consumption of Gas	=	11,40,000 Metered units (1,900 × 50 mt.× 12 months)
	Gas Supply	=	13,41,176 Metered units {11,40,000 × (100 ÷ 85)}

3. Cash Inflow

	(₹)
Rent (1,900 × 4 Quarters × ₹10)	76,000
Add: Consumption Charge (11,40,000 × ₹0.4)	4,56,000
Less: Cost of Company (13,41,176 × ₹0.065)	87,176
Cash Inflow p.a.	4,44,824

One Time Connection Charge = ₹4,75,000
(₹250 × 1,900 customers)

Maximum Capital Project Cost

(Can be to allow the company to provide the service required)

By Following the Concept of Perpetuity

(Investment − ₹4,75,000) × 17% = ₹4,44,824

∴ Investment = ₹30,91,612

Road Transport

Problem-2

A company presently brings coal to its factory from a nearby yard and the rate paid for transportation of coal from the yard located 6 km away to factory is ₹ 50 per tonne. The total coal to be handled in a month is 24,000 tonne.

The Company is considering proposal to buy its own truck and has the option of buying either a 10 tonne capacity or a 8 tonne capacity truck.

The following information is available:

	10 Tonne Truck	***8 Tonne Truck***
Purchase Price (₹)	*10,00,000*	*8,50,000*
Life (Year)	*5*	*5*
Scrap Value at the end of 5th year	*Nil*	*Nil*
K.M. per litre of Diesel	*3*	*4*
Repair / Maintenance per Truck p.a. (₹)	*60,000*	*48,000*
Other Fixed Expenses p.a. (₹)	*60,000*	*36,000*
Lubricants & Sundries per 100 km (₹)	*20*	*20*

Each truck will daily make 5 trips (to and fro) on an average for 24 days in a month.

Cost of Diesel ₹ 15 per litre.

Salary of Drivers ₹ 3,000 per month – Two Drivers will be required for a Truck.

Other staff expenses ₹ 1,08,000 p.a.

Required

Present a comparative Cost Sheet on the basis of above data showing transport cost per tonne of operating 10 and 8 Truck at full capacity utilisation.

Solution

Comparative Statement of Cost Sheet

(Showing Transport Cost *per tonne* of Operating 10 tonne and 8 tonne Trucks at Full Capacity)

	10 Tonne Truck (₹)	**8 Tonne Truck (₹)**
Fixed Charges (p.m.):		
Drivers' Salary (W.N.-1)	1,20,000 (40 × ₹3,000)	1,50,000 (50 × ₹3,000)
Staff Expenses	9,000	9,000
Other Fixed Expenses	5,000	3,000
Operating & Maintenance Charges (p.m.):		
Depreciation (W.N.-2)	3,33,333	3,54,167
Diesel Cost (W.N.-3)	1,44,000 (9,600 litres × ₹15)	1,35,000 (9,000 litres × ₹15)
Lubricants & Sundries (W.N.-3)	5,760 (28,800 / 100 × ₹20)	7,200 (36,000 / 100 × ₹20)
Repairs & Maintenance	1,00,000 (20 trucks × ₹5,000)	1,00,000 (25 trucks × ₹4,000)
Total Cost	7,17,093	7,58,367
Tonnage Carried	24,000	24,000
Cost per Tonne	29.88	31.60

Conclusion

A comparison of Cost *per tonne* by using 10 tonne trucks is most economical. The Cost paid for bringing Coal *per tonne* presently viz. ₹ 50/- is very high.

Working Notes

Capacity of Trucks	**10 tonne**	**8 tonne**
W.N.-1 **Total Number of Trucks & Drivers Required**		
Total Effective Trips *per day* ...(A)	5	5
No. of Working Days *per month* ...(B)	24	24
Total Effective Trips *per month* ...(C) = (A) × (B)	120	120
Coal Brought to the Factory *per truck per month* (tonnes)	1,200	960
No. of Trucks Required	20 (24,000 / 1,200)	25 (24,000 / 960)
To Handle 24,000 tonne of Coal [Total Number of Drivers Required (2 Drivers *per truck*)]	40	50
W.N.-2 **Total Monthly Depreciation**		
No. of Trucks ...(A)	20	25
Depreciation *per truck* (p.a.) (₹)	2,00,000	1,70,000
Depreciation *per truck* (p.m.) (₹) ...(B)	16,666.66	14,166.66
Total Monthly Depreciation ...(A) × (B)	3,33,333	3,54,167
W.N.-3 **Diesel Required**		
Total km. run *per truck* (p.m.) (6 KM × 10 Trips × 24 Days)	1,440	1,440
Total km. run by all trucks (p.m.)	28,800 (1,440 km × 20 trucks)	36,000 (1,440 km × 25 trucks)
K.M. *per litre* of Diesel	3	4
Diesel Required (litres)	9,600 (28,800 / 3 km)	9,000 (36,000 km / 4 km)

Problem-3

Expert Roadways Services Pvt. Ltd. is planning to run a fleet of 15 buses in Birpur City on a fixed route. Company has estimated a total of 2,51,85,000 passenger kilometers per annum. It is estimated buses to have 100% load factor. Buses are purchased at a price of ₹ 44,00,000 per unit whose scrape value at the end of 5 years life is ₹ 5,50,000. Seating capacity of a bus excluding a Driver's seat is 42. Each bus can give a mileage of 5 kmpl. Average cost of fuel is ₹ 66 per liter. Cost of Lubricants & Sundries per 1,000 km would be ₹ 3,300. Company will pay ₹ 27,500 per month to Driver and two attendants for each bus.

Other annual charges per bus: Insurance ₹ 55,000, Garage Charges ₹ 33,000, Repairs & Maintenance ₹ 55,000. Route Permit Charges upto 20,000 km is ₹ 5,500 and ₹ 2,200 for every additional 5,000 km or part thereof.

Required

(i) Calculate a suggested fare per passenger/km taking into account markup on cost @20% to cover general overheads and sufficient profit.

(ii) The Transport Sector of Birpur is highly regulated. The Government has fixed the fare @ ₹ 1.35 for next 2 years. Comment on the two year's profitability taking into consideration the inflation rate of 8%.

Note: Route permit charges is not subject to Inflation.

Solution

(i) Statement Suggesting "Fare *per passenger – km* (Each Bus)"

Particulars	**Cost per annum (₹)**
Fixed Expenses:	
Insurance	55,000.00
Garage Charges	33,000.00
Depreciation	7,70,000.00
Running Expenses:	
Repair and Maintenance	55,000.00
Cost of Lubricants and Sundries	1,38,517.50
Fuel Cost	5,54,070.00
Salary of Driver and Two Attendants	3,30,000.00
Route Permit Charges	16,500.00
Total Cost *per annum*	19,52,087.50
Add: Markup @ 20% of Total Cost or 16.67% of Total Revenue	3,90,417.50
Total Revenue	23,42,505.00

Rate *per passenger- km* equals to ₹1.395

Workings

Total Passenger Kms	=	2,51,85,000
Total Buses	=	15
Passenger Kms*per bus*	=	16,79,000 (2,51,85,000 Kms / 15)
Total Passenger Capacity *per bus*	=	42 – 2
	=	40
Annual Distance Covered *by a bus*	=	41,975 Kms. (16,79,000Kms/ 40)

(ii) Regulated Fare *per passenger km* is ₹1.35

Profitability Statement for *Each Bus*

Particulars		Year 1 (₹)	Year 2 (₹)
Fixed Expenses:			
Insurance		59,400.00	64,152.00
Garage Charges		35,640.00	38,491.20
Depreciation		7,70,000.00	7,70,000.00
Running Expenses:			
Repair and Maintenance		59,400.00	64,152.00
Cost of Lubricants and Sundries		1,49,598.90	1,61,566.81
Fuel Cost		5,98,395.60	6,46,267.25
Salary of Driver and Two Attendants		3,56,400.00	3,84,912.00
Route Permit Charges		16,500.00	16,500.00
Total Cost	[A]	20,45,334.50	21,46,041.26
Total Revenue (Regulated)	[B]	22,66,650.00	22,66,650.00
Profit	[B] – [A]	2,21,315.50	1,20,608.74
Profit to Total Revenue		9.76%	5.32%

The gross margin is showing a downward trend because the cost components have taken into the effect of inflation hence increasing year by year but the total revenue has remained stagnant due to Government regulations which resulted in reduction in gross margin per bus.

The company's gross margin to total revenue ratio has come out to be 9.76% and 5.32% in first and second year respectively but initially the company's desired gross margin to total revenue ratio is 16.67% to cover general overheads and sufficient profit. Though the amount of general overheads is not given but we can safely assume that they may also subject to inflation i.e. increase year by year then in such case the company needs to maintain or increase its gross margin per bus to maintain its net profit after general overheads which is not possible in regulated environment. The information about regulated fare in the given case is regarding first two years only but if this regulated fare scenario persists for further years then the project may not be viable for the company.

Air Transport

Problem-4

Modern Airways owns a single jet aircraft and operates between EXETOWN and WYETOWN. Flights leave EXETOWN on Mondays and Thursdays and depart from WYETOWN on Wednesdays and Saturdays. Modern Airways cannot afford any more fights between EXETOWN and WYETOWN. Only tourist class seats are available on its flights. An analyst has collected the following information:

Seating capacity per plane……………………………………………..360

Average passengers per flight……………………………………………200

Flights per week…………………………………………………………… 4

Flights per year……………………………………………………………..208

Average one-way fare……………………………………………………..₹ 5,000

Variable fuel costs…………………………………………………………₹ 1,40,000 per flight

Food service to passengers (not charged to passengers)……………₹ 200 per passenger

Commission paid to travel agents paid by Modern Airways…………8% of fare on each ticket booked on Modern Airways.

(Assume that all Modern Airways tickets are booked by travel agents)

Fixed annual lease costs allocated to each flight………………………₹ 5,30,000 per flight

Fixed ground services (maintenance, check-in, Baggage handling) costs allocated to each flight………………………₹ 70,000 per flight

Fixed salaries of flight crew allocated to each flight……………………₹ 40,000 per flight

For the sake of simplicity, assume that fuel costs are unaffected by the actual number of passengers on a flight.

Required

(a) What is the operating income that Modern Airways makes on each one way flight between EXETOWN and WYETOWN?

(b) *The market research department of Modern Airways indicates that lowering the average one way fare to ₹ 4,800 will increase the average number of passengers per flight to 212. Should Modern Airways lower its fare?*

(c) *Zed Tours and Travels, a tour operator, approaches Modern Airways to charter its jet aircraft twice each month, first to take Zed's international tourists from EXETOWN to WYETOWN and then bring the tourists back from WYETOWN to EXETOWN. If Modern Airways accepts the after, it will be able to offer only 184 (208 minus 24) of its own flights each year. The terms of the charter are :*

   (i) *For each one-way flight Zed will pay Modern ₹7,50,000 to charter the plane and to use its flight crew and ground service staff.*

   (ii) *Zed will pay for fuel costs.*

   (iii) *Zed will pay for all food costs.*

On purely financial considerations, should Modern Airways accept the offer from Zed Tours and Travels? What other considerations should Modern Airways consider in deciding whether or not to charter its plane to Zed Tours and Travels?

Solution

(a) Statement of "Operating Income of Modern Airways"

[Operating between EXETOWN and WYETOWN (on each one way flight)]

	(₹)
Fare Received *per flight* (200 Passengers × ₹5,000)	10,00,000
Less: Variable Costs *per flight*	
Commission Paid (₹10,00,000 × 8%)	80,000
Food Services (200 Passengers × ₹200)	40,000
Fuel Costs	1,40,000
Contribution *per flight*	7,40,000
Less: Fixed Costs *per flight*	
Fixed Annual Lease Costs	5,30,000
Baggage Handling (Fixed Ground Services Costs)	70,000
Fixed Salaries of Flight Crew	40,000
Operating Income *per flight*	1,00,000

(b) Should Modern Airways Lower Its Fare?

	(₹)
Fare Received *per flight* (212 Passengers × ₹4,800)	10,17,600
Less: Variable Costs *per flight*	
Commission (₹10,17,600 × 8%)	81,408
Food Services (212 Passengers × ₹200)	42,400
Fuel Costs	1,40,000
Contribution *per flight*	7,53,792

Modern Airways *should lower its fare* as it would *increase its contribution towards profit* by ₹13,792 *per flight* (₹7,53,792 − ₹ 7,40,000).

(c) Financial consideration of Modern Airways to Charter its plane to Zed Tours and Travel should use option (b) and not (a).

Under option (b) Modern Airways Receives Contribution *per flight*: ₹7,53,792

Modern Airways would get *per flight,* If it charters the plane: ₹7,50,000

A comparison of the above data clearly shows that the Modern Airways would be financially better off by not chartering the plane.

Other consideration with regard to chartering a plane to Zed Tours and Travels-

(i) The loss of contribution involved in chartering a plane is ₹ 3,792 (per flight). This loss is on a lower side as compared with uncertainties about the number of passengers on scheduled flights.

(ii) Modern Airways passengers may be inconvenienced when a plane is chartered to Zed Tour and Travel. They may go to other airlines.

(iii) The relationship between the two parties is important. If it is not a long term arrangement, Modern Airways may lose.

Problem-5

Flyway Ltd. has hired an aircraft to specially operate between cities A and B. All the seats are economy class.

The following information is available:

Seating capacity of the aircraft……………………………………260 passengers

Average number of passengers per flight……………………….240 passengers

Average one-way fare from A to B…………………………………₹ 5,000 per passenger

Fuel costs per flight from A to B……………………………………₹ 90,000

Food cost (A to B sector)..₹ 300 per passenger

(no charge to passenger)

Commission to travel agents...10% of the fare

(All tickets are through agents)

Annual lease costs allocated to each flight..........................₹ 2,00,000

Ground services, baggage handling/checking in

service costs per flight A to B..₹ 40,000

Flight crew salaries per flight A to B...................................₹ 48,000

There .is an offer from another airlines operator, Haltgo Ltd. for a stop-over at destination D, which is on the way from A to B. Due to this, the flight will operate from A to D, then from D to B.

The following terms are considered for the stop-over:

50 seats from D to B will be booked by Haltgo at ₹ 2,700 per ticket, whether or not Haltgo is able to sell them to its customers. No agents' commission is payable on these tickets. However, Snacks must be provided to these passengers also by Flyway Ltd. at no further charge to Haltgo or the passengers.

A maximum of 60 tickets can be sold by Flyway's travel agents for the A to D sector at a fare of ₹ 3,000 per passenger.

Since the stop-over wastes more time, 25 of Flyway's original passengers in the A to B sector will voluntarily drop out in favour of other airlines offering direct flights between A and B.

Due to the stop-over fuel costs will increase from ₹ 90,000 to ₹ 1,35,000. Additional airport landing / baggage handling charges of ₹ 19,000 per stop-over will have to be incurred by Flyway Ltd.

Flyway Ltd. will have to serve snacks to all the passengers in the D to B sector, at no charge to passengers. Each snack will cost Flyway ₹ 200. This will be in addition to the original food at ₹ 300 served in the A to D sector.

You may assume that fuel costs are not affected by the actual number of passengers in the flight, ignore non-financial considerations, additional wear and tear to aircraft due to extra landing/take-off.

Required

Without considering Haltgo's offer,

(i) What is the profit earned by Flyway Ltd. per flight from A to B?

(ii) What is the Break-even number of passengers for each flight from A to B?

Considering the effects of Haltgo's offer,

(iii) Evaluate whether Flyway should accept the offer.

(A detailed profitability statement is not essential. Only figures relevant for the cost-revenue analysis are required.)

Solution

Statement Showing "Allocation of Seats in the Aircraft"

Existing Situation	
For Destination A to B	
Seating Capacity of the Aircraft	260 Passengers
Average Number of Passengers *per flight*	240 Passengers
Proposed Situation	
For Destination D to B	
Seats Booked by Haltgo Ltd.	50 Seats
For Destination A to B	
Seats Available {260 (capacity) − 50 (booked by Haltgo Ltd. for destination D to B)}	210 Seats
Requirement of Regular Passengers {240 (original no. of passengers) − 25 (no. of passengers drop out due to wastage of time)}	215 Seats
Possible Allocation of Seats to Regular Passengers	210 Seats
For Destination A to D	
Seats Available {260 (capacity) − 210 (seats allocated to regular passengers of destination A to B)}	50 Seats
Requirement of Agents (tickets can be sold by Flyway's travel agents)	60 Seats
Possible Allocation to Agents of Flyway Ltd.	50 Seats

Existing Situation

Profit per Flight

	(₹)	(₹)
Revenue *per passenger* (Gross Fare)		5,000
Less: Total Variable Cost *per passenger:*		
10% Commission on Fare	500	
Food	300	800
Contribution *per passenger*		4,200
Contribution *per flight* (Contribution for 240 Passengers)		10,08,000
Less: Fixed Costs *per flight*		
Fuel Cost	90,000	
Annual Lease Cost	2,00,000	
Ground Service, Baggage Handling / Checking in	40,000	
Flight Crew Salaries	48,000	3,78,000
Profit *per flight*		6,30,000

Break-even Point

Break-even Number of Passengers@ $\left(\frac{₹3,78,000}{₹4,200}\right)$	90 Passengers

@ $\text{Break-even Number of Passengers} = \frac{\text{Total Fixed Cost per Flight}}{\text{Contribution per Passenger}}$

Proposed Situation

Contribution per Passenger (A to D)

	(₹)	(₹)
Revenue *per passenger* (Gross Fare)		3,000
Less: Total Variable Cost *per passenger:*		
10% Commission on Fare	300	
Food#	300	600
Contribution *per passenger*		2,400

Statement Showing "Additional Revenue / Expenditure from Haltogo Ltd.'s Offer"

	Additional	
	Cost (₹)	**Revenue (₹)**
Revenue from Destination D to B (50 Seats × ₹2,700)		1,35,000
Contribution from Destination A to D (50 Seats × ₹2,400)		1,20,000
Contribution Lost for Destination A to B (30 Seats* × ₹4,200)	1,26,000	
Snacks (260 Passengers × ₹200)	52,000	
Fuel Cost	45,000	
Airport Landing / Baggage Handling Charges	19,000	
Total	**2,42,000**	**2,55,000**

* *240 Seats (existing) Less 210 Seats (proposed)*

All the passengers booked for destination A to D are also served food free of cost

Flyway Ltd. will gain ₹13,000 (₹2,55,000 – ₹2,42,000) per flight if it accepts Haltgo's offer.

Decision

Accept Haltgo's offer

Travel Agency

Problem-6

Vikas Travel Agency (VTA) specializes in flights between Delhi to Bangalore. It books passengers on Dolphin Airlines at ₹ 9,000 per round-trip ticket. Until last month, Dolphin paid VTA a commission of 10% of the ticket price paid by each passenger. This commission was VTA's only source of revenues. VTA's fixed costs are ₹ 1,40,000 per month (for salaries, rent and so on) and its variable costs are ₹ 200 per ticket purchased for a passenger. This ₹ 200 includes ₹ 150 per ticket delivery fee paid to Senti Express. (₹ 150 delivery fee applies to each ticket).

Dolphin Airlines has just announced a revised payment schedule for travel agents. It will now pay travel agents a 10% commission per ticket up to a maximum of ₹ 500. Any ticket costing more than ₹ 5,000 generates only a ₹ 500 commission, regardless of the ticket price.

Required

(i) Under the old 10% commission structure, how many round-trip tickets must VTA's sell each month (a) to break-even and (b) to earn an operating income of ₹ 70,000.

(ii) *How does Dolphin revised payment schedule affect your answers to (a) and (b) in requirement (i)?*

Solution

(i) VTA receives a 10% Commission *on each ticket* = ₹900 (10% × ₹9,000)

Commission *per ticket* = ₹900

Variable Cost *per ticket* = ₹200

Contribution *per ticket* = ₹900 − ₹200 = ₹700

Fixed Costs = ₹1,40,000 *per month*

(a) Break-even Number of Tickets

$$= \frac{\text{Fixed Costs}}{\text{Contribution } \textit{per ticket}}$$

$$= \frac{₹1,40,000}{₹700 \textit{ per ticket}}$$

= 200 tickets

(b) When Target Operating Income = ₹70,000 *per month*

Quantity of Tickets *required to be sold*

$$= \frac{\text{Fixed Costs} + \text{Target Operating Income}}{\text{Contribution } \textit{per unit}}$$

$$= \frac{₹1,40,000 + ₹70,000}{₹700 \textit{ per ticket}}$$

$$= \frac{₹2,10,000}{₹700}$$

= 300 tickets

(ii) Under the New System, VTA would receive only ₹500 on the ₹ 9,000 *per ticket*. Thus,

Commission *per ticket* = ₹500

Variable Cost *per ticket* = ₹200

Contribution *per ticket* = ₹500 − ₹200 = ₹300

Fixed Costs = ₹1,40,000 *per month*

Break-even Number of Tickets

$$= \frac{₹1,40,000}{₹300}$$

= 467 tickets (rounded up)

Quantity of Tickets *required to be sold* $= \dfrac{₹\,2,10,000}{₹\,300}$

= 700 tickets

The ₹500 cap on the Commission *paid per ticket* causes the Break-even Point to more than double (from 200 to 467 tickets) and

The Tickets *required to be sold* to earn ₹70,000 per month to also more than double (from 300 to 700 tickets).

As would be expected, travel agents will react *very negatively* to the Dolphin Airlines decision to change commission payments.

Hotels / Lodges

Problem-7

A Hotel having 50 single rooms is having 80% occupancy in normal season (8 months) and 50% in off- season (4 months) in a year (take 30 days month).

Annual Fixed Expenses	*(₹ Lakh)*
Salary of the Staff (excluding Room Attendant)	*7.50*
Repair & Maintenance	*2.60*
Depreciation on Building & Furniture	*2.40*
Other Fixed Expenses like Dusting, Sweeping etc	*3.25*
Total	*15.75*

Variable Expenses (per Guest per Day)	
Linen, Laundry & Security Support	*₹ 30.00*
Electricity & Other Facilities	*₹ 20.00*
Misc Expenses like Attendant etc	*₹ 25.00*

Management wishes to make a Margin of 25% of Total Cost.

Required

(a) *Calculate the Tariff Rate per Room.*

(b) *Calculate the Break Even Occupancy in Normal Season assuming 50% Occupancy is Off-Season.*

(c) *Management is proposing 10% cut in Tariff to improve Occupancy at 100% and 70% in Normal Season and Off-Season respectively. Give your views on it.*

(d) *What is the minimum rise in Occupancy % to take care of risk of fall in Profit due to Tariff-Cut?*

Solution

(a)	Variable Cost *per Room-Day*	=	₹75 (₹30 + ₹20 + ₹25)
	Total Occupancy	=	12,600 Room-Days (50 × 30 × 8 × 0.8 + 50 × 30 × 4 × 0.5)
	Total Variable Cost	=	₹9.45 lakhs (12,600 Room-Days × ₹75)
	Fixed Cost	=	₹15.75 lakhs
	Total Cost	=	₹25.20 lakhs (₹9.45 lakhs + ₹15.75 lakhs)
	Profit (25% of Total Cost)	=	₹6.30 lakhs (25% of ₹25.20 lakhs)
	Tariff *per Day*	=	₹250.00 [(₹25, 20,000 + ₹6,30,000) / 12,600 Room-Days]
(b)	Contribution *per Day*	=	₹175.00 (₹250 − ₹75)
	BEP (Room–Day)	=	9,000 Room-Days (₹15,75,000 / ₹175)
	During Off Season *for 4 months*		
	Rooms Occupied	=	3,000 Days (50 × 30 × 4 × 0.5)
	For BEP,		
	Occupancy During Normal Period	=	6,000 Days i.e. Occupancy 50%
(c)	If 10% Discount is allowed,		
	Tariff	=	₹225 *per Room-Day*
	Contribution per Room-Day (with tariff cut)	=	₹150 (₹225 − ₹75)
	Total Occupancy	=	16,200 Room-Days (50 × 30 × 8) + (50 × 30 × 4 × 0.7)
	Total Contribution *for the year*	=	₹24.30 lakhs (16,200 Room-Days × ₹150)
	Fixed Cost (unchanged)	=	₹15.75 lakhs
	Profit	=	₹8.55 lakhs

As the Proposal increases the Profit, it may be accepted.

(d) To maintain the Same Profit,

Contribution Required	=	₹22.05 lakhs
With New Tariff,		
Contribution *per day*	=	₹150
Number of Room-Days Occupied	=	14,700 Room-Days (₹22,05,000 / 150)
Increase % in Occ. Required	=	16.67 % [(14,700 – 12,600) / 12,600]

Problem-8

The manager of a hotel providing lodging facilities wants to expand his services to include manual booking (reservation or cancellation) of railway tickets for his clients. He does not want to have electronic booking due to operational difficulty. He has the following information:

	₹ per month
Proportion of rent allocated for office space	*4,000*
General telephone expenses allocated to this service	*2,400*
Proportion of security charges / maintenance expenses allocated	*1,600*
Salary to person exclusively doing the booking of tickets	*20,000*
Mobile phone charges exclusive to person booking ticket	*3,000*
Share of general miscellaneous fixed expense allocated	*1,000*
Conveyance incurred to book tickets *(To and fro charges to the nearest booking station) (Fixed per month)*	*4,000*

The manager estimates that there will be 2,500 booking per month for 3 months of peak season. 1,000 bookings per month for 2 months of moderate business and 700 bookings per month during the remaining period. He cannot charge more than prevailing rate of ₹ 30 per booking charged by other agents.

Required

(i) *Calculate the total cost per booking.*

(ii) *What is the estimated profit the manger hopes to achieve for the full year?*

(iii) *What should be the average minimum volume to justify the setting up of the new service?*

Solution

(i) Calculation of Total Cost *per booking*

Costs Specific *to booking operations*:		
Direct Person's Salary	20,000	
Mobile Expenses	3,000	
Conveyance	4,000	27,000
Share of Other Overheads:		
Office Space	4,000	
General Telephone	2,400	
Security / Maintenance	1,600	
Miscellaneous Expenses	1,000	9,000
Total Cost Allocated *to the service*		36,000

Average Demand *per month* $\left(\frac{2{,}500 \times 3 + 1{,}000 \times 2 + 700 \times 7}{12}\right)$ = 1,200

Total Cost *per booking* $\left(\frac{\text{Total Cost } per\ month}{\text{Average Bookings } per\ month}\right)$ = $\frac{₹36{,}000}{1{,}200}$

= ₹30

(ii) Estimated Profit *to be achieved in full year*

Revenue *per ticket* = ₹30

Total Revenue *Less* Total Cost (₹30 – ₹30) = ₹0

(Assuming that other Overheads will anyway exist even if the Service is not provided, the manager can hope to achieve a Profit)

Revenue (₹30 × 1,200) = ₹36,000

Less: Variable Cost = ₹27,000

Profit = ₹9,000

(iii) Average Minimum Volume to Justify the Setting-up of New Services

Minimum Average Volume to Setup the Service will be the amount needed to recover the Specific Costs of this Service, is ₹27,000 *per month*.

Minimum Average Books = ₹27,000 ÷ ₹30

= 900 Bookings

Problem-9

Kangan Resorts operates a lodging house with attached facilities of a shopping arcade and restaurant on a National Highway. The following details are available.

(i) The lodging house has 40 twin-bedded rooms, which are to be rented for ₹ 200 per night on double occupancy basis. The occupancy ratio is expected at 85% and always both the beds in the room will be occupied. The lodging facilities are operated, for 200 days in the year during foreign tourists season time only.

(ii) As per past record the spending pattern of each tourist staying in the lodge will be as under:

₹ 50 per day in the shopping arcade and ₹ 80 per day in the restaurant.

(iii) Ratios of variable cost to respective sales volume are:

Shops	*Restaurant*
50%	*60%*

(iv) For the lodging house the variable cost on house-keeping and electricity will amount ₹ 30 per day per occupied room.

(v) Annual fixed overhead for the entire complex is estimated at ₹ 10,00,000.

Required

(i) Prepare an income statement for the next year.

(ii) The Lodging House Manager suggests a proposal of reducing room rent to ₹ 150 per day on double occupancy basis, which will increase occupancy level to 95%. Should the proposal be accepted or not?

Solution

(i) Income Statement of Kangan Resort *for the next year*

	(₹)
Sales Revenue	
Lodging House Room Receipts (40 Rooms × 200 Days × ₹200 × 85%)	13,60,000
Shopping Arcade (40 Rooms × 2 Persons × 200 Days × ₹50 × 85%)	6,80,000
Restaurant (40 Rooms × 2 Persons × 200 Days × ₹80 × 85%)	10,88,000
Less: Variable Cost	
Lodging House Rooms (40 Rooms × 200 Days × ₹ 30 × 85%)	2,04,000
Shopping Arcade (50% of ₹6,80,000)	3,40,000
Restaurant (60% of ₹10,88,000)	6,52,800

Contribution	19,31,200
Less: Fixed Cost	10,00,000
Profit (Estimated)	9,31,200

(ii) Income Statement on the Basis of Reduced Room Rent

	(₹)
Sales Revenue	
Lodging House Room Receipts (40 Rooms × 200 Days × ₹150 × 95%)	11,40,000
Shopping Arcade (40 Rooms × 2 Persons × 200 Days × ₹50 × 95%)	7,60,000
Restaurant (40 Rooms × 2 Persons × 200 Days × ₹80 × 95%)	12,16,000
Less: Variable Cost	
Lodging House Rooms (40 Rooms × 200 Days × ₹30 × 95%)	2,28,000
Shopping Arcade (50% of ₹7,60,000)	3,80,000
Restaurant (60% of ₹12,16,000)	7,29,600
Contribution	17,78,400
Less: Fixed Cost	10,00,000
Profit (Estimated)	7,78,400

The Profitability *decreases by* ₹1,52,800 (₹9,31,200 – ₹7,78,400). Hence reducing Room Rent Proposal *may not be accepted.*

Problem-10

XY Hotel has 40 bed rooms with a maximum occupancy of 490 sleeper nights per week. Average occupancy is 60% throughout the year. Meals provided to guests have been costed and the average food cost per person per day is as follows:

	(₹)
Breakfast…………………………..	*72.00*
Lunch…………………………….....	*220.00*
Dinner…………………………….	*268.00*
	560.00

Direct wages and staff meals per week are as under:

	(₹)
Housekeeping…………………	*39,040.00*
Restaurant and Kitchen………	*68,600.00*
General…………………………	*35,200.00*

Direct expenses per annum are ₹ 9,15,200 for house -keeping and ₹ 10,40,000 for restaurant. Indirect expenses amount to ₹ 68,22,400, which should be apportioned on the basis of floor area. The floor areas are as follows:

	Sq. Mt.
Bed Rooms.........................	*3,600*
Restaurant..........................	*1,200*
Service Area.......................	*600*

A net profit of 10% must be made on the restaurant taking and also on accommodation takings.

Required

Calculate what inclusive term per person should be charged per day and also show the split between meals and accommodation charges.

Solution

Statement Showing "Charges *per person per day*"

Particulars	Total (₹)	House keeping (₹)	Restaurant (₹)	General & Services (₹)
Direct Wages and Staff Meal *per week*	1,42,840	39,040	68,600	35,200
Other Direct Expenses *per week* [₹9,15,200/52; ₹10,40,000/52]	37,600	17,600	20,000	---
Sub Total − Direct Expenses	1,80,440	56,640	88,600	35,200
Direct Expenses *per week* (General)* [39,040:68,600]	---	12,767	22,433	(35,200)
Indirect Expenses *per week* (Based on floor area) [3,600:1,200]	1,31,200	98,400	32,800	---
Total	3,11,640	1,67,807	1,43,833	---

Average Occupancy (490 × 60% = 294 Sleeper Nights *per week*)

Particulars	Total (₹)	House keeping (₹)	Restaurant (₹)
Cost *per person per day* [₹1,67,807/294; ₹1,43,833/294]	1,060.00	570.77	489.23

Food Cost *per person per day*	560.00	---	560.00
Total Cost per person per day	1,620.00	570.77	1,049.23
Add: 1/9th of Cost	180.00	63.42	116.58
Charges *per person per day*	1,800.00	634.19	1,165.81

* May be apportioned to house-keeping and restaurant on any other alternative logical basis.

Problem-11

Elegant Hotel has a capacity of 100 single rooms and 20 double rooms. It has a sports centre with a swimming pool, which is also used by persons other than residents of the hotel. The hotel has a shopping arcade at the basement and a specialty restaurant at the roof top.

The following information is available:

(i) *Average occupancy: 75% for 365 days of the year.*

(ii) *Current cost are:*

	Variable Cost per Day (₹)	***Fixed Cost per Day (₹)***
Single Room:	*400*	*200*
Double room:	*500*	*250*

(iii) *Average sales per day of restaurant is ₹ 1,00,000, and contribution is at 30%. Fixed cost ₹ 10,00,000*

(iv) *The sports centre/swimming pool is likely to be used by 50 non-residents daily; average contribution per day per non-residential is estimated at ₹ 50 fixed cost is ₹ 5,00,000 per annum.*

(v) *Average contribution per month from the shopping arcade is ₹ 50,000 fixed cost is ₹ 6,00,000 per annum.*

Required

(a) *Find out rent chargeable for single and double room per day so that there is a margin of safety of 20% on hire of room and that the rent for a double room shall be kept at 120% of a single room.*

(b) *Evaluate the profitability of restaurant, sports centre and shopping arcade separately.*

Solution

Working Note

1. Single Room Occupancy Days in a Year = 100 Rooms × 365 Days × 75%
= 27,375

Double Room Occupancy Days in a Year = 20 Rooms × 365 Days × 75%
= 5,475

2. In Terms of Single Room

Total Room Occupancy Days in a Year = 27,375 + 1.20 × 5,475
= 27,375 + 6,570
= 33,945

(a) Rent Chargeable for Single and Double Room *per day*

	Occupancy Days *in a year* (W.N.-1)	Variable Cost *per day* (₹)	Fixed Cost *per day* (₹)	Total Variable Cost (₹)	Total Fixed Cost (₹)	Total Cost (₹)
	(1)	(2)	(3)	(4)=(1) × (2)	(5)=(1)× (3)	(6)=(4)+(5)
Single Room	27,375	400	200	1,09,50,000	54,75,000	1,64,25,000
Double Room	5,475	500	250	27,37,500	13,68,750	41,06,250
Add: 20% Margin of Safety on Hire of Rooms						51,32,813
Total Amount of Room Rent *to be received*						2,56,64,063

Rent *per day* of Single Room $= \frac{₹2,56,64,063}{33,945}$

= ₹756 (approx)

Rent *per day* of Double Room = ₹756 × 1.2

= ₹907 (approx)

(b)

Profitability of Restaurant:	(₹)
Total Sales *per annum* (365 Days × ₹1,00,000)	3,65,00,000
Contribution *per annum* (30% of Total Sales)	1,09,50,000
Less: Fixed Cost *per annum*	10,00,000
Profit	99,50,000

Profitability of Sport Centre:	**(₹)**
Contribution of Sport Centre *per day* (50 Persons × ₹50)	2,500
Total Contribution per annum (₹2,500 × 365 Days)	9,12,000
Less: Fixed Cost *per annum*	5,00,000
Profit	4,12,000

Profitability of Shopping Arcade:	**(₹)**
Contribution *per annum* (₹50,000 × 12 Months)	6,00,000
Less: Fixed Cost *per annum*	6,00,000
Profit	Nil

Problem-12

Mr. Perfect owns a gift–shop, a restaurant and a lodge in Shimla. Typically he operates these only during the season period of four months in a year. For the past season the occupancy rate in the lodge was 90% and level of activity in case of gift–shop and restaurant at 80%.

The relevant data for the past season were as under:

	Gift – Shop		***Restaurant***		***Lodge***	
	Amt. (₹)	***%***	***Amt. (₹)***	***%***	***Amt. (₹)***	***%***
Receipts / Sales	*48,000*	*100*	*64,000*	*100*	*1,80,000*	*100*
Expenditure :						
Cost of Sales	*26,400*	*55*	*35,200*	*55*	---	---
Supplies	*2,400*	*5*	*6,400*	*10*	*14,400*	*8*
Insurance & Taxes	*1,920*	*4*	*6,400*	*10*	*36,000*	*20*
Depreciation	*2,880*	*6*	*8,000*	*12½*	*39,600*	*22*
Salaries	*4,800*	*10*	*4,800*	*7½*	*25,200*	*14*
Electricity Charges	*960*	*2*	*3,200*	*5*	*13,500*	*7½*
Profit	*8,640*	*18*	---	---	*51,300*	*28½*

Additional information:

(1) Cost of sales and supplies vary directly with the occupancy rate in case of lodge and level of activity in case of gift–shop and restaurant.

(2) Insurance & Taxes and depreciation are for the entire period of twelve months.

(3) Salaries paid are for the season period except a chowkidar for the lodge who is paid for the full year at ₹ 400 per month.

(4) Electricity charges include fixed charges of ₹ 640, ₹ 1,920 & ₹ 9,900 for gift–shop, restaurant and lodge respectively. The balance amount varies directly with occupancy rate in case of lodge and level of activity in case of gift – shop and restaurant. Fixed electric charge are for the season except in case of lodge where ₹ 6,900 is for the season and ₹ 3,000 for the entire period of twelve months.

Mr. Perfect is interested in increasing his net income. The following two options are under his consideration:-

(1) To continue the operations during the season period only by inserting advertisement in newspapers thereby occupancy rate to reach 100% in case of lodge and 90% level of activity in respect of gift–shop and restaurant. The costs of advertisement are estimated at ₹ 12,000.

(2) To continue operations throughout the entire period of twelve months comprising season period for four months and off–season period of eight months. The occupancy rate is expected at 90% and 40% during season period and off–season period respectively in case of the lodge. The room rents are bound to be reduced to 50% of the original rate during off–season period. The level of activity of gift–shop and restaurant is expected at 80% and 30% during season and off–season period respectively but 5% discount on the original rates will have to be offered during off–season period.

Required

Which options is profitable? Suggest Mr. Perfect any other alternative based upon the above figures which can be adopted to earn more net profit. (Use incremental revenue and differential cost approach).

Solution

First Option

Incremental Revenue	**(₹)**
Gift–Shop (₹48,000 × 10 / 80)	6,000
Restaurant (₹64,000 × 10 / 80)	8,000
Lodge (₹1,80,000 × 10 / 90)	20,000
Total …(A)	34,000

Differential Cost	Gift–Shop (₹)	Restaurant (₹)	Lodge (₹)	Total (₹)
Cost of Sales	3,300 $\left(₹6,000 \times \frac{55}{100}\right)$	4,400 $\left(₹8,000 \times \frac{55}{100}\right)$	---	7,700
Supplies	300 $\left(₹6,000 \times \frac{5}{100}\right)$	800 $\left(₹8,000 \times \frac{10}{100}\right)$	1,600 $\left(₹20,000 \times \frac{8}{100}\right)$	2,700
Electricity Charges	40*	160**	400***	600
Total			…(B)	11,000

(*) $\left\{(₹960 - ₹640) \times \frac{10}{80}\right\}$,

(**) $\left\{(₹3,200 - ₹1,920) \times \frac{10}{80}\right\}$

(***) $\left\{(₹13,500 - ₹9,900) \times \frac{10}{90}\right\}$

Excess of Incremental Revenue Over Differential Cost … [(A) – (B)]	23,000
Less: Advertisement Costs	(12,000)
Additional Net Income	11,000

Second Option

Incremental Revenue:	**(₹)**
During Season period *for all the three units*	Nil
During Off – Season Period:	
Gift–Shop $\left(₹48,000 \times 2 \times \frac{30}{80} \times \frac{95}{100}\right)$	34,200
Restaurant $\left(₹64,000 \times 2 \times \frac{30}{80} \times \frac{95}{100}\right)$	45,600
Lodge $\left(₹1,80,000 \times 2 \times \frac{40}{90} \times \frac{50}{100}\right)$	80,000
Total …(A)	1,59,800

Differential Cost	Gift–Shop (₹)	Restaurant (₹)	Lodge (₹)	Total (₹)
Cost of Sales	19,800 $\left(₹36,000 \times \frac{55}{100}\right)$	26,400 $\left(₹48,000 \times \frac{55}{100}\right)$	---	46,200
Supplies	1,800 $\left(₹36,000 \times \frac{5}{100}\right)$	4,800 $\left(₹48,000 \times \frac{10}{100}\right)$	12,800 $\left(₹1,60,000 \times \frac{8}{100}\right)$	19,400
Salaries	9,600 (₹4,800 × 2)	9,600 (₹4,800 × 2)	40,800 [(₹25,200 – ₹4,800) × 2]	60,000
Electricity (fixed element)	1,280 (₹640 × 2)	3,840 (₹1,920 × 2)	13,800 (₹6,900 × 2)	18,920
Electricity (variable element)	240*	960**	3,200***	4,400
Total			… (B)	1,48,920

(*) $\left\{(₹960 - ₹640) \times \frac{30}{80} \times 2\right\}$

(**) $\left\{(₹3,200 - ₹1,920) \times \frac{30}{80} \times 2\right\}$

(***) $\left\{(₹13,500 - ₹9,900) \times \frac{40}{90} \times 2\right\}$

Excess of Incremental Revenue Over Differential Cost	…[(A) – (B)]	10,880

A comparison of the first and second option clearly shows that the first option is better as it is more Profitable. Under first option the Earnings are more by ₹120 (₹11,000 − ₹10,880) in comparison with second option.

Suggestion (Other Alternative Option)

Mr. Perfect should go for the Advertisement insertion and also continue to operate all the operations during Off Season period as well. This will give him maximum Net Earnings based upon the relevant data shown above. The Additional Net Earnings then will be:

	(₹)
Due to Advertisement	11,000
Continuing Business during Off Season too	10,880
Total Additional Earnings	21,880

Hospitals/ Health Clinics

Problem-13

A city health centre provides health and other related services to the citizens who are covered under insurance plan. The health centre receives a payment from the insurance company each time any patient attends the centre for consultation as under:

Consultations involving	*Payment from Insurance company (₹)*
No treatment	*60*
Minor treatment	*250*
Major treatment	*500*

In addition, the adult patients will have to make a co-payment which is equivalent to the amount of payment for the respective category of treatment made by the insurance company. However, children and senior citizens are not required to make any such co-payment.

The health centre will remain open for 6 days in a week for 52 weeks in a year. Each physician treated 20 patients per day although the maximum number of patients that could have been treated by a physician on any working day is 24 patients.

The health centre received a fixed income of ₹ 2,25,280 per annum for promotion of health products from the manufacturers.

The annual expenditure of the health centre is estimated as under:

Materials and Consumable (100% Variable)	*₹ 22,32,000*
Staff Salaries per annum per Employee (Fixed):	
Physician	*₹ 4,50,000*
Assistants	*₹ 1,50,000*
Administrative Staff	*₹ 90,000*
Establishment and Other Operating Costs (Fixed)	*₹ 16,00,000*

The non-financial information is as under:

(i)	*Staff:*	
	Number of Physicians Employed	*6*
	Assistants	*7*
	Administrative Staff	*2*
(ii)	*Patient Mix:*	
	Adults	*50%*
	Children	*40%*
	Senior Citizens	*10%*
(iii)	*Mix of Patient Appointments (%)*	
	Consultation requiring no Treatment	*70%*
	Minor Treatment	*20%*
	Major Treatment	*10%*

Required

(i) Calculate the Net income of the city health centre for the next year;

(ii) Determine the percentage of maximum capacity required to be utilized next year in order to break even.

Solution

(i) (1) Total Number of Patients Attended

Number of Patients Attended *per Day* by a Physician	20
Number of Physicians Employed	6
Number of Days in Week	6
Number of Weeks in a Year	52
Total Number of Patients Attended (20 × 6 × 6 × 52)	37,440

(2) Patient Mix

Adults (50%)	[37,440 × 50/100]	18,720
Children (40%)	[37,440 × 40/100]	14,976
Senior Citizens (10%)	[37,440 × 10/100]	3,744
Total		37,440

(3) Patient Appointments

No Treatment Required (70%)	[37,440 × 70/100]	26,208
Minor Treatment (20%)	[37,440 × 20/100]	7,488
Major Treatment (10%)	[37,440 × 10/100]	3,744
Total		37,440

(4) Income from Insurance Companies

	Number of Patients	(₹)	(₹)
	(A)	(B)	(A × B)
No Treatment Patients	26,208	60	15,72,480
Minor Treatment Patients	7,488	250	18,72,000
Major Treatment Patients	3,744	500	18,72,000
Total			53,16,480

(5) Co-payment from Adult Patients

Total Number of Adult Patients = 18,720

	Number of Patients	Payment (₹)	Total Payment (₹)
No Treatment Patients (70%)	13,104	60	7,86,240
Minor Treatment (20%)	3,744	250	9,36,000
Major Treatment (10%)	1,872	500	9,36,000
Total			26,58,240

(6) Net Income

	(₹)	(₹)
Payment from Insurance Companies	53,16,480	
Co-payment from Adult Patients	26,58,240	79,74,720
Other Income (Fixed)		2,25,280
Total Income	…(A)	82,00,000
Less: Variable Expenses:		
Material and Consumables		22,32,000

Less: Fixed expenses:		
Physician's Salary (6 × 4,50,000)	27,00,000	
Assistants Salary (7 × 1,50,000)	10,50,000	
Administrative Staff's Salary (2 × 90,000)	1,80,000	
Establishment and Other Operating Costs	16,00,000	55,30,000
Total Expenditure	...(B)	77,62,000
Net Income	...(A − B)	4,38,000

(ii) 1. Contribution Analysis

	(₹)
Total Fees from Insurance Companies and Adult Patients	79,74,720
Less: Variable Costs	22,32,000
Contribution	57,42,720
Average Contribution *per patient* $\left(\frac{₹57,42,720}{37,440 \text{ Patients}}\right)$	153.38

2. Break-even Patients

	(₹)
Fixed Costs	55,30,000
Less: Fixed Income	2,25,280
Net Fixed Costs	53,04,720
Break-even Patients $\left(\frac{₹53,04,720}{₹153.38}\right)$	34,585

3. Percentage of Maximum Capacity Required to be Utilized in Order to Break-even

Present utilization $= \frac{20 \text{ Patients}}{24 \text{ Patients}}$

$= 83.33\%$

At 100 % Capacity No. of Patients $= \frac{37,440 \text{Patients}}{0.8333}$

$= 44,930$ Patients

Percentage of Maximum Capacity Required *to be utilized in order to* Break-even

$$= \frac{\text{Break-even Patients}}{\text{100\% Patient Capacity}} \times 100$$

$$= \frac{34{,}585 \text{Patients}}{44{,}930 \text{Patients}} \times 100$$

$$= 76.98\% \text{ say } 77\%$$

Assumption

Patient Mix and Mix of Patient Appointments will be same in the next year.

Problem-14

A hospital operates a 40 bed capacity special health care department. The said department levies a charge of ₹ 425 per bed day from the patient using its services. The data relating to fees collected and costs for the year 2013 are as under:

	(₹)
Fees collected during the year	*34,95,625*
Variable costs based on patient days	*13,57,125*
Department fixed costs	*6,22,500*
Apportioned costs of the hospital administration charges	*10,00,000*

Besides the above, nursing staff were employed as per the following scale at ₹ 48,000 per annum per nurse.

Annual Patient Days	***No. of Nurses Required***
Less than 5,000	*3*
5,000 – 7,000	*4*
7,000 – 9,000	*6*
Above 9,000	*8*

The projections for the year 2014 are as under-

- *The costs other than apportioned overheads will go up by 10%.*
- *The apportioned overheads will increase by ₹ 2,50,000 per annum.*
- *The salary of the nursing staff will increase to ₹ 54,000 per annum per nurse.*

The occupancy of the bed capacity is not likely to increase in 2014 and consequently the management is actively considering a proposal to close down the department. In that event, the departmental fixed costs can be avoided.

Required

(i) *Present a statement to show the profitability of the department for the years 2013 and 2014.*

(ii) *Calculate the:*

- *break-even bed capacity for the year 2014*
- *increase in fee per bed day required to justify continuance of the department.*

Solution:

(i) **Statement of Profitability of Special Health Care Department**

	Year 2013 (₹)	**Year 2014 (₹)**
Total Contribution (W.N.-1, 2 & 3)	21,38,500 (8,225 Bed − Days × ₹260)	20,02,788 (8,225 Bed − Days × ₹243.50)
Less: Fixed Costs		
Department Fixed Costs	6,22,500	6,84,750
Apportioned Fixed Costs	10,00,000	12,50,000
Nursing Staff	2,88,000 (6 × ₹48,000)	3,24,000 (6 × ₹54,000)
Profit / (Loss)	2,28,000	(2,55,962)

Working Notes

1. Total Number of Bed-Days of Occupancy

$$= \frac{\text{Total Fees Collected}}{\text{Fee per Bed-Days}}$$

$$= \frac{₹34,95,625}{₹425}$$

$$= 8,225 \text{ Bed-Days}$$

2. Variable Cost per Bed-Days

2013: $= \frac{₹13,57,125}{₹8,225}$

$= ₹165$

2014: $= ₹165 \times 110\%$

$= ₹181.50$

3. Contribution per Bed-Day

2013:	=	₹425 − ₹165
	=	₹260.00
2014:	=	₹425 − ₹181.50
	=	₹243.50

4. Departmental Fixed Costs

2013:	=	₹6,22,500
2014:	=	₹6,22,500 × 110%
	=	₹6,84,750

(ii) Break-even Bed Capacity (for the year 2014)

= Total Fixed Costs ÷ Contribution *per bed day*

= ₹22,58,750 ÷ ₹243.50

= 9,276 Bed Days (approx.)

Note

This is not a valid answer because for 9,276 Bed Days 8 Nurses service will be required.

Nursing Staff Required	=	8
Remuneration of 8 Nursing Staff	=	₹4,32,000 (8 Nurses × ₹54,000)
Department Fixed Costs	=	₹6,84,750
Apportioned Fixed Costs	=	₹12,50,000
Total Fixed Costs	=	₹23,66,750
Break-even Point	=	₹23,66,750 ÷ ₹243.50
	=	9,720 Bed Days

Increase in Fee *per day* required to Justify Continuance of the Special Health Care Department

Desired Contribution	=	₹22,58,750
Bed Days of Occupancy	=	8,225
Contribution *per bed days* (₹22,58,750 / 8,225)	=	₹274.62
Variable Costs	=	₹181.50
Required Fee *per bed day*		₹456.12

Increase in Fee *per bed day*	=	₹456.12 – ₹425
	=	₹31.12

Problem-15

A Multinational company runs a Public Medical Health Center. For this purpose, it has hired a building at a rent of ₹ 10,000 per month with 5% of total taking. Health center has three types of wards for its patients namely. General ward, Cottage ward and Deluxe ward. State the rent to be charged to each bed-day for different type of ward on the basis of the following information;

1. *The number of beds of each type is General ward 100, Cottage ward 50, Deluxe ward 30.*
2. *The rent of cottage ward bed is to be fixed at 2.5 times of the General ward bed and that of Deluxe ward bed as twice of the Cottage ward bed.*
3. *The occupancy of each type of ward is as follows:*

   General ward 100%, Cottage ward 80% and Deluxe ward 60%. But, in General ward there were occasions when beds are full, extra beds were hired at a charges of ₹ 20 per bed. The total hire charges for the extra beds incurred for the whole year amount to ₹ 12,000.
4. *The Health center engaged a heart specialist from outside and on an average fees paid to him was ₹ 15,000 per trip. He makes three trips in the whole year.*
5. *The other expenses for the year were as under:*

	(₹)
Salary of Supervisors, Nurses, Ward Boys	*4,25,000*
Repairs and Maintenance	*90,000*
Salary of Doctors	*13,50,000*
Food Supplied to Patients	*40,000*
Laundry Charges for their Bed Linens	*80,500*
Medicines Supplied	*74,000*
Cost of Oxygen, X-Ray etc. (other than directly borne for treatment of Patients)	*49,500*
General Administration Charges	*63,000*

6. *Provide profit @ 20% on total taking.*
7. *The Health center imposes 8% service tax on rent received*
8. *360 days may be taken in a year.*

Solution

Statement of Total Cost
(Assuming Service Tax Doesn't Form Part of Total Taking)

	Amount (₹)	Amount (₹)
Salary of Supervisor, Nurses, Ward Boys	4,25,000	
Repairs and Maintenance	90,000	
Salary of Doctors	13,50,000	
Food Supplied to Patients	40,000	
Laundry Charges for their Bed Linens	80,500	
Medicines Supplied	74,000	
Cost of Oxygen, X-Ray etc (other than directly borne for treatment of Patients)	49,500	
General Administration Charges	63,000	21,72,000
Building Rent (12 months × ₹10,000)		1,20,000
Additional Building Rent *on takings*		5% of *total taking*
Hire Charges Extra Beds		12,000
Fees to Heart Specialists (3 trips × ₹15,000)		45,000
Total Cost		23,49,000 + 5% of *total taking*
Profit		20% on *total taking*
Total Takings		23,49,000 + 25% of *total taking*

Total Taking (assuming R to be the Rent *per day*) = 1,05,000 × R

Rent *to be charged*:

	1,05,000 × R	= 23,49,000 + 25% (1,05,000 × R)
Or,	1,05,000 R	= 23,49,000 + 26,250 R
Or,	78,750 R	= 23,49,000
Or,	R	= 29.83

No. of Beds with Equivalent Rent

Nature of Wards	Occupancy	Equivalent Ward-Days
General Ward	36,000 (100 × 360 × 100%)	36,000 (36,000 × 1)
Additional General Ward	600 (12,000 ÷ 20)	600 (600 × 1)
Cottage Ward	14,400 (50 × 360 × 80%)	36,000 (14,400 × 2.5)
Deluxe Ward	6,480 (30 × 360 × 60%)	32,400 (6,480 × 5)
Total		1,05,000

Rent to be Charged

Particulars	Basic	Service Tax	Total
General Ward	29.83	2.39	32.22
Cottage Ward	74.58	5.97	80.55
Deluxe Ward	149.15	11.93	161.08

Note

If it is assumed that Total Taking includes Service Tax also then the Rent per equivalent ward will be:

(1,05,000 × R) 1.08 = 23,49,000 + 25% {(1,05,000 × R)1.08} + {(1,05,000 × R) 0.08}

Or, 1,13,400 R = 23,49,000 + 28,350R + 8,400R

Or, 76,650 R = 23,49,000

Or, R = 30.65

Rent to be Charged

Particulars	Basic	Service Tax	Total
General ward	30.65	2.45	33.10
Cottage ward	76.63	6.13	82.76
Deluxe ward	153.25	12.26	165.51

7 Transfer Pricing

Basic Concepts

Bargained or Negotiated Prices	Under this method each decentralised unit is considered as an independent unit and such units decide the transfer price by negotiations or bargaining. Divisional managers have full freedom to purchase their requirement from outside if the prices quoted by their sister unit are lower.
Dual Rate Transfer Pricing System	In this system two separate transfer prices are used to price interdivisional transactions. In this system, accounts of both divisions show profit and accordingly performance of the division is evaluated.
Multinational Transfer Pricing	Multinational companies (MNCs), operates in different countries with different taxation laws and rates. In such an environment MNCs use to set transfer prices in such a manner which minimizes the overall tax burden, such as corporate taxes, import duties, and other tariffs etc. Sometimes import duties offset income tax effects. However many countries has laws to prevent this type of practice and tax the transaction at arm's length prices.
Objectives of Transfer Pricing System	The main-objectives of intra-company transfer pricing are as below: (i) To utilise capacity of the plant and other resources as maximum as possible. (ii) To optimise allocation of financial resources.
Pricing at Cost	In this method the goods and services are transferred at the following costs: (i) Actual Manufacturing Cost (ii) Standard Cost (iii) Full Cost (iv) Full Cost plus Mark-up

Pricing at Market Price	Under this method, the transfer prices of goods/services transferred to other units/divisions are based on market prices. Since market prices will, by and large be determined by demand and supply in the long run, it is claimed that profits which results under this method, will provide a good indicator of the overall efficiency of the various units.
Transfer Price	Transfer price can be defined as the price charged for products exchanged in internal transactions between sellers (or transferors) and buyers (or transferees) who belong to the same organisation usually a decentralised organisation.
Two Part Transfer Pricing System	In this system supplying division transfer its products to receiving division at marginal cost and a fixed fee for a particular period say per annum.

SECTION - A

Transfer Pricing - Methods

Question-1

What should be the basis of transfer pricing, if unit variable cost and unit selling price are not constant?

Answer

If unit variable cost and unit selling price are not constant then the main problem that would arise while fixing the transfer price of a product would be as follows:

There is an optimum level of output for a firm as a whole. This is so because there is a certain level of output beyond which its net revenue will not rise. The ideal transfer price under these circumstances will be that which will motivate these managers to produce at this level of output.

Essentially, it means that some division in a business house might have to produce its output at a level less than its full capacity and in all such cases a transfer price may be imposed centrally.

Question-2

(a) What will be the marketable transfer pricing procedure regarding the goods transferred under the following conditions (each condition is independent of the other)?

(i) When division are not captives of internal divisions and the divisions are free to do business both internally and externally and when there are reasonably competitive external markets for the transferred products.

(ii) If the external market for the transferred good is not reasonably competitive.

(b) Discuss the potential for maximization of income by a multinational through the use of transfer pricing mechanism.

Answer

(a) Marketable Transfer Pricing Procedure

(i) When division are not captives of internal divisions and the divisions are free to do business both internally and externally and when there are reasonably competitive external markets for the transferred products, then the most suitable transfer price would be, the market price, as it generally leads to optimal decisions.

(ii) In case, the external market for the transferred good is not reasonable competitive, following two situations may arise in this case.

(a) If there is idle capacity: Under this situation opportunity cost will be zero hence minimum transfer price should be equal to the additional outlay costs incurred upto the point of transfer (sometimes approximated by variable costs).

(b) If there is no idle capacity: Under this situation opportunity cost should be added to outlay costs for determining minimum transfer price.

(b) The potential for maximization of income by a multinational through the use of transfer pricing mechanism is based on the successful implementation of the following steps

(i) Transfer pricing may be set relatively higher for affiliates in relatively high-tax countries that purchase inputs from affiliates located in relatively low-tax countries.

(ii) Transfer prices to affiliates in countries which are subject to import duties for goods or services purchase may be set low so as to avoid host country taxes.

(iii) Transfer prices to an affiliate in a country that is encountering relatively high inflation may be set relatively high to avoid some of the adverse effects of local currency devaluation that are related to the high inflation.

(iv) Transfer prices may be set high for goods and services purchased by an affiliate operating in a country that has imposed restriction on the repatriation of income to foreign companies.

(v) Transfer prices may be set low for an affiliate that is trying to establish a competitive advantage over a local company either to break into a market or to establish a higher share of the company's business.

Transfer Pricing - Miscellaneous

Question-3

What are some goals of a 'transfer-pricing' system in an organization?

Answer

The goals of transfer pricing are that it should:

(i) Provide information that motivates divisional managers to take good economic decisions which will improve the divisional profits and ultimately the profits of the company as a whole.

(ii) Provide information which will be useful for evaluating the divisional performance.

(iii) Seek to achieve goal congruence.

(iv) Ensure that divisional autonomy is not undermined.

Question-4

"Transfer pricing is a widely debated and contested topic" – Discuss.

Answer

Usually a conflict between a division of the company and the company as a whole is faced by the management of decentralized units when products or services are exchanged among different divisions of the company. Such a conflict becomes more significant in the case of those concerns where profitability is used as criteria for evaluating the performance of each division.

The essence of decentralization is reflected in the freedom to make decisions. Under such a set up it is expected that the top management should not interfere with the decision making process of its subordinates heading different units. In other words, management of decentralized units is given autonomy with regard to decision-making. In this system top management is expected to preserve 'autonomy in decision making'. The management of such companies also expects that each division should not only achieve its own objective – necessary for evaluating the performance but should also achieve the objective of goal congruence.

A divisional head in a company under aforesaid set up is free to use a price as a transfer price for goods and services, which may provide incentive. Such a transfer price may fail to achieve the objective of 'Goal congruence' (which means a perfect congruence between division's goal and the goal of the company. In case of failure of a division to achieve the objective of 'Goal congruence' the management of the company may dictate their transfer price. Such a interference of management of the company is usually the main basis of conflict between a division and the company as a whole.

Further this conflict is aggravated if the management advocates the transfer of goods and services at cost. As such, the transfer price will not reflect a good picture about the performance of the transferring division. The profitability of the transferring division will not be known by the use of such a transfer price.

Each division appreciates the transfer of its goods/services at usual selling price/market price so as to arrive at the correct return / profitability figure, used for measuring the performance.

There is no incentive to the transferring division if goods and services are transferred at variable cost.

Question-5

Enumerate - the expected disadvantages in taking divisions as profit centres.

Answer

The expected disadvantages of taking divisions as profit centres are as follows:

- Divisions may compete with each other and may take decisions to increase profits at the expense of other divisions thereby overemphasizing short term results.
- It may adversely affect co-operation between the divisions and lead to lack of harmony in achieving organizational goals of the company. Thus it is hard to achieve the objective of goal congruence.
- It may lead to reduction in the company's overall total profits.
- The cost of activities, which are common to all divisions, may be greater for decentralized structure than centralized structure. It may thus result in duplication of staff activities.
- Top management loses control by delegating decision making to divisional managers. There are risks of mistakes committed by the divisional managers, which the top management, may avoid.
- Series of control reports prepared for several departments may not be effective from the point of view of top management.
- It may under utilize corporate competence.
- It leads to complications associated with transfer pricing problems.
- It becomes difficult to identity and defines precisely suitable profit centres.
- It confuses division's results with manager's performance.

SECTION - B

Transfer Price - Shared Contribution / Market Price Method

Problem-1

A company is engaged in the manufacture of edible oil. It has three divisions as under:

(i) Harvesting oil seeds and transportation thereof to the oil mill.

(ii) Oil Mill, which processes oil seeds and manufactures edible oil.

(iii) Marketing Division, which packs the edible oil in 2 kg. containers for sale at ₹ 150 each container.

The Oil Mill has a yield of 1,000 kgs of oil from 2,000 kg of oil seeds during a period. The Marketing Division has a yield of 500 cans of edible oil of 2 kg each from every 1,000 kg of oil. The net weight per can is 2 kgs of oil.

The cost data for each division for the period are as under:

Harvesting Division	₹
Variable cost per kg of oil seed	2.50
Fixed cost per kg of oil seed	5.00
Oil Mill Division	₹
Variable cost of processed edible oil	10.00 per kg
Fixed cost of processed edible oil	7.50 per kg
Marketing Division	₹
Variable cost per can of 2 kg of oil	3.75
Fixed cost per can of 2 kg of oil	8.75

The fixed costs are calculated on the basis of the estimated quantity of 2,000 kg of oil seeds harvested, 1,000 kg of processed oil and 500 cans of edible oil packed by the aforesaid divisions respectively during the period under review.

The other oil mills buy the oil seeds of same quality at ₹ 12.50 per kg in the market. The market price of edible oil processed by the oil mill, if sold without being packed in the marketing division is ₹ 62.50 per kg of oil.

Required

(i) Compute the overall profit of the company of harvesting 2,000 kg of oil seeds, processing it into edible oil and selling the same in 2 kg cans as estimated for the period under review.

(ii) Compute the transfer prices that will be used for internal transfers from (1) Harvesting Division to Oil Mill Division and (2) from Oil Mill Division to Marketing Division under the following pricing methods:

(1) Shared contribution in relation to variable costs; and

(2) Market price.

(iii) Which transfer pricing method will each divisional manager prefer to use?

Solution

(i) Statement of the Overall Profit of the Company

(By Harvesting 2,000 Kgs. of Oil Seeds, Processing it into Edible Oil & Selling the same in 2 Kg Cans)

	Harvesting Division	Oil Mill Division	Marketing Division	Total (₹)
Output *of* each *Department*	2,000 Kgs. of Oil Seeds	1,000 Kgs. of Oil Produced	500 Cans of 2 Kg. each	---
Variable Cost (₹)	5,000 (2,000 Kgs × ₹2.50)	10,000 (1,000 Kgs × ₹10)	1,875 (500 Cans × ₹3.75)	16,875
Fixed Cost (₹)	10,000 (2,000 Kgs × ₹5)	7,500 (1,000 Kgs × ₹ 7.50)	4,375 (500 Cans × ₹8.75)	21,875
Total Cost (₹)	15,000	17,500	6,250	38,750
Sales Revenue (₹) [500 Cans × ₹150]				75,000
Profit (₹)				36,250

(ii) Working Notes

(a) Total Contribution = Sales Revenue – Total Variable Cost

= ₹75,000 – ₹16,875

= ₹58,125

(b) Amount of Shared Contribution *in relation to Variable Costs*

Harvesting Division $= ₹58,125 \times \frac{₹\,5,000}{₹16,875}$

$= ₹17,222$

Oil Mill Division $= ₹58,125 \times \frac{₹10,000}{₹16,875}$

$= ₹34,445$

Marketing Division $= ₹58,125 \times \frac{₹1,875}{₹16,875}$

$= ₹6,458$

Computation of Transfer Price *for internal transfers* under the Following Pricing Methods

(1) Shared Contribution in *relation to* Variable Costs

Transfer Price from Harvesting Division to Oil Mill Division

= Variable Cost of Harvesting Division + Shared Contribution of Harvesting Division *in relation to* Variable Costs

= ₹5,000 + ₹17,222 [W.N.-(b)]

= ₹22,222

Transfer Price from Oil Mill Division to Marketing Division

= Transfer Price from Harvesting Division to Oil Mill Division + Variable Cost of Oil Mill Division + Shared Contribution of Oil Mill Division *in relation to* Variable Costs [W.N.-(b)]

= ₹22,222 + ₹10,000 + ₹34,445

= ₹66,667

(2) Market Price

Transfer Price from Harvesting Division to Oil Mill Division

= Market Price of 2,000 Kgs. of Oil Seeds *transferred to* Oil Mill Division

= 2,000 Kgs. × ₹ 12.50

= ₹25,000

Transfer Price from Oil Mill Division to Marketing Division

= Market Price of 1,000 Kgs. of Edible Oil

= 1,000 of Kgs. × ₹62.50

= ₹62,500

(iii) Statement Showing "Profitability under Different Transfer Prices Method"

	From Harvesting Division to Oil Mill Division (₹)	**From Oil Mill to Marketing Division** (₹)	**From Marketing Division to Market (500 Cans of 2Kgs.)** (₹)
Shared Contribution Method			
Transfer Price [Refer to (1) above]	22,222	66,667	75,000
Less: Transfer Price [Refer to (ii) above]	—	22,222	66,667
Less: Variable Cost	5,000	10,000	1,875
Less: Fixed Cost [Refer to (i) above]	10,000	7,500	4,375
Profit	7,222	26,945	2,083
Market Price Method			
Transfer Price [Refer to (2) above]	25,000	62,500	75,000
Less: Transfer in Price [Refer to (ii) above]	—	25,000	62,500
Less: Variable Cost [Refer to (ii) above]	5,000	10,000	1,875
Less: Fixed cost [Refer to (i) above]	10,000	7,500	4,375
Profit	10,000	20,000	6,250

Decision

Divisional Manager of Harvesting Division would prefer the use of Market Price Method for transferring 2,000 Kgs. of Oil Seeds to Oil Mill Division because its usage increases the Profit by ₹2,778 (₹10,000 – ₹7,222) over the Shared Contribution Method. Whereas Oil Mill Division Manager would prefer the use of Shared Contribution Method over the Market Price Method because its use would increase its Profit by ₹6,945 (₹26,945 – ₹20,000). Similarly Marketing Divisional Manager would be benefited to the extent of ₹4,167 (₹ 6,250 – ₹ 2,083) by using Market Price Method.

Transfer Pricing Based on Opportunity Cost

Problem-2

Division Z is a profit center which produces four products A, B, C and D. Each product is sold in the external market also. Data for the period is:

	A	*B*	*C*	*D*
Market price per unit (₹)	*150*	*146*	*140*	*130*
Variable cost of production per unit (₹)	*130*	*100*	*90*	*85*
Labour hours required per unit	*3*	*4*	*2*	*3*

Product D can be transferred to Division Y, but the maximum quantity that may be required for transfer is 2,500 units of D.

The maximum sales in the external market are:

A……………………………..... 2,800 units

B……………………………. 2,500 units

C…………………………….. 2,300 units

D…………………………….. 1,600 units

Division Y can purchase the same product at a price of ₹ 125 per unit from outside instead of receiving transfer of product D from Division Z.

Required

What should be the transfer price for each unit for 2,500 units of D, if the total labour hours available in Division Z are 20,000 hours?

Solution

Ranking of Products When Availability of Time is the Key Factor

Products	A	B	C	D
Market Price (₹)	150	146	140	130
Less: Variable Cost (₹)	130	100	90	85
Contribution *per unit* (₹)	20	46	50	45
Labour Hours *per unit*	3 hrs.	4 hrs.	2 hrs.	3 hrs.
Contribution *per Labour Hour*	6.67	11.50	25.00	15.00
Ranking	IV	III	I	II
Maximum Demand (units)	2,800	2,500	2,300	1,600
Total No. of Hours	8,400	10,000	4,600	4,800
Allocation of 20,000 Hours on the Basis of Ranking	600*	10,000	4,600	4,800

(*) Balancing Figure

Note

Time required to meeting the demand of 2,500 units of Product D for Division Y is 7,500 hrs. This requirement of time viz. 7,500 hrs for providing 2,500 units of Product D for Division Y can be met by sacrificing 600 hours of Product A (200 units) and 6,900 hours of Product B (1,725 units).

Transfer Price = Variable Cost + Opportunity Cost

$$= ₹85 + \frac{(6,900 \text{ hrs.} \times ₹11.5 + 600 \text{ hrs.} \times ₹6.66)}{2,500 \text{ units}}$$

$$= ₹\ 85 + \frac{₹79,350 + ₹4,000}{2,500\text{units}}$$

$$= ₹85 + ₹33.34$$

$$= ₹118.34$$

Problem-3

Maryanne Ltd. has two divisions Division A and Division B. Division A produces product Z, which it sells to external market and also to Division B. Divisions in the Maryanne Ltd. are treated as profit centres and divisions are given autonomy to set transfer prices and to choose their supplier. Performance of each division measured on the basis of target profit given for each period.

Division A can produce 1,00,000 units of product Z at full capacity. Demand for product Z in the external market is for 70,000 units only at selling price of ₹ 2,500 per unit. To produce product Z Division A incurs ₹ 1,600 as variable cost per unit and total fixed overhead of ₹ 4,00,00,000. Division A has employed ₹ 12,00,00,000 as working capital, working capital is financed by cash credit facility provided by its lender bank @ 11.50% p.a. Division A has been given a profit target of ₹ 2,50,00,000 for the year.

Division B has found two other suppliers R Ltd and S Ltd. who are agreed to supply product Z.

Division B has requested a quotation for 40,000 units of product Z from Division A.

Required

(i) *Calculate the transfer price per unit of product Z that Division A should quote in order to meet target profit for the year.*

(ii) *Calculate the two prices Division A would have to quote to Division B, if it became Maryanne Ltd. policy to quote transfer prices based on opportunity costs.*

Solution

(i) Transfer Price *per unit* of Product Z that Division A Should Quote *in order to meet* Target Profit

Quotation for the 40,000 units of product Z should be such that meet Division A's target profit and interest cost on working capital. Therefore the minimum quote for product Z will be calculated as follows:

Particulars	**Amount (₹)**
Target Profit (given for the year)	2,50,00,000
Add: Interest Cost on Working Capital (₹12,00,00,000 @11.5%)	1,38,00,000
Required Profit	3,88,00,000
Add: Fixed Overhead	4,00,00,000
Target Contribution	7,88,00,000
Less: Contribution Earned --- External Sales {60,000 units × (₹ 2,500 – ₹1,600)}	5,40,00,000
Contribution Required – Internal Sales	2,48,00,000
Contribution *per unit* of Product Z (₹ 2,48,00,000 ÷ 40,000 units)	620
Transfer Price of Product Z to Division B (Variable Cost *per unit* + Contribution *per unit*)	2,220

(ii) The Two Transfer Prices Based on Opportunity Costs

For the 30,000 units (i.e. maximum capacity – maximum external market demand) at variable cost of production i.e. ₹ 1,600 per unit.

For the next 10,000 units (i.e. external market demand – maximum possible sale) at market selling price i.e. ₹ 2,500 per unit.

Problem-4

A large business consultancy firm is organized into several divisions. One of the divisions is the Information Technology (IT) division which provides consultancy services to its clients as well as to the other divisions of the firm. The consultants in the IT divisions always work in a team of three professional consultants on each day of consulting assignment. The external clients are charged a fee at the rate of ₹ 4,500 for each consulting day. The fee represents the cost plus 150% profit mark up. The break-up of cost involved in the consultancy fee is estimated at 80% as being variable and the balance is fixed.

The textiles division of the consultancy firm which has undertaken a big assignment requires the services of two teams of IT consultants to work five days in a week for a period of 48 weeks. While the director of the textiles division intends to negotiate the transfer price for the consultancy work, the director of IT division proposes to charge the textiles division at ₹ 4,500 per consulting day.

In respect of the consulting work of the textiles division, IT division will be able to reduce the variable costs by ₹ 200 per consulting day. This is possible in all cases of internal consultations because of the use of specialized equipment.

Required

Explain the implications and set transfer prices per consulting day at which the IT division can provide consultancy services to the textiles division such that the profit of the business consultancy firm as a whole is maximized in each of the following scenarios:

(i) Every team of the IT division is fully engaged during the 48 week period in providing consultancy services to external clients and that the IT division has no spare capacity of consultancy teams to take up the textiles division assignment.

(ii) IT division will be able to spare only one team of consultants to provide services to the textiles division during the 48 week period and all other teams are fully engaged in providing services to external clients.

(iii) A new external client has come forward to pay IT division a total fee of ₹ 15,84,000 for engaging the services of two teams of consultants during the aforesaid period of 48 weeks.

Solution

Transfer Price is ₹4,500 *for each consulting day*.

	Profit Mark-up	=	150%
	Let Cost	=	K
	Profit	=	1.5 K
	Cost + Profit	=	Transfer Price
⇒	K + 1.5 K	=	4,500
⇒	2.5 K	=	4,500
⇒	K	=	1,800
∴	Cost	=	₹1,800
	and Profit	=	1.5 K
		=	1.5 × ₹1,800
		=	₹2,700
	Variable Cost (80%)	=	₹1,800 × 80%
		=	₹1,440
	Fixed Cost (20%)	=	₹1,800 × 20%
		=	₹360

Scenario (i)

Every consultancy team is fully engaged. There is no idle time or spare capacity.

Hence, Transfer Price	=	Marginal Cost *plus* Opportunity Cost
Marginal Cost	=	₹1,440
Saving for Internal Work	=	₹200
Net Marginal Cost	=	₹1,240
[Opportunity Cost is the Lost Contribution]		
Lost Contribution	=	Contribution from External Client
	=	Fee Charged from External Client – Variable Cost
	=	₹4,500 – ₹1,440
	=	₹3,060
∴ Transfer Price	=	₹1,240 + ₹3,060
	=	₹4,300 *per consulting day per team*

Scenario (ii)

One team is idle. Idle time has no opportunity cost. Variable cost for internal work is ₹1,240 *per consulting day*. Second team is busy. Hence opportunity cost is relevant in case of second team. Hence charge of second team is ₹4,300 *per consulting day per team*.

Average of Charge (of two teams)	=	(₹1,240 + ₹4,300) ÷ 2
	=	₹2,770 *per consulting day per team*

Scenario (iii)

New Client Offers a Fee of	=	₹15,84,000
Duration (5 Days of 48 Weeks × 2 Teams)	=	480 Days
Fee *per day*	=	₹15,84,000 ÷ 480 Days
	=	₹3,300
Variable Cost	=	₹1,440
Contribution	=	₹3,300 – ₹1,440
	=	₹1,860
Fee for Consulting Day for Internal Work		
Variable Cost	=	₹1,240
Contribution Lost	=	₹1,860
Fee *to be charged*	=	₹3,100 *per consulting day per team*

Problem-5

X Division and Y Division are two divisions in the XY group of companies. X Division manufactures one type of component which it sells to external customers and also to Y Division.

Details of X Division are as follows:

Market price per component……………………………………	*₹300*
Variable cost per component…………………………………...	*₹157*
Fixed costs………………………………………………………...	*₹20,62,000 per period*
Demand from Y Division………………………………………...	*20,000 components per period*
Capacity……………………………………………………….......	*35,000 components per period*

Y Division assembles one type of product which it sells to external customer. Each unit of that product requires two of the components that are manufactured by X Division.

Details of Y Division are as follows:

Selling price per unit…………………………………………………………………………… ₹1,200

Variable cost per unit:

(i) Two components from X………………………………………………… 2 @ transfer price

(ii) Other variable costs per unit…………………………………………………………… ₹375

Fixed costs……………………………………………………………………………₹13,50,000 per period

Demand……………………………………………………………………………10,000 units per period

Capacity……………………………………………………………………………10,000 units per period

Group Transfer Pricing Policy

Transfers must be at opportunity cost.

Y must buy the components from X.

X must satisfy demand from Y before making external sales.

Required

(1) Calculate the profit for each division if the external demand per period for the components that are made by X Division is:

(i) 15,000 components

(ii) 19,000 components

(iii) 35,000 components

(2) Calculate the financial impact on the Group if Y Division ignored the transfer pricing policy and purchased all of the 20,000 components that it needs from an external supplier for ₹255 each. Your answer must consider the impact at each of the three levels of demand (15,000, 19,000 and 35,000 components) from external customers for the component manufactured by X Division.

Solution

(i) Computation of Weighted Average Transfer Price

Particulars	**External Demand 15,000 Components**	**External Demand 19,000 Components**	**External Demand 35,000 Components**
Component's Transfer Price (Base)	Variable Cost	Variable Cost *plus* Opportunity Cost for 4,000 Components	Variable Cost *plus* Opportunity Cost for 20,000 Components

Variable Cost (₹)	157.00	157.00	157.00
Opportunity Cost (₹)	0	28.60 $\left(\frac{4,000}{20,000} \times ₹143\right)$	143.00 $\left(\frac{20,000}{20,000} \times ₹143\right)$
Transfer Price (₹)	157.00	185.60	300.00

Opportunity Cost for a Component is the Contribution *forgone* by not selling it to the market.

Contribution = Market Selling Price – Variable Cost

= ₹300 – ₹157

= ₹143

Statement Showing "Profitability of Division- X"

Particulars	**External Demand 15,000 Components (₹)**	**External Demand 19,000 Components (₹)**	**External Demand 35,000 Components (₹)**
Sales :			
- Division–Y	31,40,000 (₹157 × 20,000)	37,12,000 (₹185.60 × 20,000)	60,00,000 (₹300 × 20,000)
- Market	45,00,000 (₹300 × 15,000)	45,00,000 (₹300 × 15,000)	45,00,000 (₹300 × 15,000)
Total Revenue	76,40,000	82,12,000	1,05,00,000
Less: Variable Cost (₹157 × 35,000)	54,95,000	54,95,000	54,95,000
Less: Fixed Cost	20,62,000	20,62,000	20,62,000
Profit	83,000	6,55,000	29,43,000

Statement Showing "Profitability of Division- Y"

Particulars	**External Demand 15,000 Components (₹)**	**External Demand 19,000 Components (₹)**	**External Demand 35,000 Components (₹)**
Selling Price *per unit*	1,200.00	1,200.00	1,200.00
Less: Variable Cost *per unit:* Component – X	314.00 (₹157 × 2)	371.20 (₹185.60 × 2)	600.00 (₹300 × 2)
Others	375.00	375.00	375.00

Contribution *per unit*	511.00	453.80	225.00
No. of units	10,000	10,000	10,000
Total Contribution	51,10,000	45,38,000	22,50,000
Less: Fixed Cost	13,50,000	13,50,000	13,50,000
Profit	37,60,000	31,88,000	9,00,000

(ii) Financial Impact on the Group if Y Division Ignored the Transfer Pricing Policy

Particulars	**External Demand 15,000 Components (₹)**	**External Demand 19,000 Components (₹)**	**External Demand 35,000 Components (₹)**
Extra Cost of External Purchase (₹255–₹157)× 20,000	19,60,000	19,60,000	19,60,000
Extra Contribution by External Selling by X			
0 × ₹143	0	---	---
4,000 × ₹143	---	5,72,000	---
20,000 × ₹143	---	---	28,60,000
Net Impact	(19,60,000)	(13,88,000)	9,00,000

Problem-6

Division A is a profit centre, which produces four products P, Q, R and S. Each product is sold in the external market also. Data for the period is as follows:

	P	***Q***	***R***	***S***
Market Price per unit (₹)	*350*	*345*	*280*	*230*
Variable Cost of Production per unit	*330*	*310*	*180*	*185*
Labour Hours Required per unit	*3*	*4*	*2*	*3*

Product S can be transferred to Division B but the maximum quantity that might be required for transfer is 2,000 units of S.

The maximum sales in the external market are:

P.. 3,000 units
Q.. 3,500 units
R.. 2,800 units
S.. 1,800 units

Division B can purchase the same product at a slightly cheaper price of ₹ 225 per unit instead of receiving transfers of product S from Division A.

Required

What should be transfer price for each unit for 2,000 units of S, if the total labour hours available in Division A are:

(i) 24,000 hours?

(ii) 32,000 hours?

Solution

Working Note

Ranking of Products When Availability of Time is the Key Factor

Product	P	Q	R	S
Market Price *per unit* (₹)	350	345	280	230
Less: Variable Cost of Production *per unit* (₹)	330	310	180	185
Contribution *per unit* (₹)	20	35	100	45
Labour Hours Required *per unit*	3 hrs.	4 hrs.	2 hrs.	3 hrs.
Contribution *per hour* (₹)	6.67 (₹20 ÷ 3hrs)	8.75 (₹35 ÷ 4hrs)	50 (₹100 ÷ 2hrs)	15 (₹45 ÷ 3hrs)
Ranking	IV	III	I	II

Requirement

(i) Statement Showing "Production Mix"

(When Total Available Hours in Division A are 24,000)

Product (Refer to W.N.)	Maximum Demand (units)	Hours *per unit*	Units Produced	Hours Used	Balance Hours
(a)	(b)	(c)	(d)	(e)=(b)×(c)	(f)
R	2,800	2	2,800	5,600	18,400 (24,000 – 5,600)
S	1,800	3	1,800	5,400	13,000 (18,400 – 5,400)
Q	3,500	4	3,250	13,000	0 (13,000 – 13,000)
P	3,000	3	0	0	0

Note

Time required to meet the demand of 2,000 units of Product S for Division B is 6,000 hrs. This requirement of time viz., 6,000 hours for providing 2,000 units of Product S for Division B can be met by sacrificing the production of 1,500 units of Product Q (1,500 units × 4 hrs.).

Statement Showing "Transfer Price for each unit for 2,000 units of S"

Transfer Price	2,000 units of Product S (₹)	Per unit of Product S (₹)
Variable Cost	3,70,000	185.00
Opportunity Cost of the Contribution Foregone *by not producing* 1,500 units of Q (1500 units × ₹35)	52,500	26.25
Transfer Price	4,22,500	211.25

(ii) Statement of Product Mix (When Total Available Hours in Division A are 32,000)

Product (Refer to W.N.)	Maximum Demand (units)	Hours *per unit*	Units Produced	Hours Used	Balance Hours
(a)	(b)	(c)	(d)	(e)=(b)×(c)	(f)
R	2,800	2	2,800	5,600	26,400 (32,000 – 5,600)
S	1,800	3	1,800	5,400	21,000 (26,400 – 5,400)
Q	3,500	4	3,500	14,000	7,000 (21,000 – 14,000)
P	3,000	3	2,333	7,000	0 (7,000 – 7,000)

Note

The required time for producing 2,000 units of Product S for Division B is 6,000 hrs. This requirement can be met by sacrificing the output of 2,000 units of Product P.

Statement of Transfer Price for each unit for 2,000 units of S

Transfer Price	2,000 units of Product S (₹)	Per unit of Product S (₹)
Variable Cost	3,70,000	185.00
Opportunity Cost of the Contribution Foregone *by not producing* 2,000 units of P (2,000 units × ₹20)	40,000	20.00
Transfer Price	4,10,000	205.00

Problem-7

Bright Furniture Company has two divisions Division' FXR' and Division 'FQR'. Both divisions are independent. Each division serves a different market in the furniture industry.

Division 'FXR' manufactures furniture that is used by the canteens/ coffee bars. The division plans to introduce cushioned seat for the counter chairs. A cushioned seat currently made by the Division 'FQR' for use on its stylish stool could be modified for use on the new counter chair. Division 'FQR' can make the necessary modifications to the cushioned seat easily.

The raw materials used in Division 'FXR' seat are slightly different and should cost about 20 percent more than those used in Division 'FQR' stylish stool. However, the labour time should be the same because the seat fabrication operation is basically the same.

Division 'FQR' is operating at full capacity. By making the cushion seats for Division 'FXR', Division 'FQR' have to cut its production of stylish stools. However, Division 'FQR' can increase its production of normal stools. The labour time freed by not having to fabricate the frame or assemble the stylish stool can be shifted to the frame fabrication and assembly of the normal stool. Division 'FQR' can switch its labour force between these two models of stools without any loss of efficiency. Labour hours cannot be increase. Division 'FQR' has excess demand for both products. Following are Division 'FQR''s standard costs for the two stools and a schedule of Division 'FQR''s manufacturing overhead.

'FQR' DIVISION
Standard Selling Price and Cost

	Stylish Stool		Normal Stool	
	(₹)	(₹)	(₹)	(₹)
Selling Price		225.00		160.00
Less: Raw Materials				
Framing	32.60		39.04	
Cushioned Seat				
- Padding	9.60		---	
- Vinyl	16.00		---	
Moulded Seat (Purchased)	---	58.20	24.00	63.04
Less: Direct Labour				
Frame Fabrication				
- (0.5 × ₹ 30.00/DLH#)	15.00		---	
- (0.5 × ₹ 30.00/DLH)	---		15.00	
Cushion Fabrication				

- (0.5 × ₹ 30.00/DLH)	15.00		---	
Assembly*				
- (0.5 × ₹ 30.00/DLH)	15.00		---	
- (0.3 × ₹ 30.00/DLH)	---	45.00	9.00	24.00
Less: Manufacturing Overhead				
- (1.5 DLH × ₹ 51.20/DLH)		76.80		---
- (0.8 DLH × ₹ 51.20/DLH)		---		40.96
Profit / (Loss)		45.00		32.00

(*)Attaching seats to frames and attaching rubber feet

(#) DLH refers to Direct Labour Hour

'FQR' DIVISION
Manufacturing Overhead Budget

Overhead Item	(₹)
Indirect Material (Variable - at Current Market Prices)	16,80,000
Indirect Labour (Variable)	15,00,000
Supervision (Non Variable)	10,00,000
Power (Use Varies with Activity; Rates are Fixed)	7,20,000
Heat and Light (Non Variable - Same Regardless of Production)	5,60,000
Miscellaneous Overheads (Non Variable - Any Change in Amounts or Rates is Independent of Production)	8,00,000
Depreciation (Fixed)	68,00,000
Employee Benefits (20% of Supervision, Direct and Indirect Labour)	23,00,000
Total Overhead	1,53,60,000
Capacity in DLH	3,00,000
Overhead Rate / DLH	₹ 51.20

Required

Assume that you are the corporate controller. What transfer price would you recommend for a 200 unit lot of seats?

Solution

Working Note

(1) Statement Showing Variable Cost *per* 200-unit lot

	(₹)	(₹)
Cushion Material:		
- Padding	9.60	
- Vinyl	16.00	
Total Cushion Material	25.60	
Cost Increase by 20%	5.12	
Cost of Cushioned Seat		30.72
Cushion Fabrication Labour (₹30 × 0.5)		15.00
Variable Overhead (W.N.-2) (₹20 × 0.5)		10.00
Variable Cost *per Cushioned Seat*		55.72
Total Variable Cost *per* 200-unit lot (₹55.72 × 200)		11,144

(2) Statement Showing Fixed Overhead & Variable Overhead Rate per Direct Labour Hour

	Variable Amount		Fixed Amount	
	(₹)	(₹)	(₹)	(₹)
	Total	Per DLH	Total	Per DLH
Indirect Material	16,80,000	5.60	---	---
Indirect Labour	15,00,000	5.00	---	---
Supervision	---	---	10,00,000	3.33
Power	7,20,000	2.40	---	---
Heat and Light	---	---	5,60,000	1.87
Miscellaneous Overheads	---	---	8,00,000	2.67
Depreciation	---	---	68,00,000	22.67
Employee Benefits:				
- 20% Direct Labour*	18,00,000	6.00	---	---
- 20% Supervision	---	---	2,00,000	0.66
- 20% Indirect Labour	3,00,000	1.00	---	---
	60,00,000	20.00	93,60,000	31.20

Variable Overhead Rate	=	₹60,00,000 ÷ 3,00,000
	=	₹20.00 / DLH
Fixed Overhead Rate	=	₹93,60,000 ÷ 3,00,000
	=	₹31.20 / DLH

* Direct Labour Cost

0.2 (₹ 10,00,000 + DL + ₹ 15,00,000)	=	₹23,00,000
0.2 DL	=	₹18,00,000
DL	=	₹90,00,000

(3) Statement Showing "Loss of Contribution Margin from Outside Sales"

	Stylish Stool (₹)	Normal Stool (₹)
Selling Price	225.00	160.00
Less: Material	58.20	63.04
Less: Labour	45.00 (₹30.00 × 1.5)	24.00 (₹30.00 × 0.8)
Less: Variable Overhead	30.00 (₹20.00 × 1.5)	16.00 (₹20.00 × 0.8)
Contribution Margin *per unit*	91.80	56.96
Units Produced (units)	200	250 (W.N.- 4)
	18,360	14,240

Amount of Contribution Margin Lost as a result of shifting production to the Normal Stool ₹4,120 (₹18,360 – ₹14,240).

(4) Number of Economy Office Stools *that can be produced*

Labour Hours *to make* a 200-unit lot of Stylish Stools (1.50 × 200)	300 Hrs
Less: Labour Hours *to make* a 200-unit lot of Cushioned Seats (0.50 × 200)	100 Hrs
Labour Hours *available for* Normal Stool	200Hrs
Labour hours *required to make* one Normal Stool	0.8 Hrs / Stool
Use of Extra Labour *devoted to* Normal Stool Production (200 / 0.8)	250 Stools

Since the 'FQR' Division is operating at Full Capacity, the Transfer Price must consider the Division's Variable Costs of Manufacturing the Seat *plus* the Lost Contribution Margin that will result from *losing outside sales*. Thus, the Transfer Price (W.N.-1 & 3) equals to ₹15,264 (₹11,144 + ₹4,120).

Negotiated Transfer Price

Problem-8

Tripod Ltd. has three divisions – X, Y and Z, which make products X, Y and Z respectively. For Division Y, the only direct material is product X and for Z, the only direct material is product Y. Division X purchases all its raw material from outside. Direct selling overhead, representing commission to external sales agents are avoided on all internal transfers. Division Y additionally incurs ₹ 10 per unit and ₹ 8 per unit on units delivered to external customers and Z respectively. Y also incurs ₹ 6 per unit picked up from X, whereas external suppliers supply at Y's factory at the stated price of ₹ 85 per unit.

Additional information is given below:

	Figures (₹)/unit		
	X	***Y***	***Z***
Direct Materials (external supplier rate)	*40*	*85*	*135*
Direct Labour	*30*	*50*	*45*
Sales Agent's Commission	*15*	*15*	*10*
Selling Price (in external market)	*110*	*170*	*240*
Production Capacity (units)	*20,000*	*30,000*	*40,000*
External Demand (units)	*14,000*	*26,000*	*42,000*

Required

Discuss the range of negotiation for Managers X, Y and Z, for the number of units and the transfer price for internal transfers.

Solution

Analysis of Range of Negotiation for Manager of Division X

(Figures in ₹)

Division X

	Outside Sales	**Sales to Y (Range)**
Selling Price	110	70 - 79*
Less: Commission	15	-- - --
Net Selling Price	95	70 – 79
Less: Variable Cost	70	70 – 70

Contribution *per unit*	25	0 - 9
Units	14,000	6,000 - 6,000
Total Contribution (Units × Contribution *per unit*)	3,50,000	0 - 54,000

(*) External Rate – Transport Expense

Analysis of Range of Negotiation for Manager of Division Y

(Figures in ₹)

Division Y

	Outside Sales			**Sale to Div. Z**		
	From Division X		**From Outside**	**From Division X**		**From Outside**
Price Range	70	79	85	70	79	85
Add: Transport	6	6	---	6	6	---
Total	76	85	85	76	85	85
Add: Direct Labour	50	50	50	50	50	50
Total	126	135	135	126	135	135
Add: Delivery Cost	10	10	10	8	8	8
Total	136	145	145	134	143	143
Add: Sales Commission	15	15	15	---	---	---
Total Cost ...(B)	151	160	160	134	143	143
Selling Price ...(A)	170	170	170	135	135	135
Contribution ...(A)-(B)	19	10	10	1	(8)	(8)

Range of Negotiations

Manager of Division X will sell 14,000 units outside at ₹110 per unit and earn contribution of ₹3.50 lakhs. Excess capacity of 6,000 units can be offered to Division Y at a price between ₹70 (variable manufacturing cost to Division X) and ₹95 (maximum amount to equal outside contribution). But Division Y can get the material outside at ₹85. So, Division Y will not pay to Division X anything above ₹79 (₹85 – ₹6) to match external available price.

Division X will be attracted to sell to Division Y only in the range of ₹71 – ₹79 per unit at a volume of 6,000 units. At ₹70, Division X will be indifferent, but may offer to sell to Division Y to use idle capacity.

Division Z will not buy from Division Y at anything above ₹135. If Division X sells to Division Y at 70 per unit, Division Y can sell to Division Z at ₹134 and earn no contribution, only for surplus capacity and if units transferred by Division X to Division Y at ₹70 per unit.

	Division Y	Division Z
Provided Division X sells to Division Y at ₹70 *per unit*	Sell 4,000 units to Division Z at ₹134 (Indifferent)	Buy 4,000 units from Division Y at ₹134 (attracted)
	Sell 4,000 units to Division Z at ₹135 (Willingly for a contribution of ₹1)	Indifferent, since market price is also ₹135

For buying from X at ₹71 – ₹79 price range, Y will be interested in selling to Z only at prices ₹136 – ₹143, which will not interest Z.

Thus Y will sell to Z only if X sells to Y at ₹70 per unit and Y will supply to Z maximum 4,000 units.

Transfer Pricing Decision – Different Capacity Levels

Problem-9

Tycoon Ltd. has two manufacturing departments organized into separate profit centres known as Textile unit and Process House. The Textile unit has a production capacity of 5 lacs metres cloth per month, but at present its sales is limited to 50% to outside market and 30% to process house.

The transfer price for the year 2014 was agreed at ₹ 6 per metre. This price has been fixed in line with the external wholesale trade price on 1st January, 2014. However, the price of yarn declined, which was the raw material of textile unit, with effect, that wholesale trade price reduced to ₹ 5.60 per metre with effect from 1st June, 2014. This price was however not made applicable to the sales made to the processing house of the company. The textile unit turned down the processing house request for revision of price.

The Process house refines the cloth and packs the output known as brand Rayon in bundles of 100 metres each. The selling price of the Rayon is ₹ 825 per bundle. The process house has a potential of selling a further quantity of 1,000 bundles of Rayon provided the overall prices is reduced to ₹ 725 per bundle. In that event it can buy the additional 1,00,000 metres of cloth from textile unit, whose capacity can be fully utilised. The outside market has no further scope.

The cost data relevant to the operations are:

	Textile unit (₹)	*Process house (₹)*
Raw material (per metre) on 1st June, 2014	*3.00*	*Transfer price*
Variable cost	*1.20 (per metre)*	*80 (per bundle)*
Fixed cost (per month)	*4,12,000*	*1,00,000*

Required

(i) Prepare statement showing the estimated profitability for June, 2014 for Textile unit and Process house and company as a whole on the following basis:

(a) At 80% and 100% capacity utilisation of the Textile unit at the market price (external wholesale trade price on 1st January, 2014) and the transfer price to the Processing house of ₹ 6 per metre.

(b) At 80% capacity utilisation of the Textile unit at the market price of ₹ 5.60 per metre and the transfer price to the Processing house of ₹ 6 per metre.

(c) At 100% capacity utilisation of the Textile unit at the market price of ₹ 5.60 per metre and the transfer price to the Processing house of ₹ 5.60 per metre.

(ii) Comment on the effect of the company's transfer pricing policy on the profitability of Processing house.

Solution

(i) (a)

At 80% Level

Textile Unit	(₹)	Process House	(₹)
Sales (4,00,000 Mtr. × ₹6)	24,00,000	Sales (1,50,000 Mtr. ÷ 100 Mtr. × ₹ 825)	12,37,500
Less: Raw Material (4,00,000 Mtr. × ₹3)	12,00,000	*Less:* Transfer Price (1,50,000 Mtr. × ₹6)	9,00,000
Less: Variable Cost (4,00,000 Mtr. × ₹1.2)	4,80,000	*Less:* Variable Cost (1,500 Bundles × ₹ 80)	1,20,000
Less: Fixed Cost	4,12,000	*Less:* Fixed Cost	1,00,000
Profit	3,08,000	Profit	1,17,500

Overall Profit *equals* to ₹4,25,500 (₹3,08,000 + ₹1,17,500).

At 100% Level

Textile Unit	(₹)	Process House	(₹)
Sales (5,00,000 Mtr. × ₹6)	30,00,000	Sales (2,50,000 Mtr. ÷ 100 Mtr. × ₹725)	18,12,500
Less: Raw Material (5,00,000 Mtr. × ₹3)	15,00,000	*Less:* Transfer Price (2,50,000 Mtr. × ₹6)	15,00,000
Less: Variable Cost (5,00,000 Mtr. × ₹1.2)	6,00,000	*Less:* Variable Cost (2,500 Bundles × ₹80)	2,00,000
Less: Fixed Cost	4,12,000	*Less:* Fixed cost	1,00,000
Profit	4,88,000	Profit	12,500

Overall Profit *equals* to ₹5,00,500 (₹4,88,000 + ₹12,500).

(b)

At 80% Level (Market Price ₹5.60 and Transfer Price ₹6)

Textile Unit	(₹)	Process House	(₹)
Sales [(2,50,000 Mtr. × ₹5.6) + (1,50,000 Mtr. × ₹6.0)]	23,00,000	Sales (1,50,000 Mtr. ÷ 100 Mtr. × ₹ 825)	12,37,500
Less: Raw Material (4,00,000 Mtr. × ₹3)	12,00,000	*Less:* Transfer Price (1,50,000 Mtr. × ₹6)	9,00,000
Less: Variable Cost (4,00,000 Mtr. × ₹1.2)	4,80,000	*Less:* Variable Cost (1,500 Bundles × ₹ 80)	1,20,000
Less: Fixed Cost	4,12,000	*Less:* Fixed Cost	1,00,000
Profit	2,08,000	Profit	1,17,500

Overall Profit *equals* to ₹3,25,500 (₹2,08,000 + ₹1,17,500).

(c)

Sales 100% Level at (₹ 5.60)

Textile Unit	(₹)	Process House	(₹)
Sales (5,00,000 Mtr. × ₹5.6)	28,00,000	Sales (2,50,000 Mtr. ÷ 100 Mtr. × ₹725)	18,12,500
Less: Raw Material (5,00,000 Mtr. × ₹3)	15,00,000	*Less:* Transfer Price (2,50,000 Mtr. × ₹5.6)	14,00,000

Less: Variable Cost (5,00,000 Mtr. × ₹1.20)	6,00,000	*Less:* Variable Cost (2,500 Bundles × ₹80)	2,00,000
Less: Fixed Cost	4,12,000	*Less:* Fixed Cost	1,00,000
Profit	2,88,000	Profit	1,12,500

Overall Profit *equals* to ₹4,00,500 (₹2,88,000 + ₹1,12,500).

(ii) Comments on the Profitability of 'Processing House'

		Transfer Price (₹)	Profit (₹)
(a)	80% Capacity	6.00	1,17,500
	100% Capacity	6.00	12,500
(b)	80% Capacity	6.00	1,17,500
(c)	100% Capacity	5.60	1,12,500

Processing House will not be interested to buy more than 1,50,000 meters from textile units.

Transfer Pricing Decision – Different Demand Levels

Problem-10

The two manufacturing divisions of a company are organized on profit centre basis. Division X is the only source of a component required by Division Y for their product 'P'. Each unit of P requires one unit of the said component. As the demand of the product is not steady, orders for increased quantities can be obtained by manipulating prices.

The manager of Division Y has given the following forecast:

Sales per Day (units)	*Average Price per Unit of P (₹)*
5,000	*393.75*
10,000	*298.50*
15,000	*247.50*
20,000	*208.50*
25,000	*180.00*
30,000	*150.75*

The manufacturing cost (excluding the cost of the component from Division X) of P in Division Y is ₹ 14,06,250 on first 5,000 units and ₹ 56.25 per unit in excess of 5,000 units.

Division X incurs a total cost of ₹ 5,62,500 per day for an output upto 5,000 components and the total costs will increase by ₹ 3,37,500 per day for every additional 5,000 components manufactured. The Manager of Division X has set the transfer price for the component at ₹ 90 per unit to optimize the performance of his Division.

Required

(i) *Prepare a divisional profitability statement at each level of output, for Division X and Y separately;*

(ii) *Find out the profitability of the company as a whole at the output level where:*

(a) *Division X's net profit is maximum;*

(b) *Division Y's net profit is maximum.*

(iii) *Find out at what level of output, the company will earn maximum profit, if the company is not organized on profit centre basis.*

Solution

(i) **Statement Showing "Profitability of Division X"**

No. of Components (a)	Transfer Price *for the component* to Division Y @ ₹ 90 *per unit* (b)	Total Cost of Components (₹) (c)	Profit / (Loss) (₹) (d) = (b) – (c)
5,000	4,50,000	5,62,500	(1,12,500)
10,000	9,00,000	9,00,000	__
15,000	13,50,000	12,37,500	1,12,500
20,000	18,00,000	15,75,000	2,25,000
25,000	22,50,000	19,12,500	3,37,500
30,000	**27,00,000**	**22,50,000**	**4,50,000**

Statement Showing "Profitability of Division Y"

No. of Components (a)	Sale Revenue on Average Price Basis (₹) (b)	Component Cost (Transfer Price) to Division Y (₹) (c)	Manufacturing Cost in Division Y (₹) (d)	Total Cost (₹) (e) = (c)+(d)	Profit / (Loss) (₹) (f) = (b)-(e)
5,000	19,68,750	4,50,000	14,06,250	18,56,250	1,12,500
10,000	**29,85,000**	**9,00,000**	**16,87,500**	**25,87,500**	**3,97,500**
15,000	37,12,500	13,50,000	19,68,750	33,18,750	3,93,750
20,000	41,70,000	18,00,000	22,50,000	40,50,000	1,20,000
25,000	45,00,000	22,50,000	25,31,250	47,81,250	(2,81,250)
30,000	45,22,500	27,00,000	28,12,500	55,12,500	(9,90,000)

(ii) Profitability of the Company as a Whole

(a) At 30,000 units level, at which Division X's Net Profit is *maximum*

	(₹)
Profit of Division X	4,50,000
Profit of Division Y	(9,90,000)
Operating Profitability/ (Loss) of the Company	(5,40,000)

(b) At 10,000 units level, at which Division Y's Net Profit is *maximum*

	(₹)
Profit of Division X	NIL
Profit of Division Y	3,97,500
Operating Profitability of the Company	3,97,500

(iii) Profitability of the Company, *if it is not organized* on Profit Centre Basis

No. of Components (a)	Sales Revenue on Average Basis (₹) (b)	Cost of Component to Division X (₹) (c)	Manufacturing Cost in Division Y (₹) (d)	Total Cost (₹) (e)=(c)+(d)	Profit/ (Loss) (₹) (f)=(b)–(e)
5,000	19,68,750	5,62,500	14,06,250	19,68,750	-
10,000	29,85,000	9,00,000	16,87,500	25,87,500	3,97,500
15,000	**37,12,500**	**12,37,500**	**19,68,750**	**32,06,250**	**5,06,250**
20,000	41,70,000	15,75,000	22,50,000	38,25,000	3,45,000
25,000	45,00,000	19,12,500	25,31,250	44,43,750	56,250
30,000	45,22,500	22,50,000	28,12,500	50,62,500	(5,40,000)

The Level of Output, the company will earn *maximum* Profit; if the company is not organized on Profit Centre basis are 15,000 Components.

Problem-11

PEX is a manufacturing company of which Division PQR manufactures a single standardized product. Some of the output is sold externally whilst the remainder is transferred to Division RPQ where it is a sub-assembly in the manufacture of that division's product. PQR has the capacity (annual) to produce 30,000 units of the product. The unit costs of Division PQR's products is as under:

	(₹)
Direct Material	*40*
Direct Labour	*20*
Direct Expenses	*20*

Variable Manufacturing Overheads	*20*
Fixed Manufacturing Overheads	*40*
Sells and Packaging Expenses - Variable	*10*
	150

Annually 20,000 units of the product are sold externally at the standard price of ₹ 300 per unit.

In addition to the external sales, 10,000 units are transferred annually to Division RPQ at an internal transfer price of ₹ 290 per unit. This transfer price is obtained by deducting variable selling and packing expenses from the external price since those expenses are not incurred for internal transfers.

Division RPQ incorporates the transferred-in goods into a more advanced product. The unit costs of this product are as follows:.

	(₹)
Transferred-in-item (from Division PQR)	*290*
Direct Material and Components	*230*
Direct Labour	*30*
Variable Overheads	*120*
Fixed Overheads	*120*
Selling and Packing Expenses - Variable	*10*
	800

Division RPQ's manager disagrees with the basis used to set the transfer price. He argues that the transfers should be made at variable cost plus an agreed (minimal) mark up because his division is taking output that Division PQR would be unable to sell at the price of ₹ 300.

Partly because of this disagreement, a study of the relationship between selling price and demand has recently been carried out for each division by the company's sales director. The study has brought out the following demand schedule:

Division PQR			
Selling Price (₹)	*200*	*300*	*400*
Demand (units)	*30,000*	*20,000*	*10,000*
Division RPQ			
Selling Price (₹)	*800*	*900*	*1,000*
Demand (units)	*14,400*	*10,000*	*5,600*

The manager of the Division RPQ claims that this study supports his case. He suggests that a transfer price of ₹ 120 would give Division PQR a reasonable contribution to its fixed overheads while allowing Division RPQ to earn a reasonable profit. He also believes that it would lead to an increase of output and an improvement in the overall level of company profits.

Required

(i) Calculate the effect of the transfer price of ₹ 290 per unit on company's operating profit. Calculate the optimal product mix.

(ii) Advise the company on whether the transfer price should be revised to ₹ 120 per unit.

Solution

Contribution Analysis of Divisions

(i) Contribution – Division PQR

Selling Price (₹)	200	300	400
Less: Variable Cost (₹)	110	110	110
Contribution *per unit* (₹)	90	190	290
Demand (units)	30,000	20,000	10,000
Total Contribution (₹)	27,00,000	38,00,000*	29,00,000

(*) Optimal

The above table shows ₹300 price to be the most profitable and that cutting prices would not result in increased profits.

(ii) Contribution – Division RPQ (Transfer Price at ₹290)

Selling Price (₹)	800	900	1,000
Less: Variable Cost (₹)	680	680	680
Contribution *per unit* (₹)	120	220	320
Demand (units)	14,400	10,000	5,600
Total Contribution(₹)	17,28,000	22,00,000*	17,92,000

(*) Optimal

(iii) Contribution – Division RPQ (at Alternative Transfer Price ₹120)

Selling Price (₹)	800	900	1,000
Variable Cost (₹)	510	510	510
Contribution *per unit* (₹)	290	390	490
Demand (units)	14,400	10,000	5,600
Total Contribution(₹)	41,76,000*	39,00,000	27,44,000

(*) Optimal

The maximum capacity of the Division PQR is given as 30,000 units. Hence there is no question of internal transfer if the entire 30,000 units are sold by Division PQR in the external market. However, from the above computations it is clear that Division PQR would sell 20,000 units in external market to optimize its profit and therefore the maximum transfer to Division RPQ is 10,000 units only. The question of transferring 14,400 units would arise as an alternative to analyze the overall profitability only when Division PQR sells 10,000 units in the external market. Based on the demand projection of Division RPQ, the demand level of 5,600 units is not relevant. It can be further noted from the problem that Division RPQ will purchase the entire quantity only from Division PQR and not externally. Hence the various options would be as follows-

	Option-1	**Option-2**	**Option-3**
PQR External Sales (units)	20,000	10,000	10,000
Transfer to RPQ (units)	10,000	14,400	10,000

Overall Profitability of the Company

(iv) Transfer Price at ₹290

PQR External Sales (units)	**20,000**	**10,000**	**10,000**
Transfer to RPQ (units)	**10,000**	**14,400**	**10,000**
	(₹)	**(₹)**	**(₹)**
Contribution to Division PQR (External) [Refer Computation (i) above]	38,00,000	29,00,000	29,00,000
Contribution to Division PQR (Transfer) @ ₹190 [₹290 *less* ₹100 Variable Cost#]	19,00,000	27,36,000	19,00,000
Contribution to Division RPQ [Refer Computation (ii) above]	22,00,000	17,28,000	22,00,000
Total Contribution for the Company	79,00,000*	73,64,000	70,00,000
Less: Fixed Costs [PQR 30,000 units × ₹40 + RPQ 10,000 units × ₹120]	24,00,000	24,00,000	24,00,000
Total Company Profit	55,00,000	49,64,000	46,00,000

(*) Optimal

(v) Transfer Price at ₹ 120

PQR External Sales (units)	**20,000**	**10,000**	**10,000**
Transfer to RPQ (units)	**10,000**	**14,400**	**10,000**

	(₹)	(₹)	(₹)
Contribution to Division PQR (External) [Refer Computation (i) above]	38,00,000	29,00,000	29,00,000
Contribution to Division PQR (Transfer) @ ₹20 [₹120 *less* ₹100 Variable Cost#]	2,00,000	2,88,000	2,00,000
Contribution to Division RPQ [Refer Computation (iii) above]	39,00,000	41,76,000	39,00,000
Total Contribution for the Company	79,00,000*	73,64,000	70,00,000
Less: Fixed Costs [PQR 30,000 units × ₹40 + RPQ 10,000 units × ₹120]	24,00,000	24,00,000	24,00,000
Total Company Profit	55,00,000	49,64,000	46,00,000

(*) Optimal

Advise

The revision of transfer price has no impact on the overall profitability of the company. However, it will alter the profitability of the Divisions.

(*) The optimal level is 30,000 of Division PQR of which 20,000 units are for external sale and 10,000 units are transferred to Division RPQ under both the transfer prices.

(#) On internal transfers, Division PQR's variable cost per unit is ₹ 100, since the ₹ 10 on selling is not incurred.

Problem-12

Four products P, Q, R and S are produced by profit centre Division A. Each product is sold in the external market also. Data for the period are as follows:

	P	***Q***	***R***	***S***
Market Price per unit (₹)	*70*	*69*	*56*	*46*
Variable Cost of Production per unit (₹)	*66*	*59*	*36*	*37*
Labour Hours per unit	*3*	*2*	*2*	*3*
Specific Fixed Costs (₹) per 10,000 units of product	*2,500*	*12,600*	*15,000*	*18,000*

Product S can be transferred to Division B but the maximum quantity that might be required for transfer is 20,000 units of S. The specific fixed costs given above are avoidable if a product is not made. They are incurred for every 10,000 units.

The maximum sales (units) in the external market are:

P……………………………….. 30,000

Q……………………………….. 31,000
R……………………………….. 28,000
S……………………………….. 18,000

Division B can purchase the same product at a slightly cheaper price of ₹45 per unit instead receiving transfers of product S from Division A without any extra transport/inspection costs. B can also take partial supplies from A.

The total labour hours available in Division A is 1,92,000 hrs.

Required

(i) What is A's optimal product mix and the corresponding contribution net of specific fixed costs?

(ii) How many units should A transfer to B and at what price?

(iii) Is it in the company's interest to transfer 20,000 units of S to B?

Solution

(i) Statement Showing "Contribution *per unit* as well as Contribution *per labour hour*"

	Maximum Sales (Units)			
	30,000	**31,000**	**28,000**	**18,000**
	P	**Q**	**R**	**S**
Market Price (₹/u)	70	69	56	46
Less: Variable Cost of Production (₹/u)	66	59	36	37
Contribution (₹/u)	4	10	20	9
Labour Hours *per unit*	3	2	2	3
Contribution (₹/hr.)	1.33	5	10	3
Rank [Contribution (₹/hr.)]	IV	II	I	III
Specific Fixed Costs (₹/10,000 units)	2,500	12,600	15,000	18,000

Rank **would be same in case of 'Contribution** *net of* **Specific Fixed Cost'.**

Allocation of Labour Hours ***on the basis of ranking***

	Hrs.
Hours Available	1,92,000
Less: Allocated for R (Rank I) {28,000 units × 2 hrs.}	56,000

Balance	1,36,000
Less: Allocated for Q (Rank II) {30,000 units* × 2 hrs.}	60,000
Balance	76,000
Less: Allocated for S (Rank III) {18,000 units × 3 hrs.}	54,000
Balance	22,000
Less: Allocated for P (Rank IV) $\left\{\frac{22,000\text{ hrs.}}{3\text{ hrs.}} = 7,333.33\text{ units}\right\}$	22,000

(*)

Manufacture Product Q only up to 30,000 units, as next 1,000 units is not justified due to ₹ 12,600 being spent.

Statement Showing "Optimal Product Mix and Contribution Net of Specific Fixed Costs *on the basis of ranking*"

Product	P	Q	R	S	Total
Rank	IV	II	I	III	
Units	7,333.33	30,000	28,000	18,000	
Contribution (₹/u)	4	10	20	9	
Total Contribution (₹)	29,333.32	3,00,000	5,60,000	1,62,000	10,51,333.32
Specific Fixed Cost (₹)	2,500	37,800	45,000	36,000	1,21,300
	26,833.32	2,62,200	5,15,000	1,26,000	9,30,033.32

(ii) Statement Showing "Contribution *per unit* as well as Contribution *per labour hour* Product P & S"

	Maximum Sales/ Transfer (Units)		
	30,000	18,000	20,000
	P	$S_{EXT.}$	$S_{DIV.B}$
Market Price (₹/u)	70	46	45
Less: Variable Cost of Production (₹/u)	66	37	37
Contribution (₹/u)	4	9	8
Labour Hours *per unit*	3	3	3
Contribution (₹/hr.)	1.33	3	2.66
Rank [Contribution (₹/hr.)]	III	I	II
Specific Fixed Costs (₹/10,000 units)	2,500	18,000	18,000

Statement Showing "Computation of Qty. Transfer to Division B"

	Hrs.
Hours Available (After allocation to Q & R)	76,000
Less: Allocated for $S_{EXT.}$ (Rank I) {18,000 units × 3 hrs.}	54,000
Balance	22,000
Less: Allocated for $S_{DIV.B}$ (Rank II) $\left\{\frac{22,000\text{ hrs.}}{3\text{ hrs.}} = 7,333.33\text{ units}\right\}$	22,000

Statement Showing "Computation of Transfer Price"

	units
Variable Cost {7,333.33 units × ₹37}	2,71,333.21
Add: Loss of Contribution Net of Specific Fixed Cost "P"	26,833.32
Add: Additional Specific Fixed Cost "S"	18,000
Total	3,16,166.53
Transfer Qty.	7,333.33
Transfer Price $\left\{\frac{₹\ 3,16,166.53}{7,333.33\text{ units}}\right\}$	43.11

(iii) **Statement Showing "Qty. of 'Loss of External Sales'"**

	units
Requirement $S_{DIV.B}$	20,000
Less: On the basis of allocation (ii) $S_{DIV.B}$	7,333.33
Loss of External Sales $S_{EXT.}$	12,666.67

Statement Showing "Net Gain on Transfer of 20,000 units to Division B"

	Rs.
Savings {20,000 units × (₹45 - ₹37)}	1,60,000
Less: Loss of Contribution $S_{EXT.}$ (12,666.67 units ×₹9)	1,14,000
Less: Loss of Contribution Net of Specific Fixed Cost "P"	26,833.32
Less: Additional Specific Fixed Cost "S"	18,000
Net Gain	1,166.68

Conclusion

From the *financial perspective* net gain from transfer of 20,000 units to Division B is negligible. To take final call to transfer 20,000 units to Division B Company should consider other factors also such as its market share, future market demand, market price, and transportation cost etc.

Pricing Model

Problem-13

Eastern Company Ltd. has two Divisions namely Casnub Bogie Division (CBD) and Wagon Division (WD). CBD manufactures Casnub Bogies and WD manufactures BOBN type of Wagons. To manufacture a Wagon WD needs four Casnub Bogies. CBD is the only manufacturer of the Casnub Bogies and supplies both WD and outside customers. Details of CBD and WD for the coming financial year 2014-15 are as follows:

	CBD	***WD***
Fixed Costs (₹)	*9,20,20,000*	*16,45,36,000*
Variable Cost per unit (₹)	*2,20,000*	*4,80,000**
Capacity per month (units)	*320*	*12*

** excluding transfer costs*

Market research has indicated that the demands in the market for Eastern Company Ltd.'s products at different quotations are as follows-

For Casnub Bogies: Quotation price of ₹3,20,000 no tender will be awarded, but demand will increase by 30 Casnub Bogies with every ₹10,000 reduction in the unit quotation price below ₹3,20,000.

For Wagons: Quotation price of ₹17,10,000 no tender will be awarded, but the demand for Wagons will be increased by two Wagons with every ₹50,000 reduction in the unit quotation price below ₹17,10,000.

Required

(i) Calculate the unit quotation price of the Wagon that will maximise Eastern Company Ltd.'s profit for the financial year 2014-15.

(ii) Calculate the unit quotation price of the Wagon that is likely to emerge if the divisional managers of CBD and WD both set quotation prices calculated to maximise divisional profit from sales to outside customers and the transfer price is set at market selling (quotation) price.

[Note: If P = a – bQ then MR = a – 2bQ]

Solution

(i) Assumed Quotation Price 'P', Quantity 'Q'

The Marginal Cost of a 'Wagon' is ₹13,60,000

(₹2,20,000 × 4 Casnub Bogies + ₹4,80,000)

Demand Function for a 'Wagon'

P	=	₹17,10,000 – (₹50,000 / 2) × Q
Revenue (R)	=	Q × [17,10,000 – 25,000 × Q]
	=	17,10,000 Q – 25,000 Q^2
Marginal Revenue (MR)	=	17,10,000 – 50,000 Q
Marginal Cost (MC)	=	13,60,000

Profit is Maximum where Marginal Revenue (MR) equals to Marginal Cost (MC)

17,10,000 – 50,000 Q	=	13,60,000
Q	=	7.00 units

By putting the value of 'Q' in *Demand Function*, value of 'P' is obtained.

P	=	17,10,000 – (50,000/ 2) × Q
	=	17,10,000 – 25,000 × 7.00
	=	₹15,35,000

At ₹15,35,000 unit Quotation Price of a Wagon the Eastern Company Ltd.'s Profit will be Maximum.

(ii) At CBD the Divisional Manager would ensure that Divisional Marginal Revenue should be ***equal to*** Division's Marginal Cost so that Profit can be Maximum.

MR of a Casnub Bogies	=	MC of Manufacturing a Casnub Bogies
3,20,000 – 2(10,000/ 30) × Q	=	2,20,000
Q	=	150 units

Selling Price of a Casnub Bogie 'P' is

P	=	3,20,000 – (10,000/ 30) × 150
	=	₹2,70,000

CBD will earn Maximum Profit when it will Quote ₹2,70,000 to the Outside Market. Since, Outside Market Quotation is *Transfer Price* as well, so Transfer Price to WD will be ₹2,70,000 and it forms part of WD's Marginal Cost.

At WD, Division Manager would ensure that Divisional Marginal Revenue should be ***equal to*** Division's Marginal Cost so that Profit can be Maximum.

MR of a Wagon	=	MC of Manufacturing a Wagon
17,10,000 – 50,000 × Q	=	(₹2,70,000 × 4 Casnub Bogies) + ₹4,80,000
Q	=	3.00 units

Quotation Price of a Wagon 'P' should be:

P = ₹17,10,000 – 25,000 × 3.00

= ₹16,35,000

The unit Quotation Price of Wagon that emerges as a result of Market Based Transfer Pricing is ₹16,35,000.

Multinational Transfer Pricing

Problem-14

Celestial Electronics and Consumer Durables Corporation (CECDC), is a Taiwan (a state, Republic of China) based consumer electronics manufacturer. To expand its market share in South Asia it has formed CECDC India Pvt. Ltd. (CIPL) in India. For the purpose of performance evaluation, the Indian part is treated as responsibility centre. CIPL imports components from the CECDC and assembles these components into a LED TV to make it saleable in the Indian market. To manufacture an LED TV two units of component 'L_X' are required. The following cost is incurred by the CECDC to manufacture a unit of component 'L_X':

	Amount (TWD)
*Direct Material**	*440.00*
Direct Labour (3 hours)	*120.00*
Variable Overheads	*40.00*

(*) purchased from domestic market.

CECDC incurs TWD 30 per unit as Wharfage Charges.

CECDC has a normal manufacturing capacity of 5,00,000 units of component 'L_X' per annum, 70% of its production is exported to CIPL and rest are sold to other South-east Asian countries at TWD 750 per component. The tax authorities both in Taiwan and India, consider TWD 750 (= ₹1,500) per component 'L_X' as arm's length price for all transfers to CIPL. CIPL incurs ₹10 per unit as shipment charges.

The cost data relevant to the LED TVs are as follows:

	Amount (₹)
Variable Costs per unit:	
Direct Material (excluding component 'L_X')	*6,200*
Direct Labour	*115*
Fixed Cost:	
Office and Administrative Overheads	*1,18,00,000*
Selling & Distribution Overheads	*2,58,00,000*

CIPL can sell 1,75,000 units of LED TV at ₹11,000 per unit.

There is a dispute on the transfer pricing of component 'L_X' between the CECDC and CIPL. CECDC is in favour of charging TWD 750 per component to CIPL as it is the arm's length price and it has to pay tax on this. On the other hand CIPL in its argument saying that the substitute of component 'L_X' can be purchased from the Indian market at ₹1,490 only and moreover it has to pay import duty on import of component 'L_X' so the transfer price suggested by CECDC is not acceptable.

The following are the direct / indirect tax structure in India and Taiwan:

Type of Tax / Duty	***India***	***Taiwan***
Corporate Tax Rate	*30%*	*25%*
Import (Custom) Duty	*10%*	*15%*
Export Duty	*Nil*	*Nil*

Required

From the above information, Calculate:

(i) Minimum Price at which CECDC can transfer component 'L_X' to CIPL.

(ii) Maximum Price that can be paid by CIPL to CECDC for each component 'L_X'.

(iii) Profitability Statement for the group in TWD.

Note:

(i) For Duty and Tax calculation, consider arm's length price only.

(ii) Ignore the DTAA and other tax provisions.

(iii) Conversion Rate 1 INR = 0.50 TWD

Solution

(i) The minimum price at which CECDC can transfer component 'L_X' to CIPL is Variable Cost per unit *plus* Corporate Tax attributable to per unit of component 'L_X'

Minimum Transfer Price *per unit* of component 'L_X'

	Amount (TWD)
Direct Material	440.00
Direct Labour	120.00
Variable Overheads	40.00
Wharfage Charges	30.00
Corporate Tax attributable to per unit of component 'L_X' (W.N.1)	30.00
Total	660.00

Minimum Transfer Price *per unit* of component 'L_X' is 660 TWD or ₹1,320

(ii) Maximum Transfer Price that CIPL can pay to CECDC for every unit of component 'L_X' is the market price of component 'L_X' in domestic market *minus* cost of import (if any).

Maximum Transfer Price *per unit* of component 'L_X'

	Amount (₹)
Market Price of component 'L_X' (Indian Market)	1,490.00
Less: Import Duty (750 TWD × 2 × 10%)	150.00
Less: Shipment Cost	10.00
Total	1,330.00

Maximum Transfer Price that CIPL can pay to CECDC for every unit of component 'L_X' is ₹1,330 or 665 TWD.

(iii) **Profitability Statement for the Group (TWD' 000)**

Particulars	**LED TV**	**Component 'Lx'**	**Total**
Sales Revenue	9,62,500 (1,75,000 units × ₹11,000 × 0.50)	1,12,500 (1,50,000 units×750TWD)	10,75,000
Total Revenue		**...(A)**	**10,75,000**
Variable Manufacturing Cost (Component 'L_X')	2,10,000 (3,50,000 units × 600 TWD)	90,000 (1,50,000 units× 600TWD)	3,00,000
Wharfage Charges	10,500 (3,50,000 units × 30 TWD)	4,500 (1,50,000 units× 30TWD)	15,000
Other Variable Manufacturing Cost (excluding 'L_X')	5,52,562.50 (1,75,000 units × ₹6,315 × 0.50)	---	5,52,562.50
Import Duty	26,250 (10% × 3,50,000 units × 750TWD)	---	26,250
Shipment Cost	1,750 (3,50,000 units × ₹10 × 0.50)	---	1,750
Office and Admin. Overheads	5,900 (₹1,18,00,000 × 0.50)	---	5,900
Selling & Dist. Overheads	12,900 (₹2,58,00,000 × 0.50)	---	12,900
Corp. Taxes (W.N. 2 & 3)	30,191.25 (₹60,382.50 × 0.50)	15,000	45,191.25
Total Cost		**...(B)**	**9,59,553.75**
Profit		...(A) – (B)	1,15,446.25

Working Notes

W.N.-1

Corporate Tax Attributable to *per unit* of Component 'L_X' (TWD)

	Amount
Profit *per unit* (750 TWD – 440 TWD – 120 TWD – 40 TWD – 30 TWD)	120
Corporate tax *per unit* (25% on 120 TWD)	30

W.N.-2

Calculation of Corporate Tax paid by CIPL (₹' 000)

	Amount
Sales Revenue (1,75,000 units × ₹11,000)	19,25,000
Less: Variable Costs:	
Component 'L_X' (3,50,000 units × 750 TWD × ₹2)	5,25,000
Other Variable Costs (1,75,000 units × ₹ 6,315)	11,05,125
Less: Import Duty 10% of (3,50,000 units × 750 TWD × ₹2)	52,500
Less: Shipment Cost (3,50,000 units × ₹10)	3,500
Less: Fixed Overheads	
Office and Administrative Overheads	11,800
Selling and Distribution Overheads	25,800
Taxable Profit	2,01,275
Tax Payable @30%	60,382.50

W.N.-3

Calculation of Corporate Tax paid by CECDC (TWD)

	Amount
Profit *per unit* (750 TWD – 440 TWD – 120 TWD – 40 TWD – 30 TWD)	120
No. of units to be sold	5,00,000
Total Profit (120 TWD × 5,00,000 units)	6,00,00,000
Corporate Tax @ 25%	1,50,00,000

Problem-15

Standard Corporation Inc. (SCI) is a US based multinational company engaged in manufacturing and marketing of Printers and Scanners. It has subsidiaries spreading across *the world which either manufactures or sales Printers and Scanners using the brand name of SCI.*

The Indian subsidiary of the SCI buys an important component for the Printers and Scanners from the Chinese subsidiary of the same MNC group. The Indian subsidiary buys 1,50,000 units of components per annum from the Chinese subsidiary at CNY (¥) 30 per unit and pays a total custom duty of 29.5% of value of the components purchased.

A Japanese MNC which manufactures the same component which is used in the Printer and Scanners of SCI, has a manufacturing unit in India and is ready to supply the same component to the Indian subsidiary of SCI at ₹ 320 per unit.

The SCI is examining the proposal of the Japanese manufacturer and asked its Chines subsidiary to presents its views on this issue. The Chinese subsidiary of the SCI has informed that it will be able to sell 1,20,000 units of the components to the local Chinese manufactures at the same price i.e. ¥ 30 per unit but it will incur an excise duty @ 10% on sales value. Variable cost per unit of manufacturing the component is ¥ 20 per unit. The Fixed Costs of the subsidiaries will remain unchanged.

The Corporation tax rates and currency exchange rates are as follows:

Corporation Tax Rates		***Currency Exchange Rates***
China	*25%*	*1 US Dollar ($) = ₹61.50*
India	*34%*	*1 US Dollar ($) = ¥ 6.25*
USA	*40%*	*1 CNY (¥) = ₹ 9.80*

Required

(i) Prepare a financial appraisal for the impact of the proposal by the Japanese manufacturer to supply components for Printers and Scanners to Indian subsidiary of SCI. [Present your solution in Indian Currency and its equivalent.]

(ii) Identify other issues that would be considered by the SCI in relation to this proposal.

(Note: While doing this problem use the only information provided in the problem itself and ignore the actual taxation rules or treaties prevails in the above mentioned countries)

Solution

(i) Impact of the Proposal by the Japanese Manufacturer to Supply Components for Printers and Scanners to the Indian Subsidiary of the SCI.

On Indian Subsidiary of SCI

Particulars	**Amount (₹)**
Cost of Purchase from the Chinese Manufacturer :	
Invoiced Amount {(1,50,000 units × ¥ 30) × ₹9.80}	4,41,00,000

Add: Total Custom Duty (₹ 4,41,00,000 × 29.5%)	1,30,09,500
Total Cost of Purchase from the Chinese Manufacturer ...(A)	5,71,09,500
Cost of Purchase from Japanese Manufacturer in India:	
Invoice Amount (1,50,000 units × ₹320)	4,80,00,000
Total Cost of Purchase from Japanese Manufacturer in India ...(B)	4,80,00,000
Savings on Purchase Cost Before Corporate Taxes ...(A) – (B)	91,09,500
Less: Corporate Tax @34%	30,97,230
Savings after Corporate Taxes	60,12,270

On Chinese Subsidiary of SCI

Particulars	Amount (₹)
Loss of Contribution [{(1,50,000 – 1,20,000 units) × ¥ (30 – 20)} × ₹9.80]	29,40,000
Add: Excise Duty on Local Sale - Chinese Manufacturer [{(1,20,000 units × ¥ 30) × 10%} × ₹9.80]	35,28,000
Total Loss Before Corporate Taxes	64,68,000
Less: Tax Savings on the Losses (₹64,68,000 × 25%)	16,17,000
Net Loss after Corporate taxes	48,51,000

On SCI Group

Particulars	Amount (₹)
Saving from Indian Subsidiary	60,12,270
Loss from Chinese Subsidiary	48,17,000
Net Benefit to SCI Group	11,61,270

From the above analysis it can be seen that the proposal from the Japanese manufacturer in India is beneficial for the SCI as it give a net benefit of ₹ 11,61,270.

(ii) The SCI need to consider various other issues before reaching at a final decision of accepting the proposal of the Japanese manufacturer in India. The few suggestive issues that should be considered are as follows:

- *The longevity of the proposal of the Japanese manufacturer:* Whether Japanese manufacturer will supply the components in the future also. For this purpose a long term agreement between the Indian Subsidiary of SCI and Japanese manufacturer in India needs to be entered.
- *Certainty of the fiscal policy in India:* The Japanese manufacturer will not be able to supply the component at the present price if the fiscal policy of India will change in the future.

- *Repatriation of Profit earned in India:* Though the Indian subsidiary is making profit but it depends on the Government policy on the repatriation of profit from India to USA.
- *Operating Conditions in China:* The SCI has to make sure that the Chinese subsidiary is operating profitably and able to use the spare capacity in the future as well.
- *The fiscal policy in China:* If the Government of China liberalize its fiscal policies in China in future then the manufacturing cost will be cheaper than the today's cost.

Apart from above suggestive points the foreign relations and other tax treaties and accords should also be kept in consideration.

Transfer Pricing – Miscellaneous

Problem-16

Fox-2-Tec Ltd (F2TL) has Division 'Dx' and Division 'Dz' with full profit responsibility. The Division 'Dx' produces Component 'X' which it sells to 'outside' customers only. The Division 'Dz' produces a product called the 'Z' which incorporates Component 'X' in its design. 'Dz' Division is currently purchasing 2,500 units of Component 'X' per year from an outside supplier at a cost of ₹ 35 per unit, less a 10 percent quantity discount. 'Dx' Division can sell its entire Component 'X' to outside customers at the normal ₹ 35 price. Costs associated with manufacturing of a unit of Component 'X' are as follows:

Variable Expenses	*₹ 21*
Fixed (based on a capacity of 25,000 units per year)	*₹ 9*

F2TL's new managing director agrees for internal transfer if an acceptable transfer price can be worked out. Accordingly, he requires solution of following questions:-

(i) *If the 'Dz' Division purchases 2,500 units of Component 'X' per year from the 'Dx' Division, what price should control the transfers? Why?*

(ii) *Refer to your computations in (1). What is the lower limit and the upper limit for a transfer price? Is an upper limit relevant in this situation?*

(iii) *If the 'Dx' Division meets the price that the 'Dz' Division is currently paying to its supplier and sells 2,500 units of Component 'X' to the 'Dz' Division each year, what will be the effect on the profits of the 'Dx' Division, the 'Dz' Division, and the company as a whole?*

(iv) *If the intermediate market price for Component 'X' is ₹ 35 per unit, is there any reason why the 'Dx' Division should sell to the 'Dz' Division for less than ₹ 35? Explain.*

Solution

(i) The transfer price should be ₹35 per unit, the regular price charged to other customers. Since the 'Dx' Division is operating at capacity, it will lose ₹14 in contribution margin for each outside sale given up in favor of sales to the 'Dz' Division (₹ 35 – ₹ 21 = ₹14).

Transfer Price	=	Variable Cost *per unit* + Lost Contribution Margin *per unit* on Outside Sales
	=	₹21 + ₹14
	=	₹35

(ii) The lower limit is ₹35, the price obtained in (1). The upper limit is also ₹35, since ₹35 is the intermediate market price. That is, it would not be fair to charge the other Division more than the price being charged to regular customers. However, an upper limit is not really relevant in this situation since no transfers will be made between the two Divisions.

(iii) The price being paid to the outside supplier, net of the quantity discount, is only ₹31.50. If this price is met by the 'Dx' Division, then profits in the 'Dx' Division and in the company as a whole will drop by ₹8,750 per year.

Minimum Transfer Price	₹35
Outside Supplier's Price	₹31.50
Loss in Contribution Margin *per unit*	₹3.50
No. of units *per year*	2,500
Total Loss in Profits	₹8,750

Profits in the 'Dz' Division will remain unchanged, since it will be paying the same price internally as it is now paying externally.

(iv) Yes, if costs can be avoided as a result of the inside business. The price would then be ₹35 less the avoided costs.

Problem-17

A company has two Divisions, Division 'A' and Division 'B'. Division 'A' has a budget of selling 2,00,000 nos. of a particular component 'x' to fetch a return of 20% on the average assets employed. The following particulars of Division 'A' are also known:

Fixed Overhead.................................. ₹ 5 lakhs

Variable Cost...................................... ₹ 1 per unit

Average Assets:

Sundry Debtors................................... ₹ 2 lakhs

Inventories... ₹ 5 lakhs

Plant & Equipments............................. ₹ 5 lakhs

However, there is constraint in Marketing and only 1,50,000 units of the component 'x' can be directly sold to the Market at the proposed price.

It has been gathered that the balance 50,000 units of component 'x' can be taken up by Division 'B' Division 'A' wants a price of ₹ 4 per unit of 'x' but Division 'B' is prepared to pay ₹ 2 per unit of 'x'.

Division 'A' has another option in hand, which is to produce only 1,50,000 units of component 'x' . This will reduce the holding of assets by ₹ 2 lakhs and fixed overhead by ₹ 25,000.

Required

Advise the most profitable course of action for Division 'A'.

Solution

Working Notes

1. Profit = 20% Return on the Average Assets Employed
   = 20% × ₹12,00,000
   = ₹2,40,000
2. Desired Revenue
   (on the Sale of 2,00,000 units of Component 'x')
   = Fixed cost + Variable cost + Profit
   = ₹ 5,00,000 + ₹ 2,00,000 + ₹ 2,40,000
   = ₹ 9,40,000
3. Selling Price *per unit*
   = Desired Revenue ÷ No. of units *to be sold* of Component 'x'
   = ₹9,40,000 ÷ 2,00,000 units
   = ₹4.70 *per unit*

Advise About the Most Profitable Course of Action for Division A

Option – I: Sell, 1,50,000 units in Market and Transfer 50,000 units to Division B
Option – II: Sell only 1,50,000 units in Market

	Option – I (₹)	**Option – II (₹)**
Sales Revenue (1,50,000 units of Component 'x' @ ₹4.70 p.u) [W.N.-3]	7,05,000	7,05,000
Units of Component 'x' Transferred to Division B (@ ₹ 2/- p.u.) [under Option-I only]	1,00,000	---

Total Revenue .	8,05,000	7,05,000
Less: Cost Incurred		
- Fixed Overhead	5,00,000	4,75,000
- Variable Overhead	2,00,000	1,50,000
Profit ...(A)	1,05,000	80,000
Capital Employed ...(B)	12,00,000	10,00,000
Return on Capital Employed ...(A) / (B) × 100	8.75%	8%

Since the Return on Capital Employed under Option – I is more than that under Option – II, therefore Option – 1 is preferred over Option – II. Selection of this Option also gives an extra, Profit of ₹25,000/-.

Problem-18

AB Cycles Ltd. has two Divisions, A and B which manufacture bicycle. Division A produces bicycle frame and Division B assembles rest of the bicycle on the frame. There is a market for sub-assembly and the final product. Each Division has been treated as a profit centre. The transfer price has been set at the long-run average market price. The following data are available to each Division:

Estimated Selling Price of Final Product.................................... ₹ 3,000 per unit
Long Run Average Market Price of Sub-Assembly......................... ₹ 2,000 per unit
Incremental Cost of Completing Sub-Assembly in Division B........... ₹ 1,500 per unit
Incremental Cost in Division A.. ₹ 1,200 per unit

Required

(i) *If Division A's maximum capacity is 1,000 units p.m. and sales to the intermediate are now 800 units, should 200 units be transferred to B on long-term average price basis.*

(ii) *What would be the transfer price, if manager of Division B should be kept motivated?*

(iii) *If outside market increases to 1,000 units, should Division A continue to transfer 200 units to Division B or sell entire production to outside market?*

Solution

(i) Two Options are Available

Option - (a)	**(₹)**
Sell at the Sub Assembly Stage (after completion of Division A)	2,000
Incremental Cost in Division A	1,200
Contribution	800

Option – (b)	**(₹)**
Sell at the Final Product Stage	3,000
Cost at Division A and Division B (₹1,200 + ₹1,500)	2,700
Contribution	300

Therefore it is profitable to sell at the sub assembly stage because of *higher contribution*, provided there is a market.

Hence, if there is market at intermediate stage, first priority is to sell intermediary (Sub-Assembly). Therefore, 800 units should be sold as *sale of intermediary*.

The balance capacity available of 200 units (1,000 units – 800 units) should be transferred to Division B and it should complete the assembly and sell as *final product*, as the Company can earn ₹300 per unit for each unit of such sale.

(ii) If Division B receives the sub assembly at market price of ₹2,000, plus its own incremental cost of ₹1,500 will give total cost of ₹3,500, thereby yielding a loss of ₹500 per unit (₹3,500 – ₹3,000), whereas the Company makes a profit of ₹300 per unit.

In order to keep the manager of Division B motivated, the profit earned of ₹300 per unit should be *shared* between Division A and Division B. Hence transfer price will be variable cost of Division A + 50% of profit earned in the final product equals to ₹1,350 (₹1,200 + ₹150).

(iii) Both Divisions and the Company make higher contribution by selling to intermediate market. If the market demand increases to 1,000 units, the full quantity should be sold outside as intermediary and nothing should be transferred to Division B.

Problem-19

X Ltd. has two divisions, A and B, which manufacture products A and B respectively. A and B are profit centres with the respective Divisional Managers being given full responsibility and credit for their performance.

The following figures are presented:

	Division A (₹) Per Unit	***Division B (₹) Per Unit***
Direct Material Cost	*50*	*24**
Material A, if transferred from Division A	---	*144*
Material A, if purchased from outside	---	*160*

Direct Labour	*25*	*14*
Variable Production Overhead	*20*	*2*
Variable Selling Overhead	*13*	*26*
Selling Price in outside market	*160*	*300*
Selling Price to B	*144*	*---*
Selling Price to S Ltd.	*---*	*250*

(*) other than A

Other Information:

To make one unit of B, one unit of component A is needed. If transferred from Division A, Division B presently takes product A at ₹ 144 per unit, with Division A not incurring variable selling overheads on units transferred to Division B.

Product A is available in the outside market at ₹ 160 per unit from competitors.

Division B can sell its product B in the external market at ₹ 300 per unit, whereas, if it supplied to X Ltd.'s subsidiary, S Ltd., it supplies at ₹ 250 per unit, and need not incur variable selling overhead on units transferred to S Ltd. S Ltd. requires 6,000 units and stipulates a condition that either all 6,000 units be taken from Division B or none at all.

	Division A (units)	**Division B (units)**
Manufacturing Capacity	*20,000*	*28,000*
Demand in external market	*18,000*	*26,000*
S Ltd.'s Demand	*---*	*6,000 or zero*

Assume that Divisions A and B will have to operate during the year.

Required

Identify best strategy for:

(i) Division A?

(ii) Division B, given that Division A will use its best strategy?

(iii) For X Ltd. as a whole?

Solution

Statement Showing "Contribution *per unit*"

	Division A **(₹ per unit)**	**Division B** (If Product A is taken from Division A) **(₹ per unit)**	**Division B** (If Product A is purchased from outside market) **(₹ per unit)**
Direct Material (other than Product A)	50	24	24
Direct Labour	25	14	14
Variable Production Overhead	20	2	2
Variable Production Cost (excluding A)	95	40	40
- Product A (transferred from Division A)	---	144	---
- Product A (purchased from outside market)	---	---	160
Variable Production Cost *per unit*	95	184	200
Selling Price (if sold in outside market)	160	300	300
Less: Variable Selling Overhead	(13)	(26)	(26)
Net Selling Price (if sold in outside market)	147	274	274
Less: Variable Production Cost	(95)	(184)	(200)
Contribution *per unit* (if sold in outside market)	52	90	74
Selling Price (if sold to Division B and S Ltd. respectively)	144	250	250
Less: Variable Production Cost	(95)	(184)	(200)
Contribution *per unit*	49	66	50

(i) **Best Strategy for Division A:** Division A should produce at its full capacity of 20,000 units and sell 18,000 units to the outside market and remaining 2,000 units to Division B. The total contribution for Division A will be as calculated below:

Total Contribution

	(₹)
Sell to Outside Market (18,000 units × ₹52)	9,36,000
Sell to Division B (2,00 units × ₹49)	98,000
Total Contribution	10,34,000

(ii) **Best Strategy for Division B when Division A will use its Best Strategy:** Division B will procure 2,000 units from Division A and balance units by choosing best option from the two options calculates as below:

Option-I: Sell 6,000 units to S Ltd. And 22,000 units to Outside Market

Option-II: Only to Outside Market Sale

Production Capacity - 28,000 units

Option-I	(₹)	Option- II	(₹)
Sales to Outside Market: (20,000 units × ₹74 + 2,000 units × ₹90)	16,60,000	Sales to Outside Market: (24,000 units × ₹74 + 2,000 units × ₹90	19,56,000
Sales to S Ltd.: (6,000 units × ₹50)	3,00,000	Sales to S Ltd.:	---
Total	19,60,000	Total	19,56,000

Division B should produce at full capacity and choose option- I i.e. get 2,000 units from Division A, sell 6,000 units to S Ltd. and 20,000 units to outside market. Total contribution to Division B will be ₹19,60,000.

(iii) If Division A and B are allowed to act independent of the group synergy, total contribution to X Ltd. will be-

	(₹)
Division A	10,34,000
Division B	19,60,000
Total Contribution for X Ltd.	29,94,000

Cost from X Ltd.'s Perspective

	If 'A' made in Division A(₹)	**If 'A' purchased from outside market(₹)**
Variable Cost of Production in Division A	95	---
Variable Cost of Production in Division B	40	40
Purchase Cost from Outside	---	160
Total	135	200

Option-I	(₹)	Option- II	(₹)
Sales to Outside Market: [20,000 units × (₹274 – ₹135) + 2,000 units × (₹274 – ₹200)]	29,28,000	Sales to Outside Market: [20,000 units × (₹274 – ₹135) + 6,000 units × (₹274 – ₹200)]	32,24,000
Sales to S Ltd.: [6,000 units × (₹250 – ₹200)]	3,00,000	Sales to S Ltd.:	---
Total	32,28,000	Total	32,24,000

Choose Option-I, where X Ltd. earns a contribution of ₹32,28,000. At this option Division A transfers all products i.e. 20,000 units to Division B and Division B transfers 6,000 units to S Ltd and 22,000 units to the outside market. Division B purchases 2,000 units of Product - A from the outside market.

At this option X Ltd earns ₹2,34,000 more than the Division A & B's individual earnings i.e. ₹32,28,000 – ₹29,94,000.

Problem-20

Hardware Ltd. manufactures computer hardware products in different divisions which operate as profit centers. Printer Division makes and sells printers. The Printer Division's budgeted income statement, based on a sales volume of 15,000 units is given below. The Printer Division's Manager believes that sales can be increased by 2,400 units, if the selling price is reduced by ₹ 20 per unit from the present price of ₹ 400 per unit, and that, for this additional volume, no additional fixed costs will be incurred.

Printer Division presently uses a component purchased from an outside supplier at ₹ 70 per unit. A similar component is being produced by the Components Division of Hardware Ltd. and sold outside at a price of ₹ 100 per unit. Components Division can make this component for the Printer Division with a small modification in the specification, which would mean a reduction in the Direct Material cost for the Components Division by ₹ 1.5 per unit. Further, the Component Division will not incur variable selling cost on units transferred to the Printer Division. The Printer Division's Manager has offered the Component Division's Manager a price of ₹ 50 per unit of the component.

Component Division has the capacity to produce 75,000 units, of which only 64,000 units can be absorbed by the outside market.

The current budgeted income statement for Components Division is based on a volume of 64,000 units considering all of it as sold outside.

	Printer Division (₹ '000)	*Component Division (₹ '000)*
Sales Revenue	*6,000*	*6,400*
Manufacturing Cost		
Component	*1,050*	*-*
Other Direct Materials, Direct Labour & Variable Overhead	*1,680*	*1,920*
Fixed Overhead	*480*	*704*
Variable Marketing Costs	*270*	*384*
Fixed Marketing and Administration Overhead	*855*	*704*
Operating Profit	*1,665*	*2,688*

Required

(i) Should the Printer Division reduce the price by ₹ 20 per unit even if it is not able to procure the components from the Component Division at ₹ 50 per unit?

(ii) Without prejudice to your answer to part (i) above, assume that Printer Division needs 17,400 units and that, either it takes all its requirements from Component Division or all of it from outside source. Should the Component Division be willing to supply the Printer Division at ₹ 50 per unit?

(iii) Without prejudice to your answer to part (i) above, assume that Printer Division needs 17,400 units. Would it be in the best interest of Hardware Ltd. for the Components Division to supply the components to the Printer Division at ₹ 50?

Solution

(Amount in ₹)

Particulars	**Printer Division**			**Component Division**	
	Existing Price	**Reduction in Selling Price**	**If Component is Purchased Internally**	**Existing**	**If Transfer Effected**
Selling Price	400	380	380	100	50
Less: Component Cost	70	70	50	-	-
Less: Other Direct Materials, Direct Labour & Variable Overhead	112	112	112	30	28.50

Less: Variable Marketing Cost	18	18	18	6	-
Contribution	200	180	200	64	21.50
Volume (units)	15,000	17,400	17,400	64,000	17,400
Total Contribution	30,00,000	31,32,000	34,80,000	40,96,000	3,74,100
Volume Lost in the Market (units)					6,400*
Contribution Lost (6,400 units × ₹64)					4,09,600

(*) 17,400 units – Spare Capacity i.e. 11,000 units (75,000 units – 64,000 units)

(i) **Yes,** Printer Division should reduce price of its Printer by ₹20, as there is an increment in net income by ₹1,32,000 (₹31,32,000 – ₹30,00,000). Incremental operating profit can be found in the as below:

	(₹)
Contribution Margin of Sales increase (₹180 × 2,400 units)	4,32,000
Less: Loss in Contribution Margin on Original Volume *arising from decrease in Selling Price* (15,000 units × ₹20)	3,00,000
Increase in Operating Profit	1,32,000

(ii) **No,** The Component Division should not sell all 17,400 units to Printer Division for ₹50. If the Component Division does sell all 17,400 units to Printer Division, Component Division will only be able to sell 57,600 units to outside customers instead of 64,000 units due to the *capacity restrictions*. This would decrease Component Division's profit by ₹35,500. Supporting calculations are as follows:

	(₹)
Contribution from Sales to Printer (₹21.50 × 17,400 units)	3,74,100
Less: Loss in Contribution from Loss of Sales *to outsiders* (₹64 × 6,400 units)	4,09,600
Decrease in Operating Profit	35,500

(iii) **Yes,** it would be in the best interest of Hardware Ltd. for the Component Division to sell the units to the Printer Division at ₹50 each. The net advantage to the Hardware Ltd. is ₹3,12,500 as shown below. The net advantage is the result of the cost savings from purchasing the Component unit internally and the contribution margin lost from 6,400 units that the Component Division otherwise would sell to outsiders.

Total Company	**(₹ '000)**
Incremental Contribution- If the component is transferred within ₹ (3,480 – 3,132)	348.00

Contribution to the Component Division	374.10
Total incremental Contribution	722.10
Less: Contribution Lost by the Component Division	409.60
Net Contribution Gain	312.50

Problem-21

B Ltd. makes three products X, Y and Z in Divisions X, Y and Z respectively. The following information is given:

	X	Y	Z
Direct Material (₹ / Unit) (excluding material X for Divisions Y and Z)	8	22	40
Direct Labour (₹ / Unit)	4	6	8
Variable Overhead (₹ / Unit)	2	2	2
Selling price to outside customers (₹ / Unit)	25	65	90
Existing capacity (no. of units)	6,000	3,000	3,000
Maximum external Market demand (no of units)	5,000	5,500	5,000
Additional fixed cost that would be incurred to install additional capacity (₹)	45,000	9,000	23,100
Maximum additional units that can be produced by additional capacity	6,000	2,000	2,250

Y and Z need material X as their input. Material X is available in the market at ₹ 23 per unit. Defectives can be returned to suppliers at their cost. Division X supplies the material free from defects and hence is able to sell at ₹ 25 per unit. Each unit of Y and Z require one unit of X as input with slight modification.

If Y purchases from outside at ₹ 23 per unit, it has to incur ₹ 3 per unit as modification and inspection cost. If Y purchases from Division X, it has to incur, in addition to the transfer price, ₹ 2 per unit to modify it.

If Z gets the material from Division X, it can use it after incurring a modification cost, of ₹ 1 per unit. If Z buys material X from outside, it has to either inspect and modify it at its own shop floor at ₹ 5 per unit or use idle labour from Division X at ₹ 3 per unit. Division X will lend its idle labour as per Z's requirement even if Z purchases the material from outside.

The transfer prices are at the discretion of the Divisional Managers and will remain confidential. Assume no restriction on quantities of inter-division transfers or purchases.

Required

Discuss with relevant figures the best strategy for each division and for the company as a whole.

Solution

Statement Showing "Contribution *per unit*"

(₹)

Particulars	Division X			Division Y		Division Z
	Sale to	Internal Transfer to		Purchase from	Transfer from	Transfer from
	Outside	Y	Z	Outside	X	X
Selling Price	25.00	---	---	65.00	65.00	90.00
Transfer Price	---	24.00*	25.00#	---	---	---
Direct Material (Excluding Material 'X')	8.00	8.00	8.00	22.00	22.00	40.00
Direct Labour	4.00	4.00	4.00	6.00	6.00	8.00
Variable Overhead	2.00	2.00	2.00	2.00	2.00	2.00
Purchase Price 'X'	---	---	---	23.00	---	---
Transfer Price 'X'	---	---	---	---	24.00	25.00
Modification Cost	---	---	---	3.00	2.00	1.00
Contribution	11.00	10.00	11.00	9.00	9.00	14.00

(*) Division 'Y' will not pay Division 'X' anything more than ₹ 24, because at 24, it will incur additional cost of ₹ 2 per unit to modify it, ₹ 23 + ₹ 3 = ₹ 26, the outside cost.

(#) To purchase material X from outside is costly for Division 'Z' as after modification at own shop floor, cost of the same comes to Division 'Z' is ₹ 28 (₹ 23 + ₹ 5).

If Division 'X' goes to utilize its full capacity in that case labour would not be available for modification to Department 'Z'.

Accordingly Division 'Z' may purchase material X at ₹ 25 from Division 'X' i.e. market price to outsiders.

Statement Showing "Internal Transfer Decision (units)"

Particulars	X	Y	Z
Existing Capacity …(A)	6,000 units	3,000 units	3,000 units
Maximum Capacity *that can be added* …(B)	6,000 units	2,000 units	2,250 units
Total Maximum *that can be produced* …(C)=(A)+(B)	12,000 units	5,000 units	5,250 units
Maximum External Demand …(D)	5,000 units	5,000 units	5,000 units
Balance …(C) – (D)	7,000 units	---	250 units
Internal Transfer to Other Divisions	5,000 units to Z* 2,000 units to Y	N.A.	N.A.
Internal Transfer from Other Divisions	N.A.	2,000 units transfer from X (material X)	5,000 units transfer from X (material X)

(*) Division 'X' will supply its production to Division 'Z' first (after meeting its external requirement) as contribution from product Z is high.

Statement Showing "Decision Whether to Expand or Not"

Particulars	X	Y	Z
Additional Fixed Cost on Expansion	₹45,000	₹9,000	₹ 23,100
Contribution that can be earned by expansion	₹ 64,000 (4,000 units × ₹ 11 + 2,000 units × ₹ 10)	₹ 18,000 (2,000 units × ₹ 9)	₹ 28,000 (2,000* units × ₹ 14)
Net Benefit from Expansion	₹ 19,000	₹ 9,000	₹ 4,900
Decision	Expansion	Expansion	Expansion

(*) As maximum demand of product Z is 5,000 units which Division 'Z' first complete with existing capacity of 3,000 units. Balance 2,000 units from expansion.

Statement Showing "Net Revenue Addition"

(₹)

Particulars	X	Y	Z	Total
Contribution – External Sales	55,000 (5,000 units × ₹11)	45,000 (5,000 units × ₹ 9)	70,000 (5,000 units x ₹14)	1,70,000
Contribution – Internal Transfer	75,000 (2,000 units × ₹10 + 5,000 units × ₹11)	---	---	75,000
Additional Fixed Cost	45,000	9,000	23,100	77,100
Net Revenue Addition				1,67,900

Strategy for Company & Divisions

(i) Division 'X' will transfer maximum possible material to Division 'Z' as Division 'Z' is offering maximum transfer price to Division 'X'. At the same time Division 'Z' is fetching maximum contribution for the organisation so it is beneficial for both the Divisions as well as organisation as a whole.

(ii) As shown above all the three Divisions are getting net benefit when they are taking decision to expand and hence, all the three Divisions should expand there activity by incurring additional fixed cost on expansion.

SECTION - C

Transfer Pricing- Basic Concepts

Problem-1

G is the transferring division and R, the receiving division in a company. R has a demand for 20% of G's production capacity which has to be first met as per the company's policy. State with reason, which division, G or R enjoys more advantage in each of the following independent situations, assuming no inventory build up.

Sl. No.	***G Transfers to R at Transfer Price equal to***	***G's Production level***	***External Demand***	***Division having more advantage***	***Reason***
(i)	*Full cost: No markup*	*60%*	*40%*		
(ii)	*Market Price*	*80%*	*60%*		
(iii)	*Marginal Cost*	*100%*	*80%*		
(iv)	*Market Price*	*100%*	*90%*		

Solution

Sl. No.	**Division (More Advantage)**	**Reason**
(i)	G	G is utilizing only 40% of production capacity by selling to 'External Market' which implies that G might have not been able to recover its full fixed costs. By transferring 20% of its production capacity to division R at full cost, G will be able to recover fixed costs components.
(ii)	G	G will not be loosing any external market demand as it is within its production capacity. By transferring 20% of production capacity to division R at market price, G will earn extra contribution towards the fixed costs and profit.
(iii)	R	Here G is operating at 100% capacity level and external market demand is 80% only i.e. G is not loosing any external market demand. But by transferring 20% of production capacity to R at marginal cost i.e. at variable cost, G may not be able to recover fixed cost part of total cost. On the other hand R will be able to get these units at marginal cost only.
(iv)	G	Though G is loosing its 10% of external market demand but it would be able to earn the same revenue by transferring the goods to division R at market price. Moreover G will be able to utilize 100% of its production capacity.

Optimal Decision Making Vs Performance Evaluation

Problem-2

Global Multinational Ltd. (GML) has two Divisions 'Dx' and 'Dz' with full profit responsibility. The Division 'Dx' produces Component 'X' which it sells to 'outside' customers only. The Division 'Dz' produces a product called the 'Z' which incorporates Component 'X' in its design. 'Dz' Division is currently purchasing required units of Component 'X' per year from an outside supplier at market price.

New CEO for Indian Operations has explored that 'Dx' Division has enough capacity to meet entire requirements of Division 'Dz' and accordingly he requires internal transfer between the divisions at marginal cost from the overall company's perspective.

Manager of Division 'Dx' claims that transfer at marginal cost are unsuitable for performance evaluation since they don't provide an incentive to the division to transfer goods internally. He stressed that transfer price should be 'Cost plus a Mark-Up'.

New CEO worries that transfer price suggested by the manager of Division 'Dx' will not induce managers of both Divisions to make optimum decisions.

You are requested to help him out of the problem.

Solution

To overcome the ***optimum decision making*** and ***performance evaluation conflicts*** that can occur with ***marginal cost-based transfer pricing*** following methods has been proposed:

Dual Rate Transfer Pricing System

"With a 'Dual Rate Transfer Pricing System' the 'Receiving Division' is charged with marginal cost of the intermediate product and 'Supplying Division' is credited with full cost per unit plus a profit margin".

Accordingly Division 'Dx' should be allowed to record the transactions at *full cost per unit* plus *a profit margin*. On the other hand Division 'Dz' may be charged only *marginal cost*. Any inter divisional profits can be eliminated by accounting adjustment.

Impact:

– Division 'Dx' will earn a profit on inter-division transfers.

– Division 'Dz' can chose the output level at which the marginal cost of the product 'X' is equal to the net marginal revenue of the product 'Z'.

Two Part Transfer Pricing System

"The 'Two Part Transfer Pricing System' involves transfers being made at the marginal cost per unit of output of the 'Supplying Division' plus a lump-sum fixed fee charged by the 'Supplying Division' to the 'Receiving Division' for the use of the capacity allocated to the intermediate product."

Accordingly Division 'Dx' can transfer its products to Division 'Dz' at *marginal cost per unit* and *a lump-sum fixed fee*.

Impact:

– 'Two Part Transfer Pricing System' will inspire the Division 'Dz' to choose the optimal output level.

This pricing system also enable the Division 'Dx' to obtain a profit on inter-division transfer.

8 Uniform Costing and Inter Firm Comparison

Basic Concepts

Inter-Firm Comparison	It is technique of evaluating the performance, efficiency, costs and profits of firms in an industry. It consists of voluntary exchange of information/data concerning costs, prices, profits, productivity and overall efficiency among firms engaged in similar type of operations for the purpose of bringing improvement in efficiency and indicating the weaknesses.
Objectives of Uniform Costing	Objectives of Uniform Costing are: (i) Facilitates Comparison (ii) Eliminates Unhealthy Competition (iii) Improves Efficiency (iv) Provides Relevant Data (v) Ensures Standardisation (vi) Reduces Cost
Requisites of Inter-firm Comparison System	Requisites of Inter-firm comparison system are: (i) Centre for Inter-Comparison (ii) Membership (iii) Nature of information to be collected (iv) Method of Collection and presentation of information
Uniform Costing	When several undertakings start using the same costing principles and/or practices they are said to be following uniform costing. The basic idea behind uniform costing is that the different concerns in an industry should adopt a common method of costing and apply uniformly the same principles and techniques for better cost comparison and common good.

SECTION - A

Uniform Costing System

Question-1

What are the requisites for the installation of a Uniform Costing system?

Answer

Essential requisites for the installation of Uniform Costing are as under:

(i) The firm in the industry should be willing to share or furnish relevant data or information.

(ii) A spirit of co-operation and mutual trust should prevail among the participating firms.

(iii) Mutual exchange of ideas, methods used, special achievement made, research and know- how etc. should be frequent.

(iv) Bigger firms should take the lead towards sharing their experience and know- how with the smaller firm to enable the later to improve their performance.

(v) In case of accounting methods, principles, procedure and production method uniformity must be established.

Question-2

What is Uniform Costing? Why is it recommended?

Answer

It is not a distinct method of costing when several undertakings start using the same costing principles or practices, they are said to be following uniform costing. Different concerns in an industry should adopt a common method of costing and apply uniformly the same principles and techniques for better cost comparison and common good and helps in mutual cost control and cost reduction. Hence, it is recommended that a uniform method of costing should be adopted by the member units of an industry.

Question-3

State the limitations of Uniform Costing.

Answer

Limitations of Uniform Costing are:

(i) Sometimes it is not possible to adopt uniform standards, methods and procedures of costing in different firms due to differing circumstances in which they operate. Hence, the adoption of uniform costing becomes difficult in such firms.

(ii) Disclosure of cost information and other data is an essential requirement of a uniform costing system. Many firms do not wish to share such information with their competitors in the same industry.

(iii) Small firms in an industry believe that uniform costing system is only meant for big and medium size firms, because they cannot afford it.

(iv) It induces monopolistic trend in the business, due to which prices may be increased artificially and supplies withheld.

Question-4

What are the advantages of Uniform Costing?

Answer

The advantages accruing from the use of Uniform Costing System are as follows:

(i) The management of each firm will be saved from the exercise of developing and introducing a costing system of its own.

(ii) A costing system devised by mutual consultation and after considering the difficulties and circumstances prevailing in different firms is readily adopted and successfully implemented.

(iii) It facilitates comparison of cost figures of various firms to enable the firms to identify their weak and strong points besides controlling costs.

(iv) Optimum achievement of efficiency is attempted by all the firms by utilising the experience of other concerns in the industry.

(v) Standing in the industry of each firm will be known by making a comparison of its cost data with others.

(vi) Services of cost consultants or experts may be available jointly to each firm in the industry by sharing their experiences and expenses.

(vii) Research and development benefits of bigger firms may be made available to smaller firms.

(viii) It helps in the reduction of labour turnover, as a uniform wage system is the pre-condition of a uniform costing system.

(ix) It helps Trade Associations in negotiating with the Government for any assistance or concession in the matters of taxation, exports, subsidies, duties and prices determination etc.

(x) Unhealthy competition is avoided among the firms in the same industry in framing pricing policies and submitting tenders.

(xi) Prices fixed on the basis of uniform costing are representative of the whole industry and thus are reliable.

(xii) Uniform costing provides a basis for the comparative assessment of the performance of two firms in the same industry but in different sectors.

(xiii) It helps the Government in regulating the prices of essential commodities such as bread, sugar, cement, steel etc.

Question-5

Enumerate the objectives of Uniform Costing.

Answer

The main objectives of Uniform Costing are as follows:

(i) **Facilitates Comparison:** To facilitate the comparison of costs and performances of different units in the same industry; it provides objective basis.

(ii) **Eliminates Unhealthy Competition:** To eliminate unhealthy competition among the different units of an industry.

(iii) **Improves Efficiency:** To improve production capacity level and labour efficiency by comparing the production costs of different units with each other.

(iv) **Provides Relevant Data:** To provide relevant cost information/ data to the Government for fixing and regulating prices of the products.

(v) **Ensures Standardisation:** To bring standardisation and uniformity in the operation of participating units.

(vi) **Reduces Cost:** To reduce production, administration, selling and distribution costs, and to exercise control on fixed costs.

Inter-firm Comparison

Question-6

What are the advantages of Inter-firm Comparison?

Answer

The main advantages of Inter-firm Comparison are:

(i) Such a comparison gives an overall view of the industry as a whole to its members. The present position of the industry, progress made during the past and the future of the industry.

(ii) It helps a concern in knowing its strengths or weaknesses in relation to others so that remedial measures may be taken.

(iii) It ensures an unbiased specialized reporting on particular problems of the concern.

(iv) It develops cost consciousness among members of the industry.

(v) It helps Government in effecting price regulation.

(vi) It helps to improve the quality of products manufactured and to reduce the cost of production. It is thus advantageous to the industry as well as to the society.

Question-7

What are the limitations of Inter-firm Comparison?

Answer

The following are the limitations in the implementation of a scheme of Inter-firm Comparison:

(i) There is a fear of losing secrecy of the production method or some peculiar process or method among the top management..

(ii) Middle management is usually not convinced with the utility of such a comparison.

(iii) In the absence of a suitable cost accounting system, the figures supplied may not be reliable for the purpose of comparison.

(iv) Suitable basis for comparison may not be available.

9 Profitability Analysis –
Product Wise/ Segment Wise/ Customer Wise

Basic Concepts

Customer Profitability Analysis (CPA)	This is a relatively new technique that ABC makes possible because it creates cost pools for activities. Customers use some activities but not all, and different groups of customers have different 'activity profiles'. Different customers or categories of customers will each use different amounts of these activities and so customer profitability profiles can be built up, and customers can be charged according to the cost to serve them.
Categorisation of Indirect Costs for DPP	Categorisation of Indirect Cost for DPP is as follows: (i) Overhead cost (ii) Volume related cost (iii) Product batch cost (iv) Inventory financing costs
Direct Product Profitability (DPP)	DPP involves the attribution of both the purchase price and other indirect costs (for example distribution, warehousing and retailing) to each product line. Thus a net profit, as opposed to a gross profit, can be identified for each product. The cost attribution process utilizes a variety of measures (for example warehousing space and transport time) to reflect the resource consumption of individual products.
Market Driven Standard Costs	The allowable or target cost per unit is a market driven standard cost that has to be met if the desired profit are to be achieved.
The Balanced Scorecard	The Balanced Scorecard can be defined as 'an approach to the provision of information to management to assist strategic policy formulation and achievement'. It emphasizes the need to provide the user with a set of information, which addresses all relevant areas of performance in an objective and unbiased fashion.

SECTION - A

Profitability Analysis

Question-1

What do you mean by DPP? What are its benefits?

Answer

Direct Product Profitability (DPP) is 'Used primarily within the retail sector, and involves the attribution of both the purchase price and other indirect costs *such as distribution, warehousing, retailing* to each product line. Thus a net profit, as opposed to a gross profit, can be identified for each product. The cost attribution process utilises a variety of measures *such as warehousing space, transport time* to reflect the resource consumption of individual products.'

Benefits of Direct Product Profitability:

(i) Better Cost Analysis - Cost *per product* is analysed to know the profitability of a particular product.

(ii) Better Pricing Decision- It helps in price determination as desired margin can be added with the actual cost.

(iii) Better Management of Store and Warehouse Space- Space Cost and Benefit from a product can be analysed and it helps in management of store and warehouse in profitable way.

(iv) The Rationalisation of Product Ranges etc.

Question-2

Discuss the benefits of Customer Profitability Analysis.

Answer

Benefits of Customer Profitability Analysis

(i) It helps the supplier to identify which customers are eroding overall profitability and which customers are contributing to it.

(ii) It can help to provide a basis for constructive dialogue between buyer and seller to improve margins.

(iii) It enhances decision making related to customers.

(iv) It helps in effective cost reporting, communication and information.

(v) It helps to find out the value and profitability of each customer segment.

Balanced Scorecard

Question-3

What do you understand by a Balanced Scorecard? Give reasons why Balanced Scorecards sometimes fail to provide for the desired results. Do you think that such a scorecard is useful for external reporting purposes?

Answer

The Balanced Scorecard can be defined as 'an approach to the provision of information to management to assist strategic policy formulation and achievement. It emphasizes the need to provide the user with a set of information, which addresses all relevant areas of performance in an objective and unbiased fashion. The information provided may include both financial and non-financial elements, and cover areas such as profitability, customer satisfaction, internal efficiency and innovation'.

It is clear from the above definition that the central idea of the Balanced Scorecard is that managers should develop the measures on which they manage the business from four different perspectives:

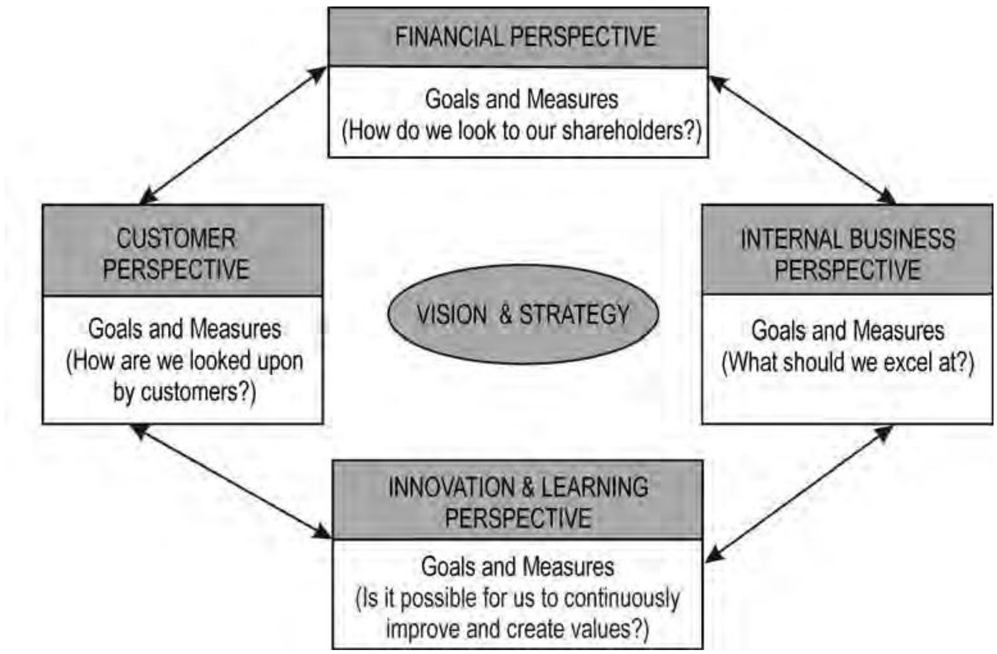
(i) Customer Perspective i.e. customer satisfaction.

(ii) Internal Business Perspective

(iii) Learning and growth prospective

(iv) Financial Perspective e.g., operating income by segments.

The following figure summarises the ideas of a Balanced Scorecard:



According to Kaplan and Norton, the ultimate result of using the Balanced Scorecard approach should be an improved long-term financial performance. Since the scorecard gives equal importance to the relevant non – financial measures, it should discourage the short term approach that leads to cuts in spending on new product development, human resource development etc which are ultimately detrimental for the future prospects of the company.

The responsibility to devise and implement a Balanced Scorecard should be that of the managers working with the business. Since every company is different, it shall need to work out for itself the various financial and non – financial measures, which need to be focused upon for its own development. Since the Balanced Scorecard is recommended as a management tool used both for internal and external reporting purposes, it is again the manager's responsibility to decide as to what information needs to be disclosed and how any problems of confidentiality can best be overcome.

The following are some reasons why Balanced Scorecards sometimes fail to provide for the desired results;

– The use of non- financial measures leads managers to think that they have a Balanced Scorecard already working for strategic purposes.

– Senior executives misguidedly delegate the responsibility of the Scorecard implementation to middle level managers.

– Companies try to copy measures and strategies used by the best companies rather than developing their own measures suited for the environment under which they function.

– There are times when Balanced Scorecards are thought to be meant for reporting purposes only. This notion does not allow a Business to use the Scorecard to manage Business in a new and more effective way.

It may be noted that the above-mentioned difficulties refer to the internal use of the Scorecard. It remains a matter of debate whether a Balanced Scorecard is applicable to external reporting. Critics argue that if the Scorecard is indeed a relevant driver of long term performance, shouldn't the information generated be of interest to the investment community? However, it has been noticed that the Scorecard does not translate easily to the investment community for the simple reason that it makes sense for individual business units and different individual projects rather than the company as a whole. Most companies have different divisions with their own mission and strategy and hence these individual scorecards cannot be aggregated into an overall corporate scorecard. However, in case the company somehow manages to overcome such a problem and indeed use its Scorecard for external reporting, it may end up passing sensitive information to its competitors which may end up being detrimental to the company in the long run. However, with changes in the thinking process of the investment community, such strategic reporting could well be accepted in the near future.

Question-4

Explain goals and performance measure for each perspective of Balanced Scorecard.

Answer

Goals and Performance Measures *for each perspective of* Balanced Scorecard

Customer Perspective

Goals	Performance Measures
Price	Competitive Price
Delivery	Number of on Time Delivery Lead Time from Receipt of Order to Delivery to Customer
Quality	Own Quality Relative to Industry Standards Number of Defects or Defect Level
Support	Response Time Customer Satisfaction Survey

Internal Business Perspective

Goals	Performance Measures
Efficiency of Manufacturing Process	Manufacturing Cycle Time
Sales Penetration	Sales Plan Increase in Number of Customer *in a unit of time*
New Product Introduction	Rate of New Product Introduction.

Innovation and Learning Perspective

Goals	Performance Measures
Technology Leadership	Performance of Product Use of Technology
Cost Leadership	Manufacture Overhead per Quarter
Market Leadership	Market Share in all Major Markets
Research and Development	Number of New Products Patents

Financial Perspective

Goals	Performance Measures
Sales	Revenue and Profit Growth
Cost of Sales	Extent in Remain Fixed or Decreased *each year*
Profitability	Return on Capital Employed
Prosperity	Cash Flows

Question-5

"In many organizations, initiatives to introduce Balanced Scorecard failed because efforts were made to negotiate targets rather than to build consensus." Elucidate the above statement.

Answer

Balanced Scorecard is a set of financial and non-financial measures relating to a company's critical success factors. It is an approach which provides information to management to assist in strategy implementation. Therefore, the components to be included in the Balanced

Scorecard must flow from strategy. The targets should be measurable and must flow from strategy and corporate plan of the company. It is necessary that managers should agree to the components and targets because in absence of a consensus, managers may not commit to the targets established by the top management. Moreover, the functions are interdependent and results in one functional area/ perspective (e.g. innovation and learning) have direct bearing on the results in other functional area / perspective (e.g. customer perspective). Therefore, it is not sufficient that individual managers agree to their targets. Successful implementation requires that the top management builds an overall consensus on the components and targets of the Balanced Scorecard. Negotiation undermines the fundamental principle that the components and targets should flow from strategy. As a result, an approach to establish targets through negotiation defeats the very purpose of Balanced Scorecard.

SECTION - B

Profitability Analysis- Product Wise/ Direct Product Profitability

Problem-1

A company produces and sells four types of dolls for children. It also produces and sells a set of dress kit for the dolls.

The company has worked out the following estimates for the next year:

Doll	***Estimated Demand***	***Standard Material Cost (₹)***	***Standard Labour Cost (₹)***	***Estimated Sales Per Unit (₹)***
A	*50,000*	*20*	*15*	*60*
B	*40,000*	*25*	*15*	*80*
C	*35,000*	*32*	*18*	*100*
D	*30,000*	*50*	*20*	*120*
Dress Kit	*2,00,000*	*15*	*5*	*50*

To encourage the sale of dress kits, a discount of 20% in its price is offered if it were to be purchased along with the doll. It is expected that the entire customer, buying dolls will also buy the dress kit.

The company's factory has effective capacity of 2,00,000 labour hours per annum on a single-shift basis and it produces all the products on that basis. The labour hour rate is ₹ 15 Overtime of labour has to be paid at double the normal rate.

Variable cost works out to 50% of direct labour cost. Fixed costs are ₹ 30 lakhs per annum.

There will be no inventory at the end of the year.

Required

Draw a conservative estimate of the year's profitability.

Solution

Statement Showing "Conservative Estimate of the Year's Profitability"

	Doll- A	Doll –B	Doll- C	Doll- D	Dress Kit
Estimated Demand (units)	50,000	40,000	35,000	30,000	2,00,000
	(₹)	(₹)	(₹)	(₹)	(₹)
Selling Price *per unit*	60.00	80.00	100.00	120.00	50.00
Less: Material Cost *per unit*	20.00	25.00	32.00	50.00	15.00
Less: Labour Cost	15.00	15.00	18.00	20.00	5.00
Less: Variable Cost (50% of Labour Cost)	7.50	7.50	9.00	10.00	2.50
Contribution *per unit*	17.50	32.50	41.00	40.00	27.50
Total Contribution on Estimated Demand	8,75,000 (50,000 × ₹17.50)	13,00,000 (40,000 × ₹33.50	14,35,000 (35,000 × ₹41)	12,00,000 (30,000 × ₹40)	55,00,000 (2,00,000 × ₹27.50)
Less: Discount (W.N.-2)	---	---	---	---	15,50,000
Net Contribution	8,75,000	13,00,000	14,35,000	12,00,000	39,50,000

	(₹)
Total Net Contribution	87,60,000
Less: Overtime Premium (38,000 hrs × ₹15) [W.N.]	(5,70,000)
Less: Fixed cost	(30,00,000)
Profit	51,90,000

Working Notes

1. **Total Labour Hours Required to Meet Estimated Demand of Four Types of Dolls and Dress Kit**

Doll (a)	Estimated Demand (units) (b)	*Standard Labour Time per Doll (c)	Total Labour Hours (d) = (b) × (c)
A	50,000	1.00 hr	50,000.00
B	40,000	1.00 hr	40,000.00
C	35,000	1.20 hrs	42,000.00
D	30,000	1.33 hrs	40,000.00
Dress Kit	2,00,000	0.33 hrs	66,000.00
Total Labour Hours *to meet estimated demand*			2,38,000.00

(*)

Standard Labour Time per Doll has been calculated by dividing Standard Labour Cost per Doll by ₹15.

Since the Total Available Hours are only 2,00,000 therefore 38,000 Hours will be utilised by employing the Labour on Overtime Basis.

2. Total Discount on the Sale of Dress Kit

Out of 2,00,000 Dress Kits, 1,55,000 were sold along with four type of Dolls. Each unit of Sale of Dress Kit along with a unit of Doll is entitled for a Discount of 20% on ₹50 i.e. ₹10. The Total Discount amount on the Sale of 1,55,000 Dress Kit comes to ₹15,50,000.

Problem-2

Jigyasa India Ltd. (JIL) has 30 retail stores of uniform sizes 'Fruity & Sweety Retails' across the country. Mainly three products namely 'Butter Jelly', 'Fruits & Nuts' and 'Icy Cool' are sold through these retail stores. JIL maintains stocks for all retail stores in a centralised warehouse. Goods are released from the warehouse to the retail stores as per requisition raised by the stores. Goods are transported to the stores through two types of vans i.e. normal and refrigerated. These vans are to be hired by the JIL.

Costs per month of JIL are as follows:

	(₹)
Warehouse Costs:	
Labour & Staff Costs	*27,000*
Refrigeration Costs	*1,52,000*
Material Handling Costs	*28,000*
Total	*2,07,000*
Head Office Cost:	
Salary & Wages to Head Office Staff	*50,000*
Office Administration Costs	*1,27,000*
Total	*1,77,000*
Retail Stores Costs:	
Labour Related Costs	*33,000*
Refrigeration Costs	*1,09,000*
Other Costs	*47,000*
Total	*1,89,000*

Average transportation cost of JIL per trip to any retail stores are as follows:

Normal Van	*₹3,200*
Refrigerated Van	*₹4,900*

The Chief Financial Manager asked his Finance managers to calculate profitability based on three products sold through Fruity & Sweety retail stores rather than traditional method of calculating profitability.

The following information regarding retail stores are gathered:

	Butter Jelly	***Fruits & Nuts***	***Icy Cool***
No. of Cartons per cubic metre (m^3)	*42*	*28*	*40*
No. of Items per cartons (units)	*300*	*144*	*72*
Sales per month (units)	*18,000*	*4,608*	*1,152*
Time in Warehouse (in months)	*1*	*1.5*	*0.5*
Time in Retail Stores (in months)	*1*	*2*	*1*
Selling Price per unit (₹)	*84*	*42*	*26*
Purchase Price per unit (₹)	*76*	*34*	*22*

Butter Jelly and Icy-Cool are required to be kept under refrigerated conditions.

Additional information:

Total Volume of All Goods Sold per month	*40,000 m^3*
Total Volume of Refrigerated Goods Sold per month	*25,000 m^3*
Carrying Volume of each van	*64 m^3*

Required

Calculate the Profit per unit using Direct Product Profitability (DPP) method.

Solution

Direct Product Profitability (DPP) Statement

(Amount in ₹)

	Butter Jelly	**Fruits & Nuts**	**Icy Cool**
Selling Price *per unit*	84.00	42.00	26.00
Less: Purchase Price *per unit*	76.00	34.00	22.00
Gross Profit ...(A)	8.00	8.00	4.00
Direct Product Costs:			

Warehouse Costs *per m³* [W.N.-1]	7.46	2.07	3.73
Retail Stores Costs *per m³* [W.N.-2]	6.36	4.00	6.36
Transportation Costs [W.N.-3]	76.56	50.00	76.56
Total DPP costs *per m³*	90.38	56.07	86.65
Items *per m³* [W.N.-4]	12,600	4,032	2,880
Cost *per item* ...(B)	0.007	0.014	0.030
Direct Product Profit ...(A) - (B)	7.993	7.986	3.97

Working Notes

(1) Warehouse Related Costs

	General Costs (₹)	Cost Related with Refrigerated Goods (₹)
Labour & Staff Costs	27,000	---
Refrigeration Costs	---	1,52,000
Material Handling Costs	28,000	---
Total	55,000	1,52,000
Volume of Goods Sold	40,000 m^3	25,000 m^3
Cost *per m³ per month*	1.38	6.08

Products	Time in Warehouse	Cost *per m³ per month* (₹)	Total Cost (₹)
Butter Jelly	1 Month	7.46 (1.38 + 6.08)	7.46
Fruits & Nuts	1.5 Months	1.38	2.07
Icy-cool	0.5 Months	7.46 (1.38 + 6.08)	3.73

(2) Retail Stores Related Costs

	General Costs (₹)	Cost Related with Refrigerated Goods (₹)
Labour Related Costs	33,000	---
Refrigeration Costs	---	1,09,000
Other Costs	47,000	---
Total	80,000	1,09,000
Volume of Goods Sold	40,000 m^3	25,000 m^3
Cost *per m³ per month*	2.00	4.36

Products	Time in Retail Stores	Cost *per m³ per month*	Total Cost
Butter Jelly	1 Month	₹6.36 (₹2.00 + ₹4.36)	₹6.36
Fruits & Nuts	2 Months	₹2.00	₹4.00
Icy-Cool	1 Month	₹6.36 (₹2.00 + ₹4.36)	₹6.36

(3) Transportation Costs

	Normal Van Costs	Refrigerated Van Costs
Cost *per trip*	₹3,200	₹4,900
Volume of Van	64 m^3	64 m^3
Cost *per m^3 per trip*	₹50.00	₹76.56

(4) No. of Items *per m^3*

Products	No. of Cartons (m^3)	No. of Items *per Cartons* (units)	No. of Items *per m^3*
Butter Jelly	42	300	12,600 (42 × 300)
Fruits & Nuts	28	144	4,032 (28 × 144)
Icy - Cool	40	72	2,880 (40 × 72)

Profitability Analysis- Customer Wise/ Customer Profitability Analysis

Problem-3

A and B are two customers of XYZ Electronics Ltd., a manufacturer of audio players. Selling price per unit is ₹5,400. Its cost of production per unit is ₹4,420.

Additional costs are:

Order Processing Cost……………………………..₹2,000 per order

Delivery Costs………………………………………₹3,500 per delivery

Details of customers A and B for the period are given below:

	Customer A	*Customer B*
Audio Players purchased(nos.)	*350*	*500*
No. of orders	*5 (each of 70 units)*	*10 (each of 50 units)*
No. of deliveries	*5*	*0*

The company's policy is to give a discount of 5% on the selling price on orders for 50 units or more, and to further give 8% discount on the undiscounted selling price if a customer uses his own transport of collect the order. Assume that production levels are not altered by these orders.

Required

(i) Analyse the profitability by comparing profit per unit for each customer.

(ii) Comment on the discount policy on delivery.

Solution

(i) **Customer's Profitability Statement**

Particulars	**Customer- A**	**Customer- B**
Sales (units)	**350**	**500**
	(₹)	(₹)
Selling Price *per unit*	5,400	5,400
Less: Discount (Quantity)	270 (₹5,400 × 5%)	270 (₹5,400 × 5%)
Less: Discount (Delivery)	---	432 (₹5,400 × 8%)
Selling Price (Net of Discounts) *per unit*	5,130	4,698
Less: Variable Cost *per unit*	4,420	4,420
Contribution *per unit*	710	278
Total Contribution	2,48,500 (₹710 × 350 units)	1,39,000 (₹278 × 500 units)
Less: Additional Overheads		
Delivery Cost	17,500 (5 × ₹3,500)	---
Order Processing Cost	10,000 (5 × ₹2,000)	20,000 (10 × ₹2,000)
Profit *per customer**	2,21,000	1,19,000
Profit *per customer per unit*	631.43	238.00

Analysis

Even though A has lower sales volume (30% lesser from B), it is contributing almost double profit that is being contributed by B as overall discount offered to customer A is quite less.

(ii) Comments on the "Discount Policy on Delivery"

Discount on delivery offered to customer B is ₹432 *per unit*. If transport for delivery is provided to customer B then the cost would have been ₹70 *per unit* (10 deliveries × ₹ 3,500 / 500 units), which is lesser by ₹362. It may also be noted that delivery cost in case of customer A is only ₹50 per unit (₹17,500 ÷ 350 units). Hence, company needs to review discount policy on delivery but significance of profitability of customer B should also be kept in mind while doing so.

Problem-4

Edward Ltd. manufactures weighing machines of standard size and sells its products to two industrial customers namely MT Ltd. and KG Ltd. and to a dealer MG Bros. having shops in different cities. The maximum retail price per unit of weighing machine is ₹ 11,000 and per unit average cost of production is ₹ 5,500 (40% is general fixed overhead cost).

The Finance Officer has been asked to undertake a customer profitability analysis and calculate and compare the profit margin per customer (before deducting general fixed overhead) to know about the real customer profitability.

Following are the additional overhead information:

Delivery Costs	*₹ 200 per Kilometer*
Emergency Delivery Cost (in addition to Delivery Cost)	*₹ 21,000 per Delivery*
Order Processing Cost	*₹ 6,000 per Order*
Specific Discount and Sales Commission	*As per Negotiation*
Product Advertisement Cost	*Actual Cost*

The following data are available for each customer:

Particulars	***MT Ltd.***	***KG Ltd.***	***MG Bros.***
Sales (in units)	*2,000*	*1,000*	*800*
Total Delivery Kilometer Travelled	*1,000*	*800*	*900*
No. of Emergency Delivery	*2*	*1*	*0*
No. of Orders Processed	*4*	*2*	*8*
Specific Discount *(Percentage of Sales Revenue)*	*25%*	*20%*	*15%*
Sales Commission *(Percentage of Sales Revenue)*	*15%*	*10%*	*5%*
Advertisement Costs (₹)	*8,75,000*	*6,15,000*	*4,30,000*

Required

Analyze the profitability for each customer, which customer is the most profitable.

Solution

Customer Profitability Statement

Particulars	**MT Ltd.**	**KG Ltd.**	**MG Bros.**
Sales (units)	2,000	1,000	800
	(₹)	**(₹)**	**(₹)**
Sales Revenue ...(A)	2,20,00,000	1,10,00,000	88,00,000
Less: Average Variable Cost ...(B) (₹5,500 × 60% = 3,300 p.u.)	66,00,000	33,00,000	26,40,000
Contribution [70% of Sales] ...(A) - (B)	1,54,00,000	77,00,000	61,60,000
Less: Additional Overheads			
Delivery Cost (No. of K.M. × ₹200)	2,00,000	1,60,000	1,80,000
Emergency Delivery Cost (No. of Emergency Delivery × ₹21,000)	42,000	21,000	----
Order Processing Cost (No. of Orders × ₹6,000)	24,000	12,000	48,000
Specific Discount	55,00,000	22,00,000	13,20,000
Sales Commission	33,00,000	11,00,000	4,40,000
Advertisement Cost	8,75,000	6,15,000	4,30,000
Profit *per customer**	54,59,000	35,92,000	37,42,000
Profit Margin *per customer** (%)	24.81%	32.65%	42.52%
Rank	III	II	I

** Before Deducting General Fixed Overhead Cost*

Analysis

The Contribution Margin is 70% for each Customer but when the other Overheads Costs *per customer* is included in the above Profitability Statement the Profitability of the three Customers become different. MG Bros. is the most Profitable Customer.

Problem-5

Oxford Medical Care Co. (OMCC) is a pharmaceutical firm, operating its entire business through its four customers Ox_1, Ox_2, Ox_3, and Ox_4. Ox_1 and Ox_2 are small pharmaceutical stores while Ox_3 and Ox_4 are large discount stores with attached pharmacies. OMCC uses discount pricing strategy and prices its products at variable cost plus 25%.

Item	*Small Pharmaceuticals*		*Large Pharmaceuticals*		*Activity Rate*
	Ox_1	*Ox_2*	*Ox_3*	*Ox_4*	
Number of Orders	*4*	*9*	*6*	*3*	*₹750*
Order Size	*₹40,000*	*₹20,000*	*₹4,25,000*	*₹4,00,000*	*n/a*
Average Discount	*4.50%*	*9.50%*	*17.50%*	*11.50%*	*n/a*
Regular Deliveries	*4*	*9*	*6*	*3*	*₹375*
Expedited Deliveries	*2*	*0*	*2*	*0*	*₹1,250*
General Administration Cost	*₹20,250*		*₹48,375*		

Required

(i) Prepare a 'Customer Profitability Statement' that shows the profit from each customer and each customer channel.

(ii) Recommend some points to improve OMCC's profit.

Solution

. **Statement Showing "Customer Profitability Analysis"**

Particulars	**Ox_1**	**Ox_2**	**Channel Total**	**Ox_3**	**Ox_4**	**Channel Total**
	Small Stores			**Large Stores**		
Revenue	1,60,000	1,80,000	3,40,000	25,50,000	12,00,000	37,50,000
Discount	7,200	17,100	24,300	4,46,250	1,38,000	5,84,250
Net Revenue	1,52,800	1,62,900	3,15,700	21,03,750	10,62,000	31,65,750
Variable Costs	1,28,000	1,44,000	2,72,000	20,40,000	9,60,000	30,00,000
Contribution Margin	24,800	18,900	43,700	63,750	1,02,000	1,65,750
Order Processing	3,000	6,750	9,750	4,500	2,250	6,750
Regular Deliveries	1,500	3,375	4,875	2,250	1,125	3,375
Expedited Deliveries	2,500	---	2,500	2,500	---	2,500
Customer Profit	17,800	8,775	26,575	54,500	98,625	1,53,125
Channel Cost			20,250			48,375
Channel Profit			6,325			1,04,750

Recommendations

Small Pharmaceuticals

Even though Ox_1 has lower sales volume (11% lesser from Ox_2), it is contributing around 67% of small store's profit as its order is for larger quantities and discount offered is very less.

OMCC is only just at breakeven point with small pharmaceuticals. To improve profit OMCC should:

(i) Coordinate with Ox_2 to *increase order size* and try to *negotiate a smaller discount*.

(ii) Try to work with Ox_1 to *reduce expedited deliveries*.

Large Pharmaceuticals

OMCC makes substantial profit from the large pharmaceuticals. Ox_4 alone contributing around 55% of total customer's profit and its order is for larger quantities. Therefore, Ox_4 is most favorable customer and may be given *little extra attention.* For Ox_3, OMCC may have *no options* but to treat it as less profitable customer as Ox_3 accounts more than 60% of sales.

Problem-6

PQR Ltd. specializes in the distribution of pharmaceutical products. It buys from pharmaceutical companies and resells to each of the three different markets:

(i) General Supermarket Chains

(ii) Drug Store Chains

(iii) Chemist Shops

The company plans to use activity based costing for analyzing the profitability of its distribution channels. The following data for the quarter ending March 2014 is given:

	General Supermarket Chains	Drug Store Chains	Chemist Shops
Average sales per delivery	₹ 96,500	₹ 32,450	₹ 6,225
Average cost of goods sold per delivery	₹ 94,650	₹ 31,800	₹ 5,950
Number of deliveries	960	2,470	8,570
Total number of orders	1,000	2,650	9,500
Average number of cartons shipped per delivery	250	75	12
Average number of hours of shelf stocking per delivery	2	0.5	0.1

The following information is available in respect of operating costs (other than cost of goods sold) for the quarter ending March 2014:

Activity Area	*Cost Driver*	*Total Cost (₹)*
Customer purchase order processing	*Purchase order by customers*	*5,91,750*
Customer store delivery	*Number of deliveries*	*9,60,000*
Cartons dispatched to customer stores	*Number of Cartons dispatched to customer stores*	*7,92,135*
Shelf stocking at customer store	*Hours of shelf stocking*	*80,240*

Required

Compute the operating income of each distribution channel for the quarter ending March 2014 using activity based costing.

Solution

Statement Showing "Operating Income of Distribution Channels of PQR Ltd."

Particulars	**General Supermarket Chains (₹)**	**Drug Store Chains (₹)**	**Chemist Shops (₹)**	**Total (₹)**
Sales (Number of Deliveries × Average Sales *per delivery*)	9,26,40,000 (960 × ₹96,500)	8,01,51,500 (2,470 × ₹32,450)	5,33,48,250 (8,570 × ₹6,225)	22,61,39,750
Less: Cost of Goods Sold (Number of Deliveries × Avg. COGS *per delivery*)	9,08,64,000 (960 × ₹94,650)	7,85,46,000 (2,470 × ₹31,800)	5,09,91,500 (8,570 × ₹5,950)	22,04,01,500
Gross Margin	17,76,000	16,05,500	23,56,750	57,38,250
Less: Operating Costs	5,20,200	6,19,425	12,84,500	24,24,125
Operating Income	12,55,800	9,86,075	10,72,250	33,14,125

Workings

Statement Showing "Operating Cost of Distribution Channels of PQR Ltd."

Particulars	**General Supermarket Chains (₹)**	**Drug Store Chains (₹)**	**Chemist Shops (₹)**	**Total (₹)**
Customer Purchase Order Processing	45,000 (₹45 × 1,000)	1,19,250 (₹45 × 2,650)	4,27,500 (₹45 × 9,500)	5,91,750
Customer Store Delivery	76,800 (₹80 × 960)	1,97,600 (₹80 × 2,470)	6,85,600 (₹80 × 8,570)	9,60,000

Cartons Dispatched to Customer Stores	3,60,000 (₹1.5 × 2,40,000)	2,77,875 (₹1.5 × 1,85,250)	1,54,260 (₹1.5 × 1,02,840)	7,92,135
Shelf Stocking at Customer Store	38,400 (₹20 × 1,920)	24,700 (₹20 × 1,235)	17,140 (₹20 × 875)	80,240
	5,20,200	6,19,425	12,84,500	24,24,125

Computation of Rate *per* Unit of Cost Allocation Base

Activity	Activity Cost [a] (₹)	Activity Driver	No. of Units of Activity Driver [b]	Cost Driver Rate [a] / [b] (₹)
Customer Purchase Order Processing	5,91,750	Purchase Order by Customers	13,150	45.00
Customer Store Delivery	9,60,000	Number of Deliveries	12,000	80.00
Cartons Dispatched to Customer Stores	7,92,135	Number of Cartons Dispatched to Customer Stores	5,28,090	1.50
Shelf Stocking at Customer Store	80,240	Hours of Shelf Stocking	4,012	20.00

No. of Units of Activity Driver→

Purchase Order by Customers = 1,000 + 2,650 + 9,500

= 13,150

Number of Deliveries = 960 + 2,470 + 8,570

= 12,000

Number of Cartons Dispatched to Customer Stores = Number of Deliveries × Average Number of Cartons Shipped *per delivery*

= (960 × 250) + (2,470 × 75) + (8,570 × 12)

= 2,40,000 + 1,85,250 + 1,02,840

= 5,28,090

Hours of Shelf Stocking = Number of Deliveries × Average Number of Hours of Shelf Stocking *per delivery*

= (960 × 2.0) + (2,470 × 0.5) + (8,570 × 0.1)

= 1,920 + 1,235 + 857

= 4,012

Profitability Analysis- Miscellaneous

Problem-7

Y Limited is a manufacturer of Cardboard boxes. An analysis of its operating income between 2012 and 2013 shows the following:

	Income Statement (amount in 2012)	***Revenue & Cost effect of Growth component in 2013***	***Revenue & Cost effect of Price recovery component in 2013***	***Cost effect of productivity component in 2013***	***Income Statement (amount in 2013)***
Revenue (₹)	*40,00,000*	*2,00,000(F)*	*4,20,000(F)*	*-*	*46,20,000*
Cost (₹)	*29,20,000*	*60,000 (A)*	*2,56,000(A)*	*58,000(F)*	*31,78,000*
Operating Income(₹)	*10,80,000*	*1,40,000(F)*	*1,64,000(F)*	*58,000(F)*	*14,42,000*

Y limited sold 4,00,000 boxes and 4,20,000 boxes in 2012 and 2013 respectively. During 2013 the market for cardboard boxes grew 3% in terms of number of units and all other changes are due to company's differentiation strategy and productivity.

Required

Compute how much of the change in operating income from 2012 to 2013 is due to the industry market size factor, productivity and product differentiation and also reconcile the profit of both years due to these factors.

Solution

Reconciliation of Operating Income

Particulars	**Amount (₹)**
Operating Income in 2012	10,80,000
Add: Change Due to Industry Market Size Factor (W.N.-1)	84,000
Changes Due to Productivity (W.N.-2)	58,000
Changes Due to Product Differentiation (W.N.-3)	2,20,000
Operating Income in 2013	14,42,000

Workings

Total Increase in Sale of Cardboard Boxes 20,000 Boxes (4,20,000 Boxes – 4,00,000 Boxes). Out of this increase in Sales of 20,000 Boxes,12,000 Boxes (3% of 4,00,000) is due to *growth in market size*, and the remaining 8,000 Boxes (20,000 Boxes – 12,000 Boxes) are due to an increase in *market share* .

W.N.1 Effect of the Industry Market Size Factor *on operating income*:

= Revenue and Cost Effect of Growth Component in 2013 ×

$$\frac{\text{Increase in Sales Unit Due to Market Growth}}{\text{Total Growth in Sales Unit (from 2012 to 2013)}}$$

$$= ₹1,40,000 \times \frac{12,000 \text{ Boxes}}{20,000 \text{ Boxes}}$$

= ₹84,000 (F)

W.N.2. Effect of Productivity *on operating income*:

= Cost Effect of Productivity Component in 2013

= ₹58,000 (F)

W.N.3 Effect of Product Differentiation *on operating income*:

Particulars	Amount (₹)
Increase in the Selling Price (Revenue Effect of the Price Recovery Component)	4,20,000 (F)
Increase in Prices of Inputs (Cost Effect of the Price Recovery Component)	2,56,000 (A)
Growth in Market Share Due to Product Differentiation* $\left(₹1,40,000 \times \frac{8,000 \text{ Boxes}}{20,000 \text{ Boxes}}\right)$	56,000 (F)
Total	2,20,000 (F)

* Revenue and Cost Effect of Growth Component in 2013 ×

$$\frac{\text{Increase in Sales Unit Due to Product Differentiation}}{\text{Total Growth in Sales Unit (from 2012 to 2013)}}$$

Problem-8

Aditya Decors Ltd. (ADL) is a leading manufacturer of luxury sanitary products and has divided its whole business into different product segments. At the Last year the management of ADL has decided to make some changes in its one of product-line 'AADee', the improved version was made available for sale from 1st of April 2014.

At the end of the financial year 2014-15, the finance and accounts department has extracted some relevant data for the product line 'AADee' to analyse the decision taken last year. The data related with AADee for the financial year 2013-14 and 2014-15 are as follows:

	2013-14	***2014-15***
No. of Units Sold	*4,00,000*	*4,30,000*
Selling Price per unit	*₹4,175*	*₹ 4,325*

Direct Materials Consumed	*24,00,000 kg.*	*25,10,000 kg.*
Cost per kg. of Direct Materials	*₹470*	*₹485*
Direct LabourUsed	*32,00,000 hrs.*	*34,80,000 hrs.*
Rate per labour hour	*₹30*	*₹ 31*
Fixed Costs	*₹1,60,00,000*	*₹ 1,76,00,000*

ADL has the capacity to produce 5,00,000 units of AADee a year.

Required

(i) Analyse the changes in the operating income from financial year 2013-14 to 2014-15 with respect to the following components:

(a) Growth, (b) Price- Recovery and (c) Productivity Components.

(ii) Reconciliation of Operating Profit from 2013-14 to 2014-15.

Solution

Analysis of Changes in the Operating Income from Financial Year 2013-14 to 2014-15

Growth Component→

Revenue Effect of Growth Component

$$= \begin{pmatrix} \text{Actual Units of Output} & - & \text{Actual Units of Output} \\ \text{Sold in 2014-15} & & \text{Sold in 2013-14} \end{pmatrix} \times \text{Selling Price in 2013-14}$$

$$= (4{,}30{,}000 \text{ units} - 4{,}00{,}000 \text{ units}) \times ₹\,4{,}175$$

$$= ₹12{,}52{,}50{,}000 \text{ (F)}$$

<u>Cost Effect of Growth Component (Variable Costs)</u>

Direct Materials

$$= \begin{pmatrix} \text{Direct Materials Required to} & & \text{Direct Materials Used to} \\ \text{Produce 4,30,000 Units} & - & \text{Produce 4,00,000 Units} \\ \text{in 2013-14} & & \text{in 2013-14} \end{pmatrix} \times \text{Cost per Kg. in 2013-14}$$

$$= \left(\frac{24{,}00{,}000 \text{ Kg.}}{4{,}00{,}000 \text{ units}} \times 4{,}30{,}000 \text{ units} - 24{,}00{,}000 \text{ Kg.} \right) \times ₹\,470$$

$$= (25{,}80{,}000 \text{ Kg.} - 24{,}00{,}000 \text{ Kg.}) \times ₹\,470$$

$$= ₹8{,}46{,}00{,}000 \text{ (A)}$$

Direct Labour

$$= \begin{pmatrix} \text{Labour Hours Required to} & & \text{Labour Hours Used to} \\ \text{Produce 4,30,000 Units} & - & \text{Produce 4,00,000 Units} \\ \text{in 2013-14} & & \text{in 2013-14} \end{pmatrix} \times \text{Rate per hr. in 2013-14}$$

$$= \left(\frac{32,00,000 \text{ hrs.}}{4,00,000 \text{ units}} \times 4,30,000 \text{ units} - 32,00,000 \text{ Kg.}\right) \times ₹\,30$$

$$= (34,40,000 \text{ hrs.} - 32,00,000 \text{ hrs.}) \times ₹\,30$$

= ₹72,00,000 (A)

Price-Recovery Component→

<u>Revenue Effect of Price-Recovery Component</u>

$$= \begin{pmatrix} \text{Selling Price in} & - & \text{Selling Price in} \\ \text{2014-15} & & \text{2013-14} \end{pmatrix} \times \begin{matrix} \text{Actual Units of Output Sold in} \\ \text{2014-15} \end{matrix}$$

= (₹4,325 – ₹4,175) × 4,30,000 units

= ₹6,45,00,000 (F)

<u>Cost Effect of Price-Recovery Component (Variable Costs)</u>

Direct Material

$$= \begin{pmatrix} \text{Direct Material} & & \text{Direct Material} \\ \text{Price in} & - & \text{Price in} \\ \text{2014-15} & & \text{2013-14} \end{pmatrix} \times \begin{pmatrix} \text{Direct Material Required to} \\ \text{Produce 4,30,000 Units in} \\ \text{2013-14} \end{pmatrix}$$

= (₹485 – ₹470) × 25,80,000 kg.

= ₹3,87,00,000 (A)

Direct Labour

$$= \begin{pmatrix} \text{Labour Hour Rate in} & - & \text{Labour Hour Rate in} \\ \text{2014 – 15} & & \text{2013 – 14} \end{pmatrix} \times \begin{matrix} \text{Labour Hours Required to Produce} \\ \text{4,30,000 units in 2013 – 14} \end{matrix}$$

= (₹ 31 – ₹ 30) × 34,40,000 hrs.

= ₹34,40,000 (A)

<u>Cost effect of Price-Recovery Component (Fixed Costs)</u>

$$= \begin{pmatrix} \text{Rate per Unit} & - & \text{Rate per Unit} \\ \text{in 2014-15} & & \text{in 2013-14} \end{pmatrix} \times \begin{matrix} \text{Actual Units of Capacity in Last Year,} \\ \text{if Adequate to Produce Current Year's Output in Last Year} \end{matrix}$$

$$= \left(\frac{₹1,76,00,000}{5,00,000\,\text{units}} - \frac{₹1,60,00,000}{5,00,000\,\text{units}}\right) \times 5,00,000 \text{ units}$$

= (₹35.2 – ₹32) × 5,00,000 units

= ₹16,00,000 (A)

Productivity Component→

Productivity Component (for Variable Costs)

Direct Material

$$= \begin{pmatrix} \text{Direct Materials Used} & & \text{Direct Materials Required} \\ \text{to Produce 4,30,000} & - & \text{to Produce 4,30,000} \\ \text{units in 2014-15} & & \text{units in 2013-14} \end{pmatrix} \times \text{Cost per Kg. in 2014-15}$$

= (25,10,000kg. – 25,80,000 kg.) × ₹ 485

= ₹3,39,50,000 (F)

Direct Labour

$$= \begin{pmatrix} \text{Labour Hours Used} & & \text{Labour Hours Required} \\ \text{to Produce 4,30,000 Units} & - & \text{to Produce 4,30,000 Units} \\ \text{in 2014-15} & & \text{in 2013-14} \end{pmatrix} \times \text{Rate per Hour in 2014-15}$$

= (34,80,000 hours – 34,40,000 hours) × ₹ 31

= ₹12,40,000 (A)

Reconciliation of Operating Profit from 2013-14 to 2014-15

	Amount (₹)	Amount (₹)
Operating Profit in 2013-14 (Refer to Working Note)		43,00,00,000
Add: Revenue effect of Growth Component	12,52,50,000	
Revenue effect of Price-Recovery	6,45,00,000	
Productivity Component (Direct Material)	3,39,50,000	22,37,00,000
Less: Cost effect of Growth Component (Direct Material)	8,46,00,000	
Cost effect of Growth Component (Direct Labour)	72,00,000	
Cost effect of Price-Recovery (Direct Material)	3,87,00,000	
Cost effect of Price-Recovery (Direct Labour)	34,40,000	
Cost effect of Price-Recovery (Fixed Cost)	16,00,000	
Productivity Component (Direct Labour)	12,40,000	13,67,80,000
		51,69,20,000

Working Note

Calculation of Operating Profit in 2013-14 and 2014-15

	2013-14 (₹)	2014-15 (₹)
Sales (₹ 4,175 × 4,00,000 units; ₹ 4,325 × 4,30,000)	167,00,00,000	185,97,50,000
Less: Costs		
Direct Materials (₹470 × 24,00,000 Kg.;₹485 × 25,10,000 Kg.)	112,80,00,000	121,73,50,000
Direct Labour (₹ 30 × 32,00,000 hrs.; ₹31 × 34,80,000 hrs.)	9,60,00,000	10,78,80,000
Fixed Cost	1,60,00,000	1,76,00,000
Operating Profit	43,00,00,000	51,69,20,000
Increase/ (Decrease) in Operating Profit	8,69,20,000	

SECTION - C

Balanced Scorecard- Resort

Problem-1

"Hard Rock Coconut" is an exclusive resort located in a famous Island of Pacific Ocean that vows to isolate its guests from the hustle and bustle of everyday life. Its leading principle is "all contemporary amenity wrapped in old-world charisma". Each of the resort's 18 villas has a separate theme like Castle, Majestic, Ambassador, Royal Chateau, Coconut, Lemon, Balinese etc and guests often ask for a specific villa when they make reservations. Villas are Ideal for families or friends travelling together and these villas feature luxurious accommodation spanning two floors. Since it is located within a 300-acre estate on white sand beach, the resort offers its guests a wide variety of outdoor activities such as horseback riding, hiking, diving, snorkeling, sailing, golf and so on. Guests could also while away the day relaxing in the pool and availing themselves of the resort's world-famous spa "Hard Coco Spa". The dining room, which only has three tables for the public, is acceptable proud of its 4-star rating.

Required

Develop a Balanced Scorecard for "Hard Rock Coconut". It is sufficient to give two measures in each of the four perspectives.

Solution

The following is a possible **Balanced Scorecard** for **"Hard Rock Coconut"**

Financial Perspective	Economic Value Added
	Revenue *per villa*
Customer Perspective	% repeat customers
	Number of customer complaints
Internal Business	Service rating of spa
	Staff hours *per guest*
	% cost spent for maintenance
	Travel guide rank for restaurant
Innovation and Learning	Employee retention
	Number of new services offered

Balanced Scorecard- Supermarket

Problem-2

ABC Ltd. has supermarkets located in most towns and cities. Over the last few years, profits have fallen. ABC Ltd. has recognized that customer care has been paid insufficient attention. ABC Ltd. has now realized the importance of the customer experience at its supermarkets.

ABC Ltd. has introduced a loyalty card scheme that rewards customers with discount vouchers based on their spend and buying patterns at supermarkets in an attempt to earn the loyalty of its customers.

The management of ABC Ltd. is considering the introduction of a Balanced Scorecard approach to manage the performance of its stores.

Required

Recommend an objective and a suitable performance measure for each of three non-financial perspectives of a Balanced Scorecard that ABC Ltd. could use to support its new strategy of improving the customer experience. You should state three perspectives, an objective and a performance measure for each one of the three perspectives.

Solution

Non- Financial Perspective	Objective	Performance Measure
Customer Perspective	Increase the customer loyalty. *Or* Retaining the existing customers.	Percentage of customers using loyalty cards. *Or* No. of discount vouchers redeemed.
Internal Business Perspectives	For customers to pay for goods in a reasonable time. *Or* Paying proper attention to the customers and their product enquiries. *Or* Provide necessary support to the existing loyal customers.	Time spent by customers in queuing to pay for products at a check out. *Or* Time spent by customers care executives in handling customers queries. *Or* No. of times home delivery made.

Learning & Growth Perspectives	To have qualified staffs able to meet the needs of the customer. *Or* Adding new products for new segments.	No. of staff training days. *Or* No. of schemes launched.

Balanced Scorecard- Banking Company

Problem-3

Classify the following measures under appropriate categories in a Balanced Scorecard for a banking company which excels in it s home loan products:

(i) *A new product related to life insurance is being considered for a tie up with the successful housing loan disbursements.*

e.g. every housing loan applicant to be advised to take a life policy or compelled to take a fire insurance policy.

(ii) *How different sectors of housing loans with different interest rates have been sanctioned, their volumes of growth in the past 4 quarters.*

(iii) *How many days are taken to service a loan, how many loans have taken longer, what additional loans are to be released soon, etc.*

Solution

(i)	New Product *tie up*	--- Innovation / Learning Perspective
(ii)	Growth of Volume	--- Financial Perspective
(iii)	Time for Loan / Fresh Products	--- Customer Perspective

Problem-4

Your Bank Ltd., was established on the 30th September, 1940 under the provisions of Co-operative Societies Act by the eminent professionals to encourage self-help, thrift, cooperation among members. Bank was issued Banking License under Banking Regulation Act, 1949 on October 25, 1986 to carry out the Banking Business within the national capital and since then the Bank has been growing continuously. At present, Bank has large number of membership of individuals from different sections. The Bank has 12 branches in the NCT of Delhi. Bank offers 'traditional counter service'. Opening hours are designed to coincide with local market days.

Board of Directors were worried from growing popularity of new style banks. These banks offer diverse range of services such as direct access to executive management, a single point of *contact to coordinate all banking needs, appointment banking to save time, free online banking services 24/7, free unlimited ATM access etc.*

It has now been decided that the bank will focus on "What Customers Want" and will use a balanced scorecard to achieve this goal.

Required

Produce, for each of the three non-financial perspectives of a 'Balanced Scorecard', an objective and a performance measure that the bank could use with appropriate reason.

Solution

Internal Business Process Perspective

Objective: Cross-sell Products

Measure: Products Purchased *per customer*

Reason: Cross-selling, or encouragement customers to purchase additional products e.g. insurance, forex etc. is a *measure of customer satisfaction*. Only if a service is perceived as highly satisfactory the service would be repeated/ additional products or services would be accepted.

Learning and Growth Perspective

Objective: Increase the Number of New Products or Services Sold

Measure: Number of Customers Buying the New Products/ New Services

Reason: Long term financial success requires bank to create new products / services (e.g. internet banking, ATM access) that will meet emerging needs of current / future customers such as 24/7 banking.

Customer Perspective

Objective: Increase Customer Loyalty

Measure: Number of Accounts Closed or Closure Request Received

Reason: Customer loyalty describes the extent to which bank maintains durable relations to its customers. The share of existing customers should have a high importance as it indicates about image and reputation. Closure request is not a good sign for bank. Bank should investigate reasons for the same and take appropriate actions to improve services offered to retain customers.

☞

Other **Objectives** and **Measures** are also possible but they must relate to the bank's **Goal.**

Balanced Scorecard- Telecom Company

Problem-5

Standard Telecom Ltd. is a leading cellular service provider having a global presence. It aims to be the most innovative and trusted telecom company in the world. To achieve this aim, it is constantly working on its overall functioning. It is trying to adopt best managements practices in the world. Following are some information related to the company's performance for a particular period:

Particulars	*Current Year*	*Base Year*	*Target*
Operating Ratio	*60%*	*54%*	*Reduce it to 50%*
Average Revenue per user	*₹ 225*	*₹ 210*	*Increase it to ₹250*
Unresolved Consumer Complaints	*27,500*	*25,000*	*Reduce it by 20%*
Customer Relationship Centres	*280*	*200*	*Take the total to 250*
Employee Coverage under Training Programme	*10%*	*8%*	*At least 15%*

Required

Evaluate the performance of the company using Balance Scorecard approach.

Solution

The balanced scorecard is a method which displays organisation's performance into four dimensions namely financial, customer, internal and innovation. The four dimensions acknowledge the interest of shareholders, customers and employees taking into account of both long-term and short-term goals. The detailed analysis of performance of the company using Balance Scorecard approach as follows:

(i) **Financial Perspective:** Operating ratio and average revenue will be covered in this prospective.

Company is unable to achieve its target of reducing operating ratio to 50% instead it has increased to 60%. Company is required to take appropriate steps to control and manage its operating expenses. Average revenue per user has increased from ₹ 210 to ₹ 225 but remains short of targeted ₹ 250. This is also one of the reasons of swelled operating ratio. Company can boost up its average revenue per user either by increasing the price of its services or by providing more paid value added services.

(ii) **Customer Perspective:** Service complaints will be covered under this perspective. The company had set a target of reducing unresolved complaints by 20% instead unresolved complaints have risen by 10%[(27,500-25,000)/(25,000) × 100]. It shows dissatisfaction is increasing among the consumers which would adversely impact the consumer's general perception about the company and company may lose its consumers in long run.

(iii) **Internal Business Perspective:** Establishing customer relationship centres will be covered under this perspective. Company has established 80 relationship centres in the current period exceeding its target of 50 (250-200) to cater to the needs of existing consumers as well as soliciting new consumers. This shows the seriousness of the company towards the consumer satisfaction and would help them in the long run.

(iv) **Learning and Growth Perspective:** Employee training programmes are covered under this perspective.

Company had set a target to cover at least 15% employee under its training programmes but covered only 10%. This could hurt capabilities of the employees which are needed for long term growth of the organisation necessary to achieve the objectives set in the previous three perspectives. People or the human resource of the company is one of the three principle sources where organisational learning and growth comes.

Balanced Scorecard- Fitness Centre

Problem-6

Fitness Solution is a family owned fitness club, founded in 2010 by Peter and Albert with traditional style equipment. Club commenced operations in February 2011 within a shopping mall so that members after working out, can conveniently shop, dine, pick up their children from enrichment classes or go to the cinema.

Peter and Albert, the owners, pride themselves for providing a customized / tailored program by taking into account a person's medical history, present fitness level, fitness goals, fitness interests and offer many other small amenities that might be difficult to get in a larger Fitness Centre. They believe –

"Each individual is unique and requires a specialized program plan which should be customized and tailored to his/her needs."

They have a number of loyal members even though they offer the traditional style equipment.

Peter and Albert take care of most of the routine operations, along with a small permanent staff, and temporary staff.

Required

(i) Identify at least three 'Critical Success Factors' for Fitness Solution.

(ii) Construct a 'Balance Scorecard' for Fitness Solution. (2 measures for each of the 4 perspectives are sufficient)

Solution

(i) Fitness Solution's main **Critical Success Factors** are

(a) Developing and maintaining a high level of customer satisfaction.

(b) Offering facilities that are not much below that offered by competition.

(c) Keeping a tight cap on costs as there is considerable competitive pressure in this industry and entry barriers are not high.

(ii) The following is a possible **Balance Scorecard** for Fitness Solution

Financial Perspective	Operating expenses relative to budget
	Cash flow
	Total daily operating revenue
Customer Perspective	Turnover rate among members
	Customer satisfaction rate
Internal Perspective	Number of employee complaints
	Number of equipment not available on average day (due to maintenance)
Innovation and Learning	Number of new equipment put into service
	Number of staff participating in training courses

Balanced Scorecard- Miscellaneous

Problem-7

Identify Balance Scorecard Perspectives from the following potential measures observed in different business sectors (Healthcare/ Airlines/ Banking).

(i) Weekly Patient Complaints

(ii) Patient Satisfaction Survey

(iii) Flight Cancellation Rate

(iv) On-time Performance of an Airline

(v) Number of Grants Awarded to a Healthcare unit

(vi) Outstanding Loan Balances / Deposit Balances of a Banking Company

(vii) Employee Turnover Rate of a Healthcare unit

(viii) Patient Referral Rate

(ix) Non-interest Income of a Banking Company

(x) Lost of Bag Reports per 5,000 Passengers

Solution

Statement Showing "Balance Scorecard Perspectives for Different Business Sectors"

	Health Care	Airlines	Banking
Weekly Patient Complaints	Internal Operating Efficiency	---	---
Patient Satisfaction Survey	Customer Service & Satisfaction	---	---
Flight Cancellation Rate	---	Customer Service & Satisfaction	---
On-time Performance of an Airline	---	Internal Operating Efficiency	---
Number of Grants Awarded to a Healthcare unit	Learning and Growth	---	---
Outstanding Loan Balances / Deposit Balances of a Banking Company	---	---	Financial Strength
Employee Turnover Rate of a Healthcare unit	Learning and Growth	---	---
Patient Referral Rate	Customer Service & Satisfaction	---	---
Non-interest Income of a Banking Company	---	---	Financial Strength
Lost of Bag Reports per 5,000 Passengers	---	Customer Service & Satisfaction	---

Problem-8

In the context of a balanced scorecard, identify the perspectives of the following independent situations:

Sl. No.	*Organisation*	*Target Parameter*	*Perspective*
(i)	*Courier Company*	*100% on-time delivery of priority dispatches.*	
(ii)	*Tuition Centre*	*Set up class-on-internet facility for better reach of more number of students and absentees.*	
(iii)	*Computer Manufacturing Company*	*Set up service centres is all major cities for after sales support.*	
(iv)	*Government Taxation Department*	*Ensure Computer training to all officers above a certain rank to improve their capabilities.*	

Solution

Identification of Perspectives of Independent Situation - 'Balance Scorecard'

Sl. No.	Organization	Perspective
(i)	Courier Company	Customer Perspective
(ii)	Tuition Centre	Learning and Growth Perspective
(iii)	Computer Manufacturing Company	Internal Business Perspective
(iv)	Government Taxation Department	Learning and Growth Perspective

PRACTICE MANUAL

Final Course

PAPER : 5

ADVANCED MANAGEMENT ACCOUNTING

PART-B

BOARD OF STUDIES
THE INSTITUTE OF CHARTERED ACCOUNTANTS OF INDIA

This practice manual has been prepared by the faculty of the Board of Studies. The objective of the practice manual is to provide teaching material to the students to enable them to obtain knowledge and skills in the subject. In case students need any clarifications or have any suggestions to make for further improvement of the material contained herein, they may write to the Director of Studies.

All care has been taken to provide interpretations and discussions in a manner useful for the students. However, the practice manual has not been specifically discussed by the Council of the Institute or any of its Committees and the views expressed herein may not be taken to necessarily represent the views of the Council or any of its Committees.

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A WORD ABOUT PRACTICE MANUAL

The Board of Studies (BoS) has undertaken the step of developing Practice Manuals of all subjects to help the students with better understanding of the subject through a mode of questions and answers on different important topics and problems. Practice Manual and Study Material of a particular subject complements each other and all the students are expected to make holistic study of both to gain maximum benefit and acquire in-depth knowledge of the subject. The Practice Manual in the subject of "Advanced Management Accounting" has been developed by BoS taking primary input from question papers of Institute's earlier examinations over a number of years. It has been divided into sixteen chapters, keeping close correspondence with the chapters of the Study Material so as to make it an effective guidance material by providing clarification / solution to very important topics / issues, both theoretical and practical, of different chapters.

The Practice Manual will serve as a revisionary help book towards preparing for final examination of the Institute and help the students in identifying the gaps in the preparation for the examination and developing strategic plan to bridge it. The Practice Manual contains solutions to the questions which will act as a guide towards developing the skills of students on framing appropriate answer to a question and thereby to help students to improve their performance in the examination. The Practice Manual of "Advanced Management Accounting" has been thoroughly revised to cater the need of home study and distance learning approach in the Chartered Accountancy course. We would like to highlight some of the unique features of this edition of the Practice Manual of the subject "Advanced Management Accounting".

- ❖ This Practice Manual remains divided into two parts for ease of handling by the students. Part-A contains Chapters 1−9 and Part-B contains Chapters 10−16.
- ❖ Each chapter of the Practice Manual wherever possible has been divided into three sections i.e. Section A: Theory Questions, Section B: Practical Questions and Section C: Scenario Based Questions.
- ❖ This Practice Manual has more than 350 practical questions apart from handpicked theoretical and scenario based questions. All these questions have been compiled in such a manner that it will cover basic concepts, practical concepts and all kinds of adjustments required to address a question for extensive revision of the syllabus.
- ❖ Questions on emerging management accounting concepts like Life Cycle Costing, Just in Time (JIT), Value Chain Analysis, Pricing Strategy, Pareto Analysis, Multinational Transfer Pricing, Profitability Analysis, Balanced Scorecard etc. have been strengthened with introduction of new vivid questions and their solutions.

- As a part of knowledge progression, some simple questions related with the topics like Marginal Costing, Standard Costing etc. are also included in the Practice Manual to enhance the conceptual clarity to have a complete grasp on these topics to enable the students to handle advanced level of questions.
- Important definitions, equations, formulae etc. has been given at the beginning of each chapter for a quick recapitulation.
- Solutions in this Practice Manual have been given in an unhurried and step by step way so that students can understand each problem with the help of self study.
- Presentation is the hallmark of this Practice Manual. Questions and solutions thereof have been presented in a students' friendly approach.

Every effort has been made to make the Practice manual error free, however if inadvertently any error is present and found by readers they may send it to us immediately so that it can be rectified at our end.

For any further clarification/ guidance, students are requested to send their queries at ***deepak.gupta@icai.in***

Happy Reading and Best Wishes!

Paper-5, Advanced Management Accounting

Statement Showing Topic-Wise Distribution of Examination Questions Along With Marks

Chapter/ Topics (Part-B)		Term of Examination															
		May 2012		Nov. 2012		May 2013		Nov. 2013		May 2014		Nov. 2014		May 2015		Nov. 2015	
		Q	M	Q	M	Q	M	Q	M	Q	M	Q	M	Q	M	Q	M
Chapter-10	Linear Programming	4(b)	8	1(b) 7(d)	5 4	3(a)	8	5(b)	8	3(b)	6	3(a)	8	2(b)	8	4(a)	8
Chapter-11	The Transportation Problem	1(b) 3(b)	5 3	2(b)	5	4(a)	8	7(c)	4	6(c) 7(d) 7(e)	2 4 4	7(a)	4	4(b)	8	1(c)	5
Chapter-12	The Assignment Problem	7(b)	4	4(a)	8	1(c)	5	1(b)	5	1(d) 6(c)	5 2	×	×	1(b)	5	2(b)	8
Chapter-13	Critical Path Analysis	7(a)	4	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Chapter- 14	Program Evaluation and Review Technique	5(b)	8	6(c)	5	6(a) 7(d)	7 4	6(b)	8	4(b)	8	1(c) 4(b)	5 6	6(a)	8	3(b)	8
Chapter- 15	Simulation	7(c)	4	3(b)	7	7(b)	4	2(b)	8	2(b)	6	2(b)	7	5(b)	8	6(b)	8
Chapter- 16	Learning Curve Theory	×	×	5(b)	4	6(a)	4	4(b)	4	×	×	2(a)	9	7(e)	4	×	×

Note

'Q' *represents* question numbers as they appeared in the question paper of respective examination.

'M' *represents* the marks which each question carries.

PART-B

CONTENTS

(Chapters 1 to 9 of Advanced Management Accounting are in PART-A)

Appendix

10 Linear Programming

Basic Concepts

Constraint*	The feasible region within which a solution must lie.
Extreme Point Theorem	It states that an optimal solution to a LPP occurs at one of the vertices of the feasible region.
Feasible Region*	Area contained within all of the constraint lines shown on a graphical depiction of a linear programming problem. All feasible combinations of output are contained within or located on the boundaries of the feasible region.
Graphical Method	It involves the following: (i) Formulating the linear programming problem (ii) Plotting the capacity constraints on the graph paper. (iii) Identifying feasible region and coordinates of corner points. (iv) Testing the corner point which gives maximum profit. (v) For decision – making purpose, sometimes, it is required to know whether optimal point leaves some resources unutilized.
Linear Programming*	Series of linear equations used to construct a mathematical model. The objective is to obtain an optimal solution to a complex operational problem, which may involve the production of a number of products in an environment in which there are many constraints.
Methods of Linear Programming	(i) Graphical Method (ii) Simplex Method
Shadow Price*	Increase in value which would be created by having available one additional unit of a limiting resource at its original cost. This represents the opportunity cost of not having the use of the one extra unit. This information is routinely produced

	when mathematical programming (especially linear programming) is used to model activity.
Slack Variables*	Amount of each resource which will be unused if a specific linear programming solution is implemented.
Simplex Method	The Simplex Method is a computational procedure - an algorithm - for solving linear programming problems. It is an iterative optimizing technique. In the simplex process, we must first find an initial basis solution (extreme point). We then proceed to an adjacent extreme point. We continue moving from point to point until we reach an optimal solution.

(*) Source- CIMA's Official Terminology

Simplex Algorithm – Maximization

Maximize

$$Z = c_1x_1 + c_2x_2 + \text{---} + c_nx_n$$

Subject to the Constraints:

$$\begin{aligned}
k_{11}x_1 + k_{12}x_2 + \text{---} + k_{1n}x_n &\le b_1 \\
k_{21}x_1 + k_{22}x_2 + \text{---} + k_{2n}x_n &\le b_2 \\
\text{--} \quad \text{--} \quad \text{---} \quad \text{--} \quad &\text{--} \quad \text{--} \\
\text{--} \quad \text{--} \quad \text{---} \quad \text{--} \quad &\text{--} \quad \text{--} \\
k_{m1}x_1 + k_{m2}x_2 + \text{---} + k_{mn}x_n &\le b_m \\
x_1, x_2, \text{---}, x_n &\ge 0
\end{aligned}$$

- $x_1, x_2,$ ---, x_n are the **'Decision Variables'**.
- c_j **(j = 1, 2,** ---, **n)** in the objective function are called the **'Profit Coefficients'**.
- b_i **(i = 1, 2,** --- **,m)** are called **'Resources'**.
- Constants k_{ij} **(i = 1, 2, ---, m; j = 1, 2,** ---, **n)** are called **'Structural Coefficients'**.
- An inequality of the **"≤"** type is changed into an equality:

  By the addition of a *non- negative* '**Slack Variable'**. By adding a suitable positive quantity **'s_i'** to the left hand side, the inequality constraint can, be written as:

  $$k_{i1}x_1 + k_{i2}x_2 + \text{---} + k_{in}x_n + s_i = b_i \quad (i = 1, 2, \text{---}, m)$$

Solution Steps

Objective Function

$$\begin{aligned}
Z = {} & c_1x_1 + c_2x_2 + \text{---} + c_nx_n \\
& + 0s_1 + 0s_2 + \text{---} + 0s_m
\end{aligned}$$

Subject to the Constraints:

$$\begin{aligned}
k_{11}x_1 + k_{12}x_2 + \text{---} + k_{1n}x_n + s_1 &= b_1 \\
k_{21}x_1 + k_{22}x_2 + \text{---} + k_{2n}x_n + s_2 &= b_2 \\
\text{--} \quad \text{--} \quad \text{---} \quad \text{--} \quad \text{--} \quad &\text{--} \quad \text{--} \\
\text{--} \quad \text{--} \quad \text{---} \quad \text{--} \quad \text{--} \quad &\text{--} \quad \text{--} \\
k_{m1}x_1 + k_{m2}x_2 + \text{---} + k_{mn}x_n + s_m &= b_m \\
x_1, x_2, \text{---}, x_n, s_1, s_2, \text{---}, s_m &\ge 0
\end{aligned}$$

- Note that *slack variables have been allocated zero coefficients in the objective function* as these variables typically contribute nil amount to the value of objective function.

INITIAL SIMPLEX TABLEAU											
C_j (Contribution per Unit)			c_1	c_2	---	c_n	0	0	---	0	Minimum Ratio X_B / k_{ij}
C_B	Basic Variables (B)	Value of Basic Variables b (= X_B)	x_1	x_2	---	x_n	s_1	s_2	---	s_m	
			Real Variables				Slack Variables				
			x_1	x_2	---	x_n	s_1	s_2	---	s_m	
C_{B_1}	s_1	b_1 (= x_{B_1})	k_{11}	k_{12}	---	k_{1n}	1	0	---	0	---
C_{B_2}	s_2	b_2 (= x_{B_2})	k_{21}	k_{22}	---	k_{2n}	0	1	---	0	---
-	-	-	-	-	---	-	-	-	---	-	---
-	-	-	-	-	---	-	-	-	---	-	---
C_{B_m}	s_m	b_m (= x_{B_m})	k_{m1}	k_{m2}	---	k_{mn}	0	0	---	1	---
$Z_j = \sum C_{Bi} X_j$			0	0	---	0	0	0	---	0	
Net Contribution *per unit* ($C_j - Z_j$)			$c_1 - z_1$	$c_2 - z_2$	---	$c_n - z_n$	0	0	---	0	

- In the first row **'C_j'** we write the 'Coefficients of the *Real Variables* and *Slack Variables*' in the 'Objective Function' ($\underline{c_1, c_2, c_3, ---, c_n}$, $\underline{0, 0, ---, 0}$). These values will remain unchanged in the subsequent tableaus.
- In the first column labeled **'C_B'**, we list the 'Coefficients of the *Basic Variables*' in the 'Objective Function'. In initial tableau: $C_{B_1} = 0$, $C_{B_2} = 0$, ---, $C_{B_m} = 0$.
- In the second column **'Basic Variables'** we place the 'Basic Variables'. In initial tableau we place 'Slack Variables ($s_1, s_2, s_3,$ ---, s_m)' as 'Basic Variables' *to eliminate the impact of them first*.
- **'The Matrix'** under **'Real Variables Columns ($x_1, x_2,$ ---, x_n)'** in the tableau represents the 'Coefficients of the *Decision Variables*' in the 'Constraints Set'.
- **'The Matrix'** under **'Slack Variables Columns (s_1, s_2, ---, s_m)'** in the initial simplex tableau represents the 'Coefficients of the *Slack Variables*' in the 'Constraint Set'.
- To get **'Z_j'** row under a column, we *multiply the entries of that column by the corresponding entries of 'C_B' column and add the product*. In initial tableau value of 'Zj' with respect to 'Real Variable Columns' and 'Slack Variable Columns' remains '0' only.
- The last row **'$C_j - Z_j$'** called the **'Index Row** or **Net Evaluation Row'**. In initial tableau value of '$C_j - Z_j$' with respect to 'Slack Variable Columns' remains '0' only.
- If all the elements or entries in the $C_j - Z_j$ row are **Negative or Zero** then the current solution is **Optimum**.
- **If current solution is not optimum**, it can be further enhanced by *eliminating one* <u>*basic variable*</u> and *replacing it by some* <u>*non-basic*</u> *one*. For this

- ✓ We now decide the '**Variable to Enter'** in the solution mix (Basic Variable Column). Column with *<u>largest positive entry</u>* in the C_j – Z_j row is called **'Key Column'** (indicated by ↑). The non-basic variable at the top of the key column is the '**Entering Variable'** that will replace a basic variable.
- ✓ Next step is to determine **'Leaving Variable'** (Basic Variable *t*o be replaced). This can be trace by dividing each number in the 'X_B' column by the corresponding number in 'Key Column'. We compute ratio (b_1/k_{1j}, b_2/k_{2j}, ---, b_m/k_{mj}). The row corresponding to the *<u>minimum of these ratios</u>* is **'Key Row'** (indicated by ←). Corresponding basic variable in the key row known as the 'Leaving (Departing) Variable'.
- ✓ **'Key Element'** is the number that lies at the *junction* of the key column and key row.
- ✓ Constructing <u>Second Tableau</u>.
  - **New values for the key row** are computed by simply dividing *every element of key row* by *key element*.
  - **New values of the elements in the remaining rows** for the new table can be obtained by performing elementary row operation on all rows *so that all elements except the key element in the key column are zero*. For each row other than the key row, we use following formula-

    New Row Number = Number in Old Rows-{(Corresponding Number in Key Row) × (Corresponding Fixed Ratio)}

    $$\text{Corresponding Fixed Ratio} = \frac{\text{Old Row Number in Key Column}}{\text{Key Number}}$$
- ✓ Compute Z_j and $C_j – Z_j$ rows. If all the numbers in $C_j – Z_j$ rows are either Negative or Zero, an optimum solution has been obtained. *If any of the numbers in $C_j – Z_j$ row is Positive repeat the steps as explained above until an optimum solution has been obtained.*

Simplex Algorithm - Minimization

Minimize

$$Z = c_1x_1 + c_2x_2 + \text{---} + c_nx_n$$

Subject to the Constraints:

$$\begin{aligned} k_{11}x_1 + k_{12}x_2 + \text{---} + k_{1n}x_n &\geq b_1 \\ k_{21}x_1 + k_{22}x_2 + \text{---} + k_{2n}x_n &\geq b_2 \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} &\quad \text{--} \quad \text{--} \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} &\quad \text{--} \quad \text{--} \\ k_{m1}x_1 + k_{m2}x_2 + \text{---} + k_{mn}x_n &\geq b_m \\ x_1, x_2, \text{---}, x_n &\geq 0 \end{aligned}$$

- $x_1, x_2, \text{---}, x_n$ are the **'Decision Variables'**.
- c_j **(j = 1, 2,** ---, **n)** in the objective function are called the **'Cost Coefficients'**.
- b_i **(i = 1, 2,** --- **,m)** are called **'Resources'**.
- Constants k_{ij} **(i = 1,2,** ---**,m; j = 1, 2,** ---,**n)** are called **'Structural Coefficients'**.
- An inequality of the **"≥"** type is changed into an equality:

  By the subtraction of a *non negative* '**Surplus Variable'**. By subtracting positive quantity **'s_i'** from the left hand side, the inequality constraint can, be written as:

  $$k_{i1}x_1 + k_{i2}x_2 + \text{---} + k_{in}x_n - s_i = b_i \quad (i = 1, 2, \text{---}, m)$$

  If $x_1, x_2, \text{---}, x_n$ are set equal to Zero, then s_i (i = 1, 2, ---, m) turn out to be negative, violating the *non-negativity* restriction. Therefore, to circumvent this, we introduce another similar device '**Artificial Variable'** represented by **'A_i'**.

  $$k_{i1}x_1 + k_{i2}x_2 + \text{---} + k_{in}x_n - s_i + A_i = b_i \quad (i = 1, 2, \text{---}, m)$$

Solution Steps

Objective Function

$$\begin{aligned} Z = \; & c_1x_1 + c_2x_2 + \text{---} + c_nx_n \\ & + 0s_1 + 0s_2 + \text{---} + 0s_m \\ & + MA_1 + MA_2 + \text{---} + MA_m \end{aligned}$$

Subject to the Constraints:

$$\begin{aligned} k_{11}x_1 + k_{12}x_2 + \text{---} + k_{1n}x_n - s_1 + A_1 &= b_1 \\ k_{21}x_1 + k_{22}x_2 + \text{---} + k_{2n}x_n - s_2 + A_2 &= b_2 \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} \quad \text{--} \quad \text{--} &\quad \text{--} \quad \text{--} \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} \quad \text{--} \quad \text{--} &\quad \text{--} \quad \text{--} \\ k_{m1}x_1 + k_{m2}x_2 + \text{---} + k_{mn}x_n - s_m + A_m &= b_m \\ x_1, x_2, \text{---}, x_n, s_1, s_2, \text{---}, s_m, A_1, A_2, \text{---}, A_m &\geq 0 \end{aligned}$$

- Note that 'Surplus Variables' have been allocated 'Zero Coefficients' in the Objective Function. While 'Artificial Variables' have been allocated a Very Large Number indicated by **'M'**.

INITIAL SIMPLEX TABLEAU

C_j (Cost per Unit)			c_1	c_2	---	c_n	0	0	---	0	M	M	---	M	X_B / k_{ij}
C_B	Basic Variables (B)	Value of Basic Variables b ($=X_B$)	x_1	x_2	---	x_n	s_1	s_2	---	s_m	A_1	A_2	---	A_m	
			Real Variables				Surplus Variables				Artificial Variables				
			x_1	x_2	---	x_n	s_1	s_2	---	s_m	A_1	A_2	---	A_m	
C_{B_1}	A_1	b_1 ($= x_{B_1}$)	k_{11}	k_{12}	---	k_{1n}	-1	0	---	0	1	0	---	0	---
C_{B_2}	A_2	b_2 ($= x_{B_2}$)	k_{21}	k_{22}	---	k_{2n}	0	-1	---	0	0	1	---	0	---
-	-	-	-	-	---	-	-	-	---	-	-	-	---	-	---
-	-	-	-	-	---	-	-	-	---	-	-	-	---	-	---
C_{B_m}	A_m	b_m ($= x_{B_m}$)	k_{m1}	k_{m2}	---	k_{mn}	0	0	---	-1	0	0	---	1	---
$Z_j = \sum C_{Bi} X_j$			z_1	z_2	---	z_n	-M	-M	---	-M	M	M	---	M	
Net Evaluation Row ($C_j - Z_j$)			$c_1 - z_1$	$c_2 - z_2$	---	$c_n - z_n$	M	M	---	M	0	0	---	0	

- In the first row **'C_j'** we write the 'Coefficients of the *Real Variables*, *Surplus Variables*, and *Artificial Variables*' in the 'Objective Function' (c_1, c_2, c_3, ---, c_n, 0, 0, ---, 0, M, M, ---, M). These values will remain unchanged in the subsequent tableaus.
- In the first column labeled **'C_B'**, we list the 'Coefficients of the *Basic Variables*' in the 'Objective Function'. In initial tableau: C_{B_1} = M, C_{B_2} = M, ---, C_{B_m} = M.
- In the second column **'Basic Variables'** we place the 'Basic Variables'. In initial tableau we place 'Artificial Variables (A_1, A_2, A_3, ---, A_m)' as 'Basic Variables' *to eliminate the impact of them first*.
- **'The Matrix'** under **'Real Variables Columns (x_1, x_2, ---, x_n)'** in the tableau represents the 'Coefficients of the *Decision Variables*' in the 'Constraints Set'.
- **'The Matrix'** under **'Surplus Variables Columns (s_1, s_2, ---, s_m)'** in the initial simplex tableau represents the 'Coefficients of the *Surplus Variables*' in the 'Constraint Set'.

- **'The Matrix'** under **'Artificial Variables Columns (A_1, A_2, ---, A_m)'** in the initial simplex tableau represents the 'Coefficients of the *Artificial Variables*' in the 'Constraint Set'.
- To get **'Z_j'** row under a column, we *multiply the entries of that column by the corresponding entries of 'C_B' column and add the product*. In initial tableau value of 'Zj' with respect to 'Surplus Variables Columns' remains '-M' only. While value of 'Zj' with respect to 'Artificial Variables Columns' remains 'M' only.
- The last row **'$C_j - Z_j$'** called the **'Index Row** or **Net Evaluation Row'**. In initial tableau value of '$C_j - Z_j$' with respect to 'Surplus Variables Columns' remains 'M' only. While value of '$C_j - Z_j$' with respect to 'Artificial Variable Columns' remains 'Zero' only.
- If all the elements or entries in the $C_j - Z_j$ row are **Positive or Zero** then the current solution is **Optimum**.
- **If current solution is not optimum**, it can be further enhanced by *eliminating one <u>basic variable</u>* and *replacing it by some <u>non-basic</u> one*. For this
  - ✓ We now decide the '**Variable to Enter'** in the solution mix (Basic Variable Column). Column with <u>*largest negative entry*</u> in the $C_j - Z_j$ row is called **'Key Column'** (indicated by ↑). The non-basic variable at the top of the key column is the '**Entering Variable'** that will replace a basic variable.
  - ✓ Next step is to determine **'Leaving Variable'** (Basic Variable *t*o be replaced). This can be trace by dividing each number in the 'X_B' column by the corresponding number in 'Key Column'. We compute ratio (b_1/k_{1j}, b_2/k_{2j}, ---, b_m/k_{mj}). The row corresponding to the <u>*minimum of these ratios*</u> is **'Key Row'** (indicated by ←). Corresponding basic variable in the key row known as the 'Leaving (Departing) Variable'.
  - ✓ **'Key Element'** is the number that lies at the *junction* of the key column and key row.
  - ✓ Constructing <u>Second Tableau</u>.
    - **New values for the key row** are computed by simply dividing *every element of key row* by *key element*.
    - **New values of the elements in the remaining rows** for the new table can be obtained by performing elementary row operation on all rows *so that all elements except the key element in the key column are zero*. For each row other than the key row, we use following formula.

      New Row Number = Number in Old Rows-{(Corresponding Number in Key Row) × (Corresponding Fixed Ratio)}

$$\text{Corresponding Fixed Ratio} = \frac{\text{Old Row Number in Key Column}}{\text{Key Number}}$$

✓ Compute Z_j and $C_j - Z_j$ rows. If all the numbers in $C_j - Z_j$ rows are either Positive or Zero, an optimum solution has been obtained. *If any of the numbers in $C_j - Z_j$ row is negative repeat the steps as explained above until an optimum solution has been obtained.*

Primal – Dual

Primal LP Problem

Maximize

$$Z = c_1x_1 + c_2x_2 + \text{---} + c_nx_n$$

Subject to the Constraints:

$$\begin{array}{rcl} k_{11}x_1 + k_{12}x_2 + \text{---} + k_{1n}x_n & \le & b_1 \\ k_{21}x_1 + k_{22}x_2 + \text{---} + k_{2n}x_n & \le & b_2 \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} & \text{--} & \text{--} \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} & \text{--} & \text{--} \\ k_{m1}x_1 + k_{m2}x_2 + \text{---} + k_{mn}x_n & \le & b_m \\ x_1, x_2, \text{---}, x_n & \ge & 0 \end{array}$$

Corresponding Dual LP Problem

Minimize

$$Z = b_1y_1 + b_2y_2 + \text{---} + b_my_m$$

Subject to the Constraints:

$$\begin{array}{rcl} k_{11}y_1 + k_{21}y_2 + \text{---} + k_{m1}y_m & \ge & c_1 \\ k_{12}y_1 + k_{22}y_2 + \text{---} + k_{m2}y_m & \ge & c_2 \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} & \text{--} & \text{--} \\ \text{--} \quad \text{--} \quad \text{---} \quad \text{--} & \text{--} & \text{--} \\ k_{1n}y_1 + k_{2n}y_2 + \text{---} + k_{mn}y_m & \ge & c_n \\ y_1, y_2, \text{---}, y_m & \ge & 0 \end{array}$$

☞

Types of Constraint	Extra Variable Required	Coefficients of Extra Variables in the Objective Function	
		Max Z	**Min Z**
Less than or equal to (≤)	A Slack Variable is to be added	0	0
Greater than or equal to (≥)	A Surplus Variable is to be subtracted	0	0
	and An Artificial Variable is to be added.	-M	+M
Equal to (=)	Only an artificial variable is to be added	-M	+M

SECTION - A

Linear Programming & Applications

Question-1

Write short notes on the characteristics of the dual problem.

Answer

Characteristics of the dual problem:

(i) For any linear programming model called primal model, there exists a companion model called the dual model.

(ii) The number of constraints in the primal model equals the number of variables in the dual model.

(iii) The number of variables in the primal problem equals the number of constraints in the dual model.

(iv) If the primal model has a maximization objective then the dual model will have a minimization objective and vice-versa. Inequalities get reversed.

(v) The solution of the primal model yields the solution of the dual model. Also, an optimal simplex table for the dual model yields the optimal solution to the primal model. Further, the objective functions of the two optimal tables will have identical values.

(vi) Dual of the prima's dual problem is the primal problem itself.

(vii) Feasible solutions to a primal and dual problem are both optimal if the complementary slackness conditions hold. If this relationship does not hold, than either the primal solution or the dual solution or both are no optimal.

(viii) If the primal problem has no optimal solution because of infeasibility, then the dual problem will have no optimal solution because of unboundedness.

(ix) If the primal has no optimal solution because of unboundedness, then the dual will have no optimal solution because of infeasibility.

Question-2

What are the practical applications of Linear Programming?

Answer

In addition to its wide use in industrial and administrative applications, linear programming has extensive application to agricultural, aircraft and several military problems. These are briefly discussed below.

(i) Industrial Applications: These are basically product-mix problems in which the general objective is to derive the optimal production and procurement plan for the time period under consideration. The measure of effectiveness is either a defined return that is sought to be maximized or a defined cost that is to be minimized.

(ii) Production Planning - Product Mix: An industrial concern has available a certain production capacity on various manufacturing processes and has the opportunity to utilize this capacity to manufacture various products. Typically, different products will have different selling prices, will require different amounts of production capacity at the several processes, and therefore will have different unit profits; there may also be stipulations on maximum and/or minimum production levels. The problem is to determine the optimal mix so that the total profit is maximized.

(iii) Blending Problems: These problems are likely to arise when a product can be made from a variety of available raw materials of various compositions and prices. The manufacturing process involves blending (mixing) some of these materials in varying quantities to make a product conforming to given specifications. The supply of raw materials and specifications serve as constraints in obtaining the minimum cost material blend. The solution would state the number of units of each raw material which are to be blended to make one unit of product.

(iv) Diet Problems: Diet Problems are not much different from the blending problem.

(v) Trim Problems: Trim Problems are applicable to paper industry where paper of standard width has to be cut into smaller width as per customer requirements with the objective of minimizing the waste produced.

(vi) Advertising-Mix: Advertising Mix problem is analogous to the product-mix problem.

(vii) Financial Applications: The investment portfolio selection problems can be satisfactorily handled by linear programming.

(viii) Agriculture Applications: These deal with somewhat different resource, but the objectives are nevertheless same - to maximize the return from the allocation activity or to minimize some defined cost.

(ix) Flight Scheduling Applications: Linear programming has been effectively applied to a variety of operational scheduling problems.

Other applications of linear programming include structural design, scheduling military tanker fleet, minimizing the number of carriers to meet a fixed schedule, the least ballast shipping required to meet a specific shipping program, cost cutting in business, fabrication scheduling, computations of maximum flows in network, steel production scheduling, stocks and flows the balancing of assembly lines, etc.

Question-3

What are limitations of Linear Programming Technique?

Answer

Important limitations of linear programming problems are as follows:

(i) A primary requirement of linear programming is that the objective function and every constraint function must be linear. This requires that the measure of effectiveness and resource usage must be proportional to the level of each activity conducted individually. However, programming problems which are non-linear arise quite frequently. It is occasionally possible to reformulate a non-linear programming problem into the linear programming format so that the simplex method can be used. This is, however, the fortunate exception rather than the rule.

(ii) It may not be possible to solve those problems using linear programming, in which non-linearity arises because of joint interactions between some of the activities regarding the total measure of effectiveness or total usage of some resource. Hence linear programming problem requires that the total measure of effectiveness and total resource usage resulting from the joint performance of the activities must equal the respective sums of these quantities resulting from each activity being performed individually.

In some situations, it may not be true. For example, consider a situation where by a product is produced with the scrap material from the primary product. The material would still have to be procured if only one of the two products were produced. However, the total material requirements if both products are produced is less than the sum of requirements is each were produced individually. It may not be possible to handle such situation with linear programming problems.

(iii) In linear programming problem, fractional values are permitted for the decisions variables. However, many decision problems require that the solution for decision variable should be obtained in non-fractional values. Rounding-off the values obtained by linear programming techniques may not result into an optimal solution in such cases.

(iv) In linear programming problem, coefficients in the objective function and the constraint equations must be completely known and they should not change during the period of study i.e. they should be known constraints. In practical situation, it may not be possible to state all coefficients in the objective function and constraints with certainty. Furthermore, these coefficients may actually be random variables, each with an underlying probability distribution for the values. Such problems cannot be solved using linear programming.

Question-4

***"**Coefficients in the objective function and the constraint equations must be completely known and they should not change during the period of study."*

Elucidate the above statement in respect of linear programming.

Answer

In linear programming problem, *coefficients in the objective function and the constraint equations must be completely known* and they should not change during the period of study. They should be known constraints. In practical situation, it may not be possible to state all coefficients in the objective function and constraints with certainty. Furthermore, these coefficients may actually be random variables, each with an underlying probability distribution for the values. Such problems cannot be solved using linear programming.

Question-5

Identify three Similarities and three Differences between Linear Programming Model and Transportation Model.

Answer

Similarities

(i) Both the models have an objective function.

(ii) Both models' objective functions are linear.

(iii) Both the models require non-negativity constraints.

Differences

(i) The general linear programming problem may be of *maximization* or *minimization* type, whereas, transportation problem predominately deals with *minimization* problem.

(ii) A general linear programming problem is solved by using *simplex algorithm*; whereas transportation problem is solved by using *transportation algorithm* (as simplex method is less appropriate to solve).

(iii) The resources, for which the structural constraints are built up is *homogeneous* in transportation model; whereas in Linear Programming model they are *heterogeneous*.

SECTION - B

LPP-Formulation

Problem-1

A firm buys casting of P and Q type of parts and sells them as finished product after machining, boring and polishing. The purchasing cost for casting are ₹ 3 and ₹ 4 each for parts P and Q and selling costs are ₹ 8 and ₹ 10 respectively. The per hour capacity of machines used for machining, boring and polishing for two products is given below:

Capacity (per hour)	***Parts***	
	P	***Q***
Machining	*30*	*50*
Boring	*30*	*45*
Polishing	*45*	*30*

The running costs for machining, boring and polishing are ₹ 30, ₹ 22.5 and ₹ 22.5 per hour respectively.

Required

Formulate the linear programming problem to find out the product mix to maximize the profit.

Solution

Let the firm by x units of castings of P and y units of castings of Q which are sold as finished product after machining, boring and polishing.

Conditions:

According to the given data, the capacity constraints of machining, boring and polishing machines on per hour basis have been formulated as below:

$$\frac{x}{30}+\frac{y}{50} \leq 1 \quad \text{(Machining Constraint)}$$

Or $$50x + 30y \leq 1{,}500$$

$$\frac{x}{30}+\frac{y}{45} \leq 1 \quad \text{(Boring Constraint)}$$

Or $$45x + 30y \leq 1{,}350$$

$$\frac{x}{45}+\frac{y}{30} \leq 1 \qquad \text{(Polishing Constraint)}$$

Or $30x + 45y \leq 1{,}350$

Objective function:

In order to compute the profit/per unit of castings of P and castings of Q, we will first calculate the total cost per unit for each casting of P and Q. Running cost for machining is ₹ 30 per hour and it can produce 30 units of casting of P type on one hour. Hence, cost of machining for one unit of castings of P is ₹ 30/30 i.e. ₹1. Following the same procedure, the total cost and the profit per unit for castings of P and castings of Q type are calculated in the table given below:

Particulars	**Cost (per unit)**	
	Castings of P Type (₹)	**Casting of Q Type (₹)**
Machining	1.00 (30/30)	0.60 (30/50)
Boring	0.75 (22.50/30)	0.50 (22.50/45)
Polishing	0.50 (22.50/45)	0.75 (22.50/30)
Purchasing Cost	3.00	4.00
Total Cost	5.25	5.85
Sale Price	8.00	10.00
Profit	2.75	4.15

The required product mix to maximise the profit of the firm will be given by the following relation:

Maximise $Z = 2.75x + 4.15y$

Required mathematical formulation of L.P. problem is as given below:

Maximise

$$Z = 2.75x + 4.15y$$

Subject to the Constraints:

$$50x + 30y \leq 1{,}500$$

$$45x + 30y \leq 1{,}350$$

$$30x + 45y \leq 1{,}350$$

Where $x, y \geq 0$

Problem-2

A Mutual Fund Company has ₹ 20 lakhs available for investment in Government Bonds, blue chip stocks, speculative stocks and short-term bank deposits. The annual expected return and risk factor are given below:

Type of Investment	*Annual Expected Return (%)*	*Risk Factor (0 to 100)*
Government Bonds	*14*	*12*
Blue Chip Stocks	*19*	*24*
Speculative Stocks	*23*	*48*
Short term deposits	*12*	*6*

Mutual fund is required to keep at least ₹ 2 lakhs in short-term deposits and not to exceed an average risk factor of 42. Speculative stocks must be at most 20 percent of the total amount invested.

Required

How should mutual fund invest the funds so as to maximize its total expected annual return? Formulate this as a Linear Programming Problem. Do not solve it.

Solution

Let x_1, x_2, x_3 and x_4 denote the amount of funds to be invested in government bonds, blue chip stocks, speculative stocks and short term deposits respectively. Let Z denote the total expected return.

Condition-1:

Since the Mutual Fund Company has ₹ 20 lakhs available for investment,

$$x_1 + x_2 + x_3 + x_4 \leq 20,00,000$$

Condition-2:

Also, Mutual fund is required to keep at least ₹ 2 lakhs in short-term deposits.

Hence, $$x_4 \geq 2,00,000$$

Condition-3:

Since the average risk factor for Mutual Fund should not exceed 42, we get the following constraint

$$\frac{12x_1 + 24x_2 + 48x_3 + 6x_4}{x_1 + x_2 + x_3 + x_4} \leq 42$$

Or $$12x_1 + 24x_2 + 48x_3 + 6x_4 \leq 42\,(x_1+x_2+x_3+x_4)$$

Or $-30x_1 - 18x_2 + 6x_3 - 36x_4 \leq 0$

Condition-4:

Further, speculative stock must be at most 20 per cent of the total amount invested, hence

$$x_3 \leq 0.20\,(x_1+x_2+x_3+x_4)$$

Or $-0.2x_1 - 0.2x_2 + 0.8x_3 - 0.2\,x_4 \leq 0$

Objective function:

Finally, the objective is to maximise the total expected annual return, the objective function for Mutual Fund can be expressed as

Maximise Z =

$0.14x_1 + 0.19x_2 + 0.23x_3 + 0.12x_4$

The linear programming model for the Mutual Fund Company is formulated as below:

Objective function:

Maximise

$$Z = 0.14x_1 + 0.19x_2 + 0.23x_3 + 0.12x_4$$

Subject to the Constraints:

$$x_1 + x_2 + x_3 + x_4 \leq 20{,}00{,}000$$

$$x_4 \geq 2{,}00{,}000$$

$$-30x_1 - 18x_2 + 6x_3 - 36x_4 \leq 0$$

$$-0.2x_1 - 0.2x_2 + 0.8x_3 - 0.2x_4 \leq 0$$

Where x_1, x_2, x_3 and $x_4 \geq 0$

Problem-3

The owner of Fancy Goods Shop is interested to determine, how many advertisements to release in the selected three magazines A, B and C. His main purpose is to advertise in such a way that total exposure to principal buyers of his gods is maximized. Percentages of readers for each magazine are known. Exposure in any particular magazine is the number of advertisements released multiplied by the number of principal buyers. The following data are available:

Particulars	***Magazines***		
	A	***B***	***C***
Readers	*1.0 Lakhs*	*0.6 Lakhs*	*0.4 Lakhs*
Principal buyers	*20%*	*15%*	*8%*
Cost per advertisement	*₹ 8,000*	*₹ 6,000*	*₹ 5,000*

The budgeted amount is at the most ₹ 1.0 lakh for the advertisements. The owner has already decided that magazine A should have no more than 15 advertisements and that B and C each gets at least 8 advertisements.

Required

Formulate a Linear Programming model for this problem.

Solution

Let x_1, x_2 and x_3 denote the number of advertisements to be released in three magazines A, B and C respectively. Let Z denote the total exposure to the principal buyers of the goods.

Objective function:

Since the exposure in any magazine is the number of advertisements multiplied by the number of principal buyers, therefore, the value of Z is given by:

$$Z = (0.20 \times 1{,}00{,}000)\, x_1 + (0.15 \times 60{,}000)\, x_2 + (0.08 \times 40{,}000)\, x_3$$

$$= 20{,}000x_1 + 9{,}000x_2 + 3{,}200x_3$$

Constraints:

The budgeted amount for the advertisements is at the most ₹1,00,000

Hence, $8{,}000x_1 + 6{,}000x_2 + 5{,}000x_3 \leq 1{,}00{,}000$

Also, the magazine A should have no more than 15 advertisements, B and C each should get at least 8 advertisements.

Hence, $x_1 \leq 15$,

$x_2 \geq 8$ and

$x_3 \geq 8$

The linear programming model for the problem:

Maximise

$$Z = 20{,}000x_1 + 9{,}000x_2 + 3{,}200x_3$$

Subject to the Constraints:

$$8{,}000x_1 + 6{,}000x_2 + 5{,}000x_3 \leq 1{,}00{,}000$$

$$x_1 \leq 15$$

$$x_2 \geq 8$$

$$x_3 \geq 8$$

Where x_1, x_2 and $x_3 \geq 0$

Problem-4

An agriculturist has a farm with 125 acres. He produces Radish, Mutter and Potato. Whatever he raises is fully sold in the market. He gets ₹ 5 for Radish per kg ₹ 4 for Mutter per kg and ₹ 5 for Potato per kg. The average yield is 1,500 kg of Radish per acre, 1,800 kg of Mutter per acre and 1,200 kg of Potato per acre. To produce each 100 kg of Radish and Mutter and to produce each 80 kg of Potato, a sum of ₹ 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man days for Radish and Potato each and 5 man days for Mutter. A total of 500 man days of labour at a rate of ₹ 40 per man day are available.

Required

Formulate this as a Linear Programming model to maximize the Agriculturist's total profit.

Solution

Let x_1, x_2 and x_3 be the number of acres allotted for cultivating radish, mutter and potato respectively.

Objective function:

Since the average yield of radish is 1,500 kg per acre, and the selling price for radish is ₹5/kg hence the selling amount which the agriculturist gets from one acre is-

₹5 × 1,500 kg

Or, ₹7,500

To produce 100 kg of radish, the manure cost is ₹12.50, so the manure cost per acre will be-

$$\frac{₹12.50 \times 1{,}500\,\text{kg}}{100\text{kg}}$$

Or, ₹187.50

Labour cost per acre for radish-

₹40 × 6 man days

Or, ₹240

Profit per acre for radish-

₹7,500 − ₹187.50 − ₹240

Or, ₹7,072.50

Similarly, the selling price, manure cost, labour cost and profit per acre of land for mutter and potato are also calculated and presented in the following table-

Per Acre	Radish	Mutter	Potato
Selling Price	₹7,500 (₹5 × 1,500 kg)	₹7,200 (₹4 × 1,800 kg)	₹6,000 (₹5 × 1,200 kg)

Less: Manure Cost	₹ 187.50 $\left(\frac{₹12.50 \times 1{,}500\text{ kg}}{100\text{kg}}\right)$	₹ 225 $\left(\frac{₹12.50 \times 1{,}800\text{kg}}{100\text{kg}}\right)$	₹ 187.50 $\left(\frac{₹12.50 \times 1{,}200\text{kg}}{80\text{kg}}\right)$
Less: Labour Cost	₹ 240 (₹ 40 × 6 man days)	₹ 200 (₹ 40 × 5 man days)	₹ 240 (₹ 40 × 6 man days)
Profit	₹ 7,072.50	₹ 6,775	₹ 5,572.50

Since, the agriculturist wants to maximise the total profit, hence the objective function of the problem is given by-

$$Z = 7{,}072.50x_1 + 6{,}775.00x_2 + 5{,}572.50x_3$$

The linear programming model for the problem:

Maximise

$$Z = 7{,}072.50x_1 + 6{,}775.00x_2 + 5{,}572.50x_3$$

Subject to the Constraints:

$$x_1 + x_2 + x_3 \leq 125$$

$$6x_1 + 5x_2 + 6x_3 \leq 500$$

Where $x_1, x_2, x_3 \geq 0$

Problem-5

A firm produces three products A, B and C. It uses two types of raw materials I and II of which 5,000 and 7,500 units respectively are available. The raw material requirements per unit of the products are given below:

Raw Material	***Requirement (per unit) of Product***		
	A	***B***	***C***
I	*3*	*4*	*5*
II	*5*	*3*	*5*

The labour time for each unit of product A is twice that of product B and three times that of product C. The entire labour force of the firm can produce the equivalent of 3,000 units. The minimum demand of the three products is 600, 650 and 500 units respectively. Also the ratios of the number of units produced must be equal to 2 : 3 : 4. Assuming the profits per unit of A, B and C as ₹ 50, ₹ 50 and ₹ 80 respectively.

Required

Formulate the problem as a linear programming model in order to determine the number of units of each product, which will maximize the profit.

Solution

Let the firm produce x_1 units of product A, x_2 units of product B and x_3 units of product C.

Objective function:

The profit per unit of product A, B and C is ₹ 50, ₹ 50 and ₹ 80 respectively. Since objective of the firm is to maximize the profit, therefore, the objective function is given by

Maximise

$$Z = 50x_1 + 50x_2 + 80x_3$$

Condition-1:

The firm uses two types of raw materials I and II of which 5,000 and 7,500 units respective are available. As per the given data, the raw material constraints can be formulated as given below:

$$3x_1 + 4x_2 + 5x_3 \leq 5{,}000 \text{ and}$$

$$5x_1 + 3x_2 + 5x_3 \leq 7{,}500$$

Condition-2:

The labour time for each unit of product A is twice that of product B and three times that product C. Also the entire labour force can produce the equivalent of 3,000 units.

$$x_1 + \frac{x_2}{2} + \frac{x_3}{3} \leq 3{,}000$$

Or $$6x_1 + 3x_2 + 2x_3 \leq 18{,}000$$

Condition-3:

The minimum demand of the three products is 600, 650 and 500 units respectively.

Hence, $x_1 \geq 600$,

$x_2 \geq 650$ and

$x_3 \geq 500$

Condition-4:

Since the ratios of the number of units produced must be equal to 2 : 3 : 4, therefore,

$$\frac{1}{2}x_1 = \frac{1}{3}x_2$$

Or $$3x_1 = 2x_2$$

$$\frac{1}{3}x_2 = \frac{1}{4}x_3$$

Or $4x_2 = 3x_3$

The linear programming model can be formulated as follows:

Maximise

$Z = 50x_1 + 50x_2 + 80x_3$

Subject to the Constraints:

$$3x_1 + 4x_2 + 5x_3 \leq 5{,}000$$
$$5x_1 + 3x_2 + 5x_3 \leq 7{,}500$$
$$6x_1 + 3x_3 + 2x_3 \leq 18{,}000$$
$$3x_1 = 2x_2$$
$$4x_2 = 3x_3$$
$$x_1 \geq 600$$
$$x_2 \geq 650$$
$$x_3 \geq 500$$

Problem-6

A leading Chartered Accountant is attempting to determine a 'best' investment portfolio and is considering six alternative investment proposals. The following table indicates point estimates for the price per share, the annual growth rate in the price per share, the annual dividend per share and a measure of the risk associated with each investment.

Portfolio Data

	Shares under Consideration					
	A	***B***	***C***	***D***	***E***	***F***
Current Price per Share (₹)	*80*	*100*	*160*	*120*	*150*	*200*
Projected Annual Growth Rate	*0.08*	*0.07*	*0.10*	*0.12*	*0.09*	*0.15*
Projected Annual Dividend per Share (₹)	*4.00*	*4.50*	*7.50*	*5.50*	*5.75*	*0.00*
Projected Risk in Return	*0.05*	*0.03*	*0.10*	*0.20*	*0.06*	*0.08*

The total amount available for investment is ₹ 25 lakhs and the following conditions are required to be satisfied.

(i) The maximum rupee amount to be invested in alternative F is ₹ 2,50,000.

(ii) No more than ₹ 5,00,000 should be invested in alternatives A and B combined.

(iii) *Total weighted risk should not be greater than 0.10, where*

$$\text{Total Weighted Risk} = \frac{(\text{Amount Invested in Alternative}j)(\text{Risk of Alternative}j)}{\text{Total Amount Invested in all the Alternatives}}$$

(iv) *For the sake of diversity, at least 100 shares of each stock should be purchased.*

(v) *At least 10 percent of the total investment should be in alternatives A and B combined.*

(vi) *Dividends for the year should be at least ₹ 10,000.*

Rupees return per share of stock is defined as price per share one year hence less current price per share plus dividend per share. If the objective is to maximize total rupee return, formulate the linear Programming model for determining the optimal number of shares to be purchased in each of the shares under consideration. You may assume that the time horizon for the investment is one year.

Required

The formulated LP problem is not required to be solved.

Solution

Let x_1, x_2, x_3, x_4, x_5 and x_6 denote the number of shares of companies A, B, C, D, E, and F, respectively.

The rupee return for various shares is shown as follows-

	A	B	C	D	E	F
No. of Share Purchased	x_1	x_2	x_3	x_4	x_5	x_6
Projected Growth per share (₹)	6.40 (80x0.08)	7.00 (100x0.07)	16.00 (160x0.10)	14.40 (120x0.12)	13.50 (150x0.09)	30.00 (200x0.15)
Projected Annual Dividend per share (₹)	4.00	4.50	7.50	5.50	5.75	0.00
Rupee Return per share (₹)	10.40	11.50	23.50	19.90	19.25	30.00

Objective function:

The objective of the Chartered Accountant is to maximize the total rupee return, the objective function of the linear programming problem is given by:-

Maximise $Z = 10.40x_1 + 11.50x_2 + 23.50x_3 + 19.90x_4 + 19.25x_5 + 30.00x_6$

Constraint 1:

Total amount available for investment is ₹ 25 lakhs, hence

$$80x_1 + 100x_2 + 160x_3 + 120x_4 + 150x_5 + 200x_6 \leq 25{,}00{,}000$$

Constraint 2:

The maximum rupee amount to be invested in alternative F is ₹ 2,50,000.

$$200x_6 \leq 2,50,000$$

Constraint 3:

No more than ₹ 5,00,000 should be invested in alternatives A and B combined.

$$80x_1 + 100x_2 \leq 5,00,000$$

Constraint 4:

Total weighted risk should not be greater than 0.10.

$$\frac{80x_1(0.05) + 100x_2(0.03) + 160x_3(0.10) + 120x_4(0.20) + 150x_5(0.06) + 200x_6(0.08)}{80x_1 + 100x_2 + 160x_3 + 120x_4 + 150x_5 + 200x_6} \leq 0.10$$

Or $$-4x_1 - 7x_2 + 12x_4 - 6x_5 - 4x_6 \leq 0$$

Constraint 5:

At least 100 shares of each stock should be purchased.

$$x_1 \geq 100$$
$$x_2 \geq 100$$
$$x_3 \geq 100$$
$$x_4 \geq 100$$
$$x_5 \geq 100$$
$$x_6 \geq 100$$

Constraint 6:

At least 10 percent of the total investment should be in alternatives A and B combined.

$$80x_1 + 100x_2 \geq 0.10\,(80x_1 + 100x_2 + 160x_3 + 120x_4 + 150x_5 + 200x_6)$$

Or $$72x_1 + 90x_2 - 16x_3 - 12x_4 - 15x_5 - 20x_6 \geq 0$$

Constraint 7:

Dividends for the year should be at least ₹ 10,000

$$4.00x_1 + 4.50x_2 + 7.50x_3 + 5.50x_4 + 5.75x_5 \geq 10,000$$

Combining all the constraints, the linear programming problem becomes:

Maximise $Z = 10.40x_1 + 11.50x_2 + 23.50x_3 + 19.90x_4 + 19.25x_5 + 30.00x_6$

Subject to the Constraints:

$$80x_1 + 100x_2 + 160x_3 + 120x_4 + 150x_5 + 200x_6 \leq 25,00,000$$

$$
\begin{aligned}
200x_6 &\le 2,50,000\\
80x_1 + 100x_2 &\le 5,00,000\\
-4x_1 - 7x_2 + 12x_4 - 6x_5 - 4x_6 &\le 0\\
72x_1 + 90x_2 - 16x_3 - 12x_4 - 15x_5 - 20x_6 &\ge 0\\
4.00x_1 + 4.50x_2 + 7.50x_3 + 5.50x_4 + 5.75x_5 &\ge 10,000\\
x_1 &\ge 100\\
x_2 &\ge 100\\
x_3 &\ge 100\\
x_4 &\ge 100\\
x_5 &\ge 100\\
x_6 &\ge 100
\end{aligned}
$$

Problem-7

A firm makes three types of models, which are first required to be machined and then assembled. The time (in hours) for these operations for each model is give below:

Model	*Machine Time*	*Assembly Time*
P III	*20*	*5*
P II	*15*	*4*
Celeron	*12*	*3*

The total available machine time and assembly time are 1,000 hours and 1,500 hours respectively. The selling price and other variable costs for three models are:

	P III	*P II*	*Celeron*
Selling Price (₹)	*3,000*	*5,000*	*15,000*
Labour, Material and Other Variable Costs (₹)	*2,000*	*4,000*	*8,000*

The firm has taken a loan of ₹ 50,000 from a Nationalised Bank, which is required to be repaid on 1.4.2013. In addition, the firm has borrowed ₹ 1,00,000 from XYZ Cooperative Bank. However, this bank has given its consent to renew the loan.

The balance sheet of the firm as on 31.3.2013 is as follows:

Liabilities	*(₹)*	*Assets*	*(₹)*
Capital	*1,20,000*	*Land*	*80,000*
Profit & Loss Account	*30,000*	*Buildings*	*50,000*
Long-term Loan	*2,00,000*	*Plant & Machinery*	*1,00,000*

Loan from XYZ Cooperative Bank	*1,00,000*	*Furniture etc.*	*20,000*
Loan from Nationalized Bank	*50,000*	*Cash*	*2,10,000*
Total	*5,00,000*	*Total*	*5,00,000*

The firm is required to pay a sum of ₹ 15,000 towards the salary. Interest on long-term loan is to be paid every month @ 18% per annum. Interest on loan from XYZ Cooperative and Nationalised Banks may be taken as ₹ 1,500 per month. The firm has already promised to deliver three P III, Two P II and five Celeron type of computers to M/s ABC Ltd. next month. The level of operation in the company is subject to the availability of cash next month.

The firm's Manager is willing to know that how many units of each model must be manufactured next month, so as to maximize the profit.

Required

Formulate a linear programming problem for the above.

Solution

Let x_1, x_2 and x_3 denote the number of P III, P II and Celeron computers respectively to be manufactured in the company. The following data is given:

	P III	**P II**	**Celeron**
Selling Price *per unit* (₹)	3,000	5,000	15,000
Less: Labour Material & Other Variable Cost *per unit* (₹)	2,000	4,000	8,000
Profit *per unit* (₹)	1,000	1,000	7,000

Objective function:

Since the company wants to maximize the profit, hence the objective function is given by:

Maximize

$$Z = 1{,}000x_1 + 1{,}000x_2 + 7{,}000x_3 - (₹15{,}000 + ₹3{,}000 + ₹1{,}500)$$

Condition-1:

From the data given for time required for various models and the total number of hours available for machine time and assembly time, we get the following constraints:

$$20x_1 + 15x_2 + 12x_3 \leq 1{,}000 \text{ (Machine Time Restriction)}$$

$$5x_1 + 4x_2 + 3x_3 \leq 1{,}500 \text{ (Assembly Time Restriction)}$$

Condition-2:

The level of operations in the company is subject to availability of cash next month i.e. the cash required for manufacturing various models should not exceed the cash available for the next month.

The *cash requirements* for x_1 units of P III, x_2 units of P II and x_3 units of Celeron computers are:

= $2,000x_1 + 4,000x_2 + 8,000x_3$ .....(i)

The *cash availability* for the next month from the balance sheet is as below:

= Cash Balance (₹2,10,000) *Less* Loan to repay to Nationalized Bank (₹50,000) *Less* Interest on loan from XYZ Cooperative bank and Nationalized bank (₹1,500) *Less* Interest on long term loans $\left(\frac{0.18 \times 2,00,000}{12}\right)$

Less Salary to Staff (₹15,000)

Or = ₹2,10,000 − (₹50,000 + ₹1,500 + ₹3,000 + ₹15,000)

Or = ₹1,40,500 .....(ii)

Thus, from (i) and (ii)

$$2,000x_1 + 4,000x_2 + 8,000x_3 \leq 1,40,500$$

Or

$$4x_1 + 8x_2 + 16x_3 \leq 281$$

Condition-3:

The company has also promised to deliver 3 P III, 2 P II and 5 Celeron computers to M/s ABC Ltd. Hence,

$$x_1 \geq 3,$$

$$x_2 \geq 2, \text{ and}$$

$$x_3 \geq 5$$

The LP formulation of the given problem is as follows:

Maximize

$Z = 1,000x_1 + 1,000x_2 + 7,000x_3 -$ ₹19,500

Subject to the Constraints:

$$20x_1 + 15x_2 + 12x_3 \le 1{,}000$$
$$5x_1 + 4x_2 + 3x_3 \le 1{,}500$$
$$4x_1 + 8x_2 + 16x_3 \le 281$$
$$x_1 \ge 3$$
$$x_2 \ge 2$$
$$x_3 \ge 5$$

Problem-8

Transport Ltd. Provides tourist vehicles of 3 types –

20-Seater Vans,

8-Seater Big Cars and

5-Seater Small Cars

(These seating capacities are excluding the drivers)

The company has –

4 Vehicles of the 20-Seater Van type

10 Vehicles of the 8-Seater Big Car type and

20 Vehicles of the 5-Seater Small Car types

These vehicles have to be used to transport employees of their client company from their residences to their offices and back. All the residences are in the same housing colony. The offices are at two different places, one is the Head Office and the other is the Branch. Each vehicle plies only one round trip per day, if residence to office in the morning and office to residence in the evening. Each day, 180 officials need to be transported in Route I (from residence to Head Office and back) and 40 officials need to be transported in Route II (from Residence to Branch office and back). The cost per round trip for each type of vehicle along each route is given below.

	Figs. – ₹/ Round Trip		
	20-Seater Vans	**8-Seater Big Cars**	**5-Seater Small Cars**
Route I: *Residence--Head Office and Back*	600	400	300
Route II: *Residence--Branch Office and Back*	500	300	200

Required

Formulate the information as a linear programming problem, with the objective of minimising the total cost of hiring vehicles for the client company, subject to the constraints mentioned above. (Only formulation is required. Solution is not needed).

Solution

Let i be the route and j be the type of vehicle, so that

S_{11} = No. of 20 Seater Vans on Route I

S_{12} = No. of 8 Seater Big Cars on Route I

S_{13} = No. of 5 Seater Small Cars on Route I

S_{21} = No. of 20 Seater Vans on Route II

S_{22} = No. of 8 Seater Big Cars on Route II

S_{23} = No. of 5 Seater Small Cars on Route II

	20-Seater Vans (In Numbers)	8-Seater Big Cars (In Numbers)	5-Seater Small Cars (In Numbers)
Route I: Residence--Head Office and Back	S_{11}	S_{12}	S_{13}
Route II: Residence--Branch Office and Back	S_{21}	S_{22}	S_{23}

Objective function:

Minimise Cost

$$Z = 600S_{11} + 400S_{12} + 300S_{13} + 500S_{21} + 300S_{22} + 200S_{23}$$

Condition-1:

Each day, 180 officials need to be transported in Route I (from residence to Head Office and back).

$$20S_{11} + 8S_{12} + 5S_{13} = 180$$

Each day, 40 officials need to be transported in Route II (from Residence to Branch office and back).

$$20S_{21} + 8S_{22} + 5S_{23} = 40$$

Condition-2:

Company has 4 Vehicles of the 20-Seater Van type;

$$S_{11} + S_{21} \leq 4$$

10 Vehicles of the 8-Seater Big Car type and

$$S_{12} + S_{22} \leq 10$$

20 Vehicles of the 5-Seater Small Car types

$$S_{13} + S_{23} \leq 20$$

The LP formulation of the given problem is as follows:

Minimise Cost

$$Z = 600S_{11} + 400S_{12} + 300S_{13} + 500S_{21} + 300S_{22} + 200S_{23}$$

Subject to the Constraints:

$$\begin{aligned} 20S_{11} + 8S_{12} + 5S_{13} &= 180 \\ 20S_{21} + 8S_{22} + 5S_{23} &= 40 \\ S_{11} + S_{21} &\leq 4 \\ S_{12} + S_{22} &\leq 10 \\ S_{13} + S_{23} &\leq 20 \\ S_{11}, S_{12}, S_{13}, S_{21}, S_{22}, S_{23} &\geq 0 \end{aligned}$$

Problem-9

The following matrix gives the unit cost of transporting a product from production plants P_1, P_2 and P_3 to destinations D_1, D_2 and D_3. Plants P_1, P_2 and P_3 have a maximum production of 65, 24 and 111 units respectively and destinations D_1, D_2 and D_3 must receive at least 60, 65 and 75 units respectively:

To / From	D_1	D_2	D_3	Supply
P_1	400	600	800	65
P_2	1,000	1,200	1,400	24
P_3	500	900	700	111
Demand	60	65	75	200

Required

Formulate the above as a linear programming problem.

(Only formulation is needed. Please do not solve).

Solution

Let p_id_j be the variable to denote the number of units of product from the i^{th} plant to the j^{th} destination, so that

p_1d_1 = transport from plant P_1 to D_1

p_2d_2 = transport from plant P_2 to D_2 etc.

Objective function:

Minimize

$$Z = 400p_1d_1 + 600p_1d_2 + 800p_1d_3 + 1{,}000p_2d_1 + 1{,}200\,p_2d_2 + 1{,}400\,p_2d_3 + 500\,p_3d_1 + 900\,p_3d_2 + 700\,p_3d_3$$

Subject to the:

$$\left.\begin{aligned} p_1d_1 + p_1d_2 + p_1d_3 &\leq 65 \\ p_2d_1 + p_2d_2 + p_2d_3 &\leq 24 \\ p_3d_1 + p_3d_2 + p_3d_3 &\leq 111 \end{aligned}\right\} \text{Plant Constraints}$$

and

$$\left.\begin{aligned} p_1d_1 + p_2d_1 + p_3d_1 &\geq 60 \\ p_1d_2 + p_2d_2 + p_3d_2 &\geq 65 \\ p_1d_3 + p_2d_3 + p_3d_3 &\geq 75 \end{aligned}\right\} \text{Destination Constraints}$$

All $p_id_j \geq 0$

Problem-10

An oil refinery can blend three grades of crude oil to produce quality A and quality B petrol. Two possible blending processes are available. For each production run, the older process uses 5 units of crude Q, 7 units of crude P and 2 units of crude R and produces 9 units of A and 7 units of B. The newer process uses 3 units of crude Q, 9 unit of crude P and 4 units of crude R to produce 5 units of A and 9 units of B.

Because of prior contract commitments, the refinery must produce at least 500 units of A and at least 300 units of B for the next month. It has 1,500 units of crude Q, 1,900 units of crude P and 1,000 of crude R. For each unit of A, refinery receives ₹ 60 while for each unit of B, it receives ₹ 90.

Required

Formulate the problem as linear programming model so as to maximize the revenue.

Solution

Crude Oil Type	Older Process	Newer Process	Available Crude Oil
Q	5 units	3 units	1,500 units
P	7 units	9 units	1,900 units
R	2 units	4 units	1,000 units
Output Obtained (per process)	A = 9 units B = 7 units	A = 5 units B = 9 units	
Revenue Obtained (per process)	₹1,170 (₹60 × 9 units + ₹90 × 7 units)	₹1,110 (₹60 × 5 units + ₹90 × 9 units)	

Let x_1, x_2 the number of times the refinery decides to use 'Older' process and 'Newer' process respectively.

Maximize $Z = 1{,}170x_1 + 1{,}110x_2$

Subject to

$9x_1 + 5x_2$	$\geq$	500	Commitment for A
$7x_1 + 9x_2$	$\geq$	300	Commitment for B
$5x_1 + 3x_2$	$\leq$	1,500	Availability of Q
$7x_1 + 9x_2$	$\leq$	1,900	Availability of P
$2x_1 + 4x_2$	$\leq$	1,000	Availability of R
x_1, x_2	$\geq$	0	

Problem-11

A manufacturer produces three products Y_1, Y_2, Y_3 from three raw materials X_1, X_2, X_3. The cost of raw materials X_1, X_2 and X_3 is ₹ 30, ₹ 50 and ₹ 120 per kg respectively and they are available in a limited quantity viz 20 kg of X_1, 15 kg of X_2 and 10 kg of X_3. The selling price of Y_1, Y_2 and Y_3 is ₹ 90, ₹ 100 and ₹ 120 per kg respectively. In order to produce 1 kg of Y_1, 1/2 kg of X_1, 1/4 kg of X_2 and 1/4 kg of X_3 are required. Similarly to produce 1 kg of Y_2, 3/7 kg of X_1, 2/7 kg of X_2 and 2/7 kg of X_3 and to produce 1 kg Y_3, 2/3 kg of X_2 and 1/3 kg of X_3 will be required.

Required

Formulate the linear programming problem to maximize the profit.

Solution

The information given in the Problem can be presented in the following tabular form-

Products	Raw Material (in kg) *required to produce one kg of product*			Selling Price (per kg)
	X_1	X_2	X_3	
Y_1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	₹ 90
Y_2	$\frac{3}{7}$	$\frac{2}{7}$	$\frac{2}{7}$	₹100
Y_3	---	$\frac{2}{3}$	$\frac{1}{3}$	₹120
Cost of Raw Material *per kg*	₹ 30	₹ 50	₹ 120	
Availability of Raw Material	20 kg	15 kg	10 kg	

Let the manufacturer produce y_1, y_2 and y_3 units of the products Y_1, Y_2 and Y_3 respectively.

Objective function:

From the above table, the cost of producing 1 kg of Y_1, Y_2 and Y_3 can be calculated as given below:

Cost to produce 1 kg of Y_1 $= \frac{1}{2} \times ₹30 + \frac{1}{4} \times ₹50 + \frac{1}{4} \times ₹120$

= ₹15.00 + ₹12.50 + ₹30.00

= ₹ 57.50

∴ Profit per kg of Y_1 = ₹90.00 − ₹57.50

= ₹32.50

Similarly, cost to produce 1 kg of Y_2 $= \frac{3}{7} \times ₹30 + \frac{2}{7} \times ₹50 + \frac{2}{7} \times ₹120$

$= \frac{1}{7} \times (₹90 + ₹100 + ₹240)$

= ₹61.43

∴ Profit per kg of Y_2 = ₹100 − ₹61.43

= ₹38.57

Similarly, cost to produce 1 kg of Y_3 $= \frac{2}{3} \times ₹50 + \frac{1}{3} \times ₹120$

$= \frac{₹220}{3}$

$= ₹73.33$

$\therefore$ Profit per kg of Y_3 $= ₹120 - ₹73.33$

$= ₹46.67$

Since the manufacturer wants to maximise the profit, the objective function is given by-

Maximize $Z = 32.50y_1 + 38.57y_2 + 46.67y_3$

Constraints:

Availability of Raw Material X_1

$$\frac{1}{2}y_1 + \frac{3}{7}y_2 \leq 20$$

Or $$7y_1 + 6y_2 \leq 280$$

Availability of Raw Material X_2

$$\frac{1}{4}y_1 + \frac{2}{7}y_2 + \frac{2}{3}y_3 \leq 15$$

Or $$21y_1 + 24y_2 + 56y_3 \leq 1,260$$

Availability of Raw Material X_3

$$\frac{1}{4}y_1 + \frac{2}{7}y_2 + \frac{1}{3}y_3 \leq 10$$

Or $$21y_1 + 24y_2 + 28y_3 \leq 840$$

The LP formulation of the given problem is as follows:

Maximize $Z = 32.50y_1 + 38.57y_2 + 46.67y_3$

Subject to the Constraints:

$$7y_1 + 6y_2 \leq 280$$

$$21y_1 + 24y_2 + 56y_3 \leq 1,260$$

$$21y_1 + 24y_2 + 28y_3 \leq 840$$

Where y_1, y_2 and $y_3 \geq 0$

Problem-12

In a chemical industry two products A and B are made involving two operations. The production of B also results in a by-product C. The product A can be sold at a profit of ₹ 3 per unit and B at a profit of ₹ 8 per unit. The by-product C has a profit of ₹ 2 per unit. Forecast show that upto 5 units of C can be sold. The company gets 3 units of C for each unit of B produced. The manufacturing times are 3 hrs per unit for A on each of the operation one and two and 4 hrs and 5 hrs per unit for B on operation one and two respectively. Because the product C results from producing B, no time is used in producing C. The available times are 18 hrs and 21 hrs of operation one and two respectively. The company desires to know that how much A and B should be produced keeping C in mind to make the highest profit.

Required

Formulate LP model for this problem.

Solution

Let x_1, x_2 x_3 be the number of units produced of products A, B and C respectively.

Objective function:

Then the profit gained by the industry is given by

$$Z = 3x_1 + 8x_2 + 2x_3$$

Here it is assumed that all the units of products A and B are sold.

Condition-1:

In first operation, A takes 3 hrs of manufacturer's time and B takes 4 hrs of manufacturer's time. Therefore, total number of hours required in first operation becomes-

$$3x_1 + 4x_2$$

In second operation, per unit of A takes 3 hrs of manufacturer's time and per unit B takes 5 hrs of manufacturer's time. Therefore, the total number of hours used in second operation becomes

$$3x_1 + 5x_2$$

Since there are 18 hrs available in first operation and 21 hrs in second operation, the restrictions become

$$3x_1 + 4x_2 \leq 18$$
$$3x_1 + 5x_2 \leq 21$$

Condition-2:

Since the maximum number of units of C that can be sold is 5, therefore,

$$x_3 \leq 5$$

Condition-3:

Further, the company gets three units of by product C for every unit of product B produced, therefore

$$x_3 = 3x_2$$

Now, the allocation problem of the industry can be finally put in the following linear programming problem:

Maximise

$$Z = 3x_1 + 8x_2 + 2x_3$$

Subject to the Constraints:

$$3x_1 + 4x_2 \leq 18$$
$$3x_1 + 5x_2 \leq 21$$
$$x_3 \leq 5$$
$$x_3 = 3x_2$$
$$x_1, x_2, x_3 \geq 0$$

Problem-13

An investor is interested in investing ₹ 15,00,000 in a portfolio of investments. The investment choices and expected rates of return on each one of them are:

Investment	***Projected Rate of Return***
Mutual Fund 'XY'	*15%*
Mutual Fund 'HN'	*9%*
Money Market Fund	*8%*
Government Bonds	*8.75%*
Shares 'P'	*17%*
Share 'Q'	*18%*

The investor wants at least 40% of his investment in Government Bonds. Because of the higher perceived risk of the two shares, he has specified that the combined investment in these two shares not to exceed ₹ 2,60,000. The investor has also specified that at least 25% of the investment should be in the money market fund and that the amount of money invested in shares should not exceed the amount invested in Mutual Funds. His final investment condition is that the amount invested in mutual fund 'XY' should be no more than the amount invested in mutual fund 'HN'. The problem is to decide the amount of money to invest in each alternative so as to obtain the highest annual total return.

Required

Formulate the above as a linear programming problem.

Solution

Let

u = Investment in "Mutual Fund 'XY'"
v = Investment in "Mutual Fund 'HN'"
w = Investment in "Money Market Fund"
x = Investment in "Government Bonds"
y = Investment in "Share 'P'"
z = Investment in "Share 'Q'"

Objective function:

Maximize

$$Z = 0.15u + 0.09v + 0.08w + 0.0875x + 0.17y + 0.18z$$

Condition-1:

₹ 15,00,000 to be invested -

$$u + v + w + x + y + z \leq 15,00,000$$

Condition-2:

At least 40% of investment in Government Bonds-

$$x \geq (u + v + w + x + y + z) \times 0.40$$

Or $$2u + 2v + 2w - 3x + 2y + 2z \leq 0$$

Condition-3:

Combined Investment in two shares not to exceed ₹ 2,60,000-

$$y + z \leq 2,60,000$$

Condition-4:

At least 25% of the investment in the money market fund-

$$w \geq (u + v + w + x + y + z) \times 0.25$$

Or $$u + v - 3w + x + y + z \leq 0$$

Condition-5:

Amount of money invested in shares should not exceed the amount invested in mutual funds-

$$y + z \leq u + v$$

Or $$-u - v + y + z \leq 0$$

Condition-6:

Amount invested in mutual fund 'XY' should be not be more than the amount invested in mutual fund 'HN'-

$$u \leq v$$

Or $$u - v \leq 0$$

Maximize

Z= 0.15u + 0.09v + 0.08w + 0.0875x + 0.17y + 0.18z

Subject to the Constraints:

$$u + v + w + x + y + z \leq 15,00,000$$
$$2u + 2v + 2w - 3x + 2y + 2z \leq 0$$
$$y + z \leq 2,60,000$$
$$u + v - 3w + x + y + z \leq 0$$
$$-u - v + y + z \leq 0$$
$$u - v \leq 0$$
$$u, v, w, x, y, z \geq 0$$

☞

This problem can be solved with the assumption of **Investment Exactly** ₹15,00,000

Graphical Method

Problem-14

A company manufactures two products A and B, involving three departments - Machining, Fabrication and Assembly. The process time, profit/unit and total capacity of each department is given in the following table:

	Machining (hours)	*Fabrication (hours)*	*Assembly (hours)*	*Profit (₹)*
A	*1*	*5*	*3*	*80*
B	*2*	*4*	*1*	*100*
Capacity	*720*	*1,800*	*900*	

Required

Set up Linear Programming problem to maximize profits. What will be the product-mix at maximum profit level? What will be the profit? (Solve by using graphic method)

✍ **Solution**

Let x and y denote the number of units produced for the product A & B respectively.

The linear programming model for the given problem is:

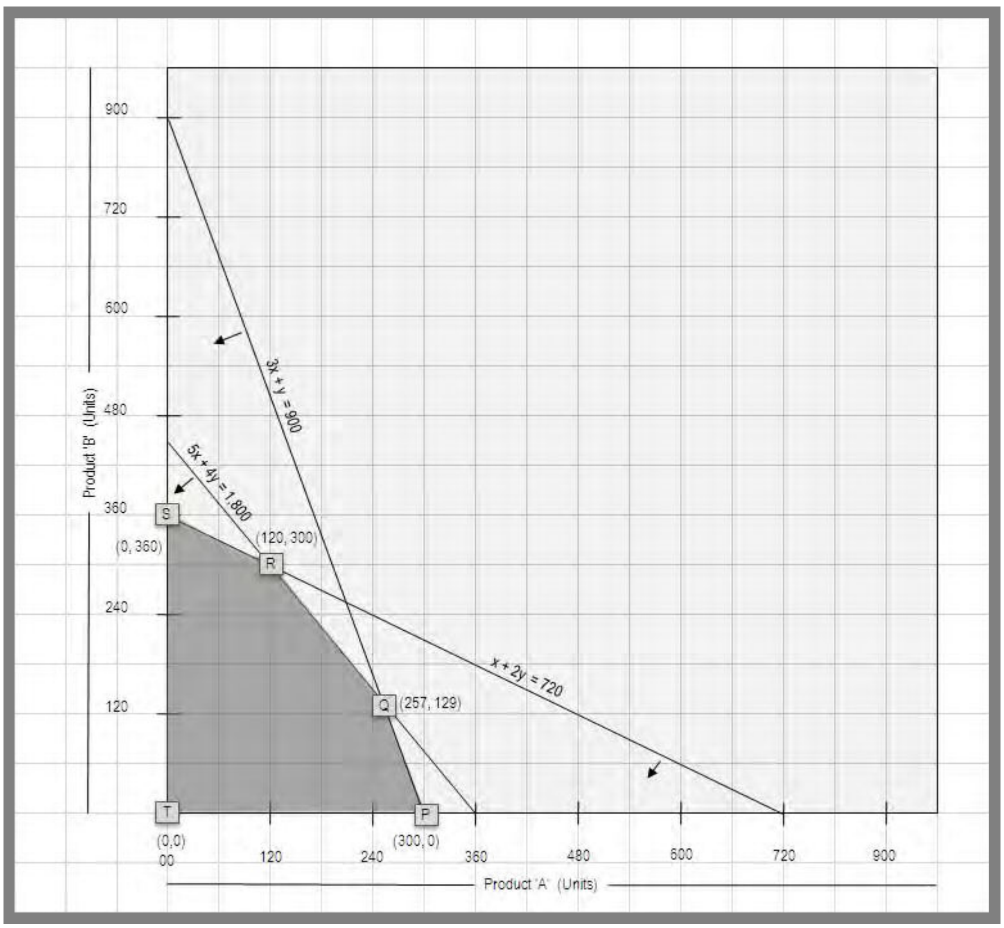
Maximize

$$Z = 80x + 100y$$

Subject to the Constraints:

$x + 2y$	$\leq$	720	(Machining Time)
$5x + 4y$	$\leq$	1,800	(Fabrication Time)
$3x + y$	$\leq$	900	(Assembly Time)
x, y	$\geq$	0	

The graphical solution for the problem is given below:



Working to find points to draw the lines and intersection points:

Points to draw	$x + 2y$	=	720
If	x	=	0
	$2y$	=	720
	y	=	720/2
		=	360
If	y	=	0
	x	=	720
	(x, y)	–	(0, 360); (720, 0)
Points to draw	$5x + 4y$	=	1,800
If	x	=	0
	$4y$	=	1,800
	y	=	450
If	y	=	0
	$5x$	=	1,800
	x	=	360
	(x, y)	–	(0, 450); (360, 0)
Points to draw	$3x + y$	=	900
If	x	=	0
	y	=	900
If	y	=	0
	$3x$	=	900
	x	=	300
	(x, y)	–	(0, 900); (300, 0)

Intersection Point (R)

$$5x + 4y = 1{,}800 \text{ (Equation1)}$$
$$x + 2y = 720 \quad \text{(Equation2)}$$

Or

$$\cancel{5x} + 4y = 1{,}800$$
$$\cancel{5x} + 10y = 3{,}600 \quad [(\text{Equation 2}) \times 5]$$
$$- \quad - \quad -$$
$$-6y = -1{,}800$$
$$y = 300$$

On putting value of y in any one of the above equation, the value of x = 120

Point R – (120, 300)

Intersection Point (Q)

$$5x + 4y = 1{,}800 \text{ (Equation1)}$$
$$3x + y = 900 \quad \text{(Equation2)}$$

Or

$$5x + \cancel{4y} = 1{,}800$$
$$12x + \cancel{4y} = 3{,}600 \quad [(\text{Equation 2}) \times 4]$$
$$- \quad - \quad -$$

$$-7x = -1,800$$
$$x = 257$$

On putting value of x in any one of the above equation, the value of y = 129

Point Q – (257, 129)

The shaded portion in the diagram represents the feasible region.

Value of the objective function at the feasible points is calculated below:

Point	**Co-Ordinates of the corner points of the feasible region (value of x and y)**	**Value of the objective function Z = 80x + 100y**
P	(300,0)	₹ 24,000
Q	(257,129)	₹ 33,460
R	(120,300)	₹ 39,600
S	(0,360)	₹ 36,000
T	(0,0)	` ₹ 0

Since at Point R company makes *maximum profit* hence product mix at Point R i.e. 120 units of Product A and 300 units of product B should be produced.

Problem-15

An advertising firm desires to reach two types of audiences – customers with annual income of more than ₹ 40,000 (target audience A) and customers with annual income of less than ₹ 40,000 (target audience B). The total advertising budget is ₹ 2,00,000. One programme of T.V. advertising costs ₹ 50,000 and one programme of Radio advertising costs ₹ 20,000. Contract conditions ordinarily require that there should be at least 3 programmes on T.V. and the number of programmes on Radio must not exceed 5. Survey indicates that a single T.V. programme reaches 7,50,000 customers in target audience A and 1,50,000 in target audience B. One Radio programme reaches 40,000 customers in target audience A and 2,60,000 in target audience B.

Required

Formulate this as a linear programming problem and determine the media mix to maximize the total reach using graphic method.

Solution

Let x be the number of programmes of T.V. advertising and y denote the number of programmes of radio advertising.

Objective function:

One T.V. programme reaches 7,50,000 customers in target audience A and 1,50,000 customers in target audience B, whereas one radio programme reaches 40,000 customers in target audience A and 2,60,000 in target audience B. Since the advertising firm desires to determine the media mix to maximise the total reach, the objective function in given by

Maximise $Z = (7,50,000 + 1,50,000)\, x + (40,000 + 2,60,000)\, y$

Or $Z = 9,00,000x + 3,00,000y$

Condition-1:

One programme of T.V. advertising costs ₹ 50,000 and that of Radio advertising cots ₹ 20,000. The total advertising budget is ₹ 2,00,000.

Hence, $50,000x + 20,000y \leq 2,00,000$

Or $5x + 2y \leq 20$

Condition-2:

Contract conditions require that there should be at least 3 programmes on T.V. and the number of programmes on Radio must not exceed 5.

Therefore, $x \geq 3$

$y \leq 5$

The linear programming model for the given problem is:

Maximise

$Z = 9,00,000x + 3,00,000y$

Subject to the Constraints:

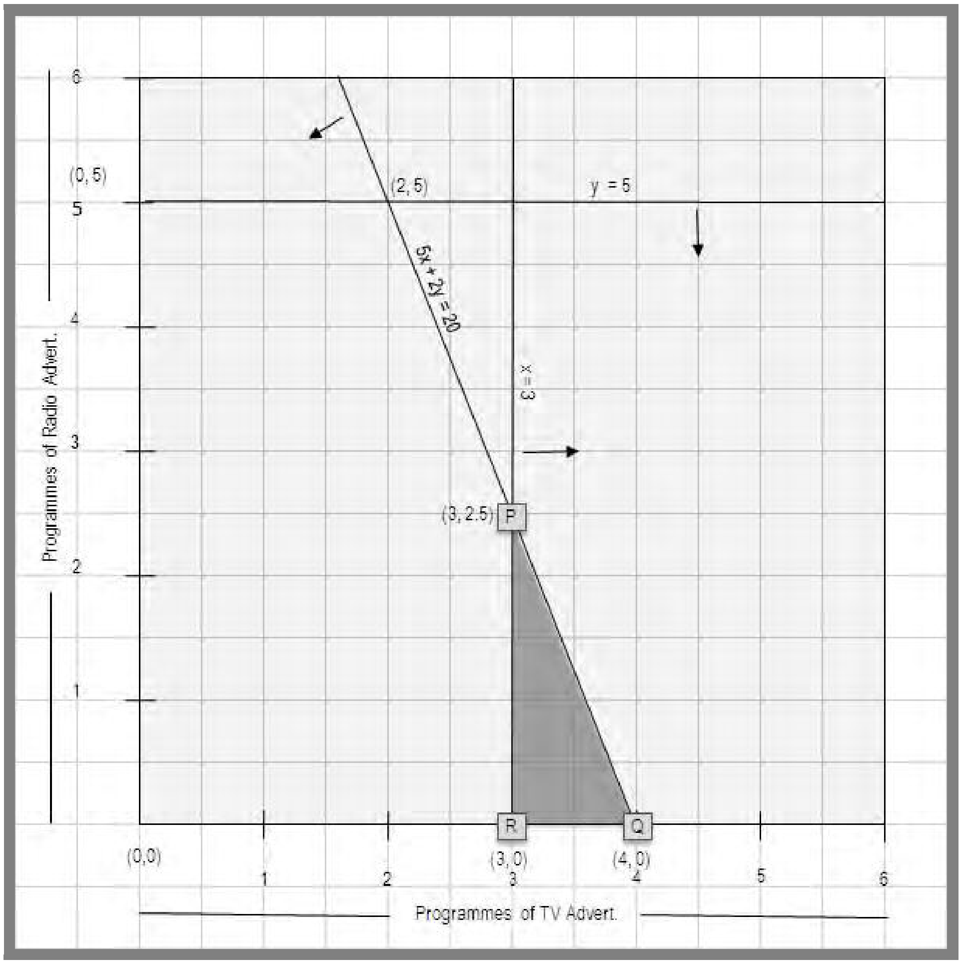
$5x + 2y \leq 20$

$x \geq 3$

$y \leq 5$

where $x, y \geq 0$

The graphical solution for the problem is given below:



Intersection Points:

Point of intersection for lines			
	x	=	3 and
	5x + 2y	=	20 is P (3, 2.5)
Similarly, lines			
	y	=	5 and
	5x + 2y	=	20 intersect at point (2, 5)
Line	x	=	0 meets
	5x + 2y	=	20 at point (0, 10)
Line	y	=	0 meets
	5x + 2y	=	20 at point Q (4, 0)

The feasible region is given by the shaded area PQR, and the feasible points are P (3, 2.5), Q (4, 0) and R (3, 0).

Value of the objective function at the above mentioned feasible points is calculated below:

Point	Co-Ordinates of the corner points of the feasible region (value of x and y)	Value of the objective function Z = 9,00,000 x + 3,00,000 y
P	(3, 2.5)	₹ 34,50,000
Q	(4, 0)	₹ 36,00,000
R	(3, 0)	₹ 27,00,000

It can be seen that the value of Z is maximum at point Q (4, 0). Thus, solution to the given problem is: x = 4, y = 0 and Maximum Z = 36,00,000.

In other words, the advertising firm should give 4 programmes on TV and no programme on Radio in order to achieve a maximum reach of 36,00,000 customers.

Problem-16

Let us assume that you have inherited ₹ 1,00,000 from your father-in-law that can be invested in a combination of only two stock portfolios, with the maximum investment allowed in either portfolio set at ₹ 75,000. The first portfolio has an average rate of return of 10%, whereas the second has 20%. In terms of risk factors associated with these portfolios, the first has a risk rating of 4 (on a scale from 0 to 10), and the second has 9. Since you wish to maximize your return, you will not accept an average rate of return below 12% or a risk factor above 6. Hence, you then face the important question. How much should you invest in each portfolio?

Required

Formulate this as a Linear Programming Problem and solve it by Graphic Method.

Solution

Let x and y be the amount to be invested in first and second stock portfolio respectively.

Objective function:

The average rate of return for first portfolio is 10% and for second portfolio, it is 20%. Since the company wishes to maximize the return from investment, the objective function is as given below:

Maximise Z = 0.10x + 0.20y

Condition-1:

The maximum amount available for investment is ₹ 1,00,000.

Hence, x + y ≤ 1,00,000

Condition-2:

Further, the maximum investment allowed in either portfolio set is ₹ 75,000.

Therefore, $x \leq 75{,}000$ and

$y \leq 75{,}000$

Condition-3:

The first portfolio has a risk rating of 4 (on a scale from 0 to 10) and the second has 9. The company will not accept a risk factor above 6.

Therefore, $4x + 9y \leq 6(x + y)$

Or $-2x + 3y \leq 0$

Condition-4:

Further, the company will not accept an average rate of return below 12%.

Hence, $0.10x + 0.20y \geq 0.12(x + y)$

Or $-0.02x + 0.08y \geq 0$

Condition-5:

Also, $x, y \geq 0$

The linear programming model for the given problem can now be formulated as follows:

Maximise

$$Z = 0.10\,x + 0.20\,y$$

Subject to the Constraints:

$$x + y \leq 1{,}00{,}000$$

$$x, y, z \leq 10{,}00{,}000$$

$$y \leq 75{,}000$$

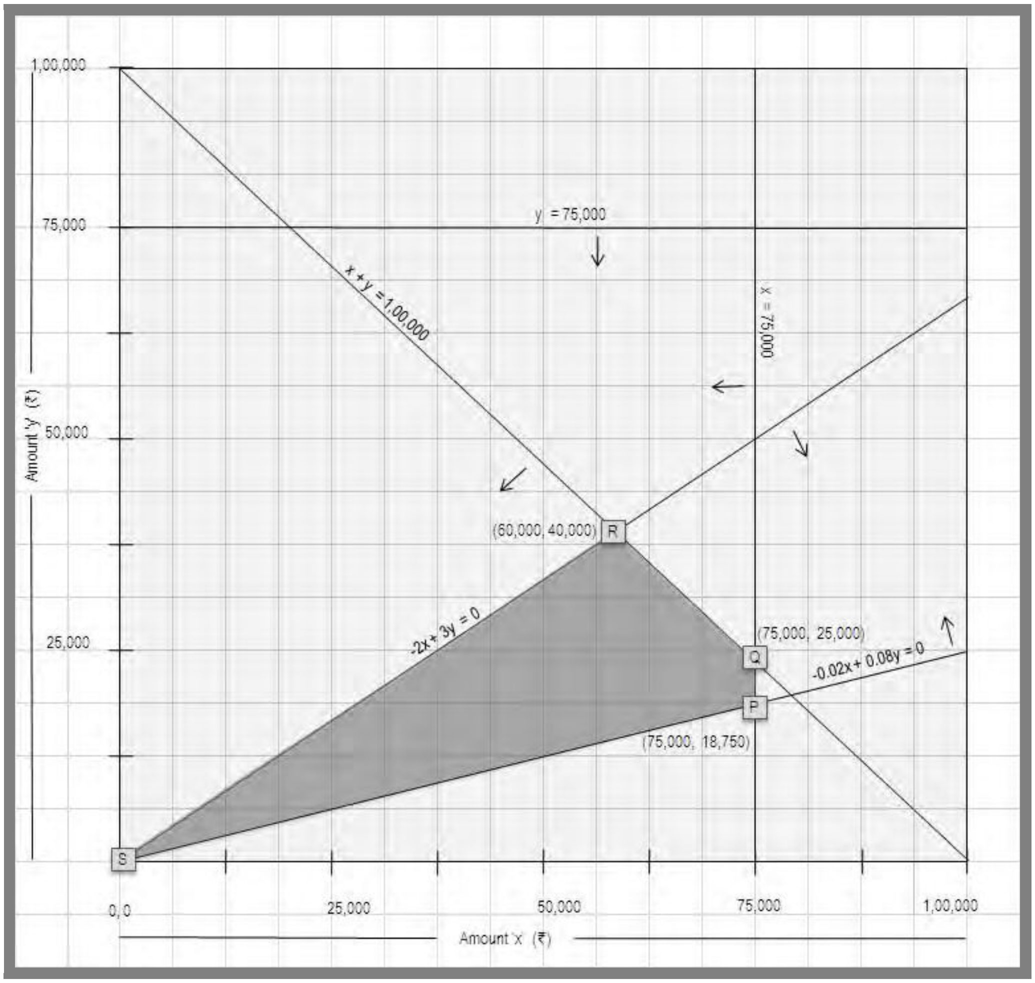
$$-x + 2y - 2z \leq 0$$

$$-3x - 6y - z \leq 0$$

$$-0.02x + 0.08y \geq 0$$

Where $x, y \geq 0$

The problem is solved graphically below:



Intersection Points:

The point of intersection for the lines		
$-2x + 3y$	=	0 and
$x + y$	=	1,00,000 is given by Intersection Point R (60,000, 40,000)
The point of intersection for the lines		
x	=	75,000 and
$x + y$	=	1,00,000 is given by Intersection Point Q (75,000, 25,000)
Similarly, the lines		
x	=	75,000 and
$-0.02x + 0.08y$	=	0 Intersect at Point P (75,000, 18,750)

Thus, the feasible region is bounded by SRQP and feasible points are S (0, 0); R (60,000, 40,000); Q (75,000, 25,000) and P (75,000, 18,750).

Value of the objective function at the above mentioned feasible points is calculated below:

Point	Co-Ordinates of the corner points of the feasible region (value of x and y)	Value of the objective function Z = 0.10 x + 0.20 y
S	(0, 0)	₹ NIL
R	(60,000, 40,000)	₹ 14,000
Q	(75,000, 25,000)	₹ 12,500
P	(75,000, 18,750)	₹ 11,250

We find that the value of the objective function is maximum (₹14,000) at point R (60,000, 40,000).

Hence, there should be investment of ₹ 60,000 in first portfolio and investment of ₹ 40,000 in second portfolio to achieve the maximum average rate of return of ₹14,000.

Problem-17

A farm is engaged in breeding pigs. The pigs are fed on various products grown in the farm. In view of the need to ensure certain nutrient constituents (call them X, Y and Z), it becomes necessary to buy two additional products say, A and B. One unit of product A contains 36 units of X, 3 units of Y and 20 units of Z. One unit of product B contains 6 units of X, 12 units of Y and 10 units of Z. The minimum requirement of X, Y and Z is 108 units, 36 units and 100 units respectively. Product A costs ₹ 20 per unit and product B ₹ 40 per unit.

Required

Formulate the above as a linear programming problem to minimize the total cost and solve this problem by using graphic method.

The data of the given problem can be summarized as under:

Nutrient Constituents	*Nutrient Content in Product*		*Minimum Requirement of Nutrient*
	A	*B*	
X	*36*	*06*	*108*
Y	*03*	*12*	*36*
Z	*20*	*10*	*100*
Cost of Product	*₹ 20*	*₹ 40*	

Solution

Let x units of product A and y units of product B are purchased.

Required mathematical formulation of L.P. problem is as given below:

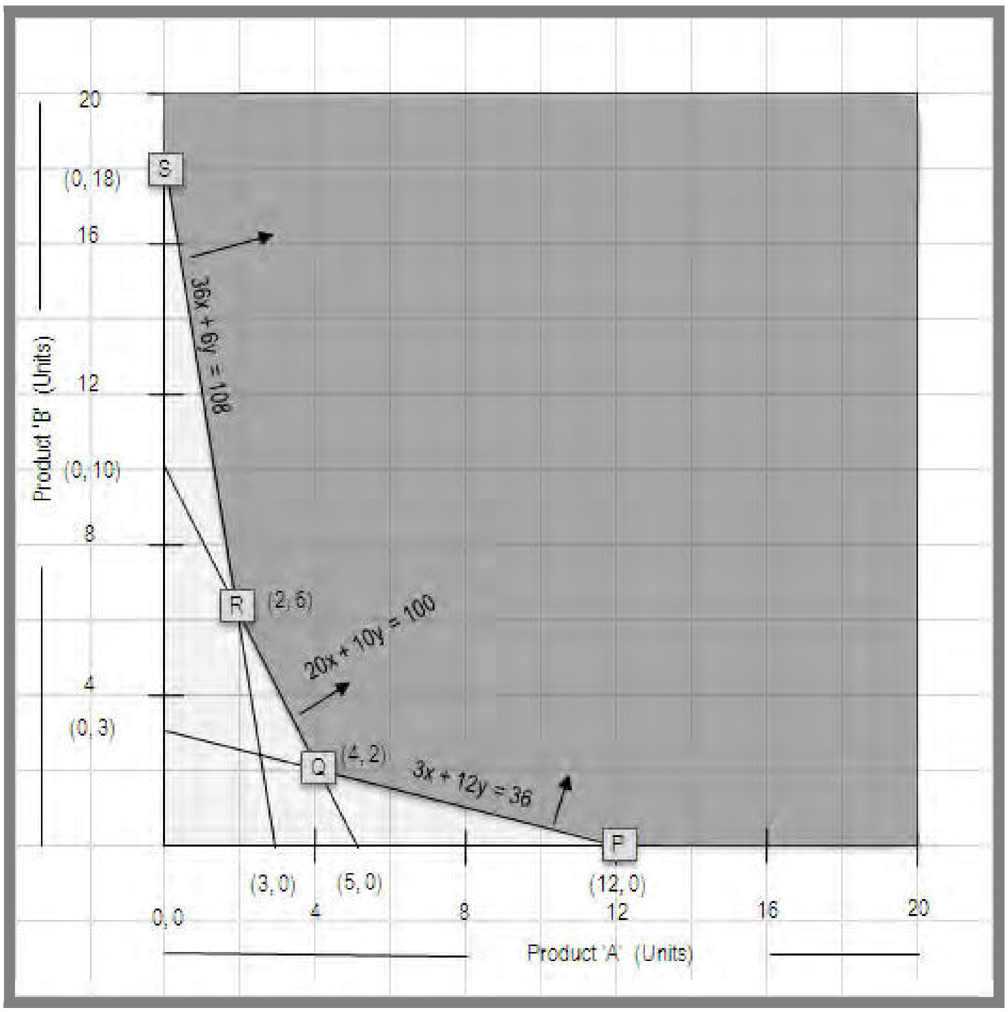
Minimize

$$Z = 20x + 40y$$

Subject to the Constraints:

$$\begin{aligned} 36x + 6y &\geq 108 \\ 3x + 12y &\geq 36 \\ 20x + 10y &\geq 100 \text{ and} \\ x,\ y &\geq 0 \end{aligned}$$

The problem is solved graphically below:



For solving the above problem graphically, consider a set of rectangular axis x, y in the plane. As each point has the coordinates of type (x, y), any point satisfying the conditions x ≥ 0 and y ≥ 0 lies in the first quadrant only.

The constraints of the given problem as described earlier are plotted by treating them as equations:

$$36x + 6y = 108$$
$$3x + 12y = 36$$
$$20x + 10y = 100$$

The area beyond these lines represents the feasible region in respect of these constraints; any point on the straight lines or in the region above these lines would satisfy the constraints.

Intersection Points:

The point of intersection for the lines 36x + 6y = 108 and 20x + 10y = 100 is given by Intersection Point R (2, 6)
The point of intersection for the lines 20x + 10y = 100 and 3x + 12y = 36 is given by Intersection Point Q (4, 2)

The coordinates of the extreme points of the feasible region are given by

S = (0, 18)
R = (2, 6)
Q = (4, 2) and
P = (12, 0)

The value of the objective function at each of these points can be evaluated as follows:

Extreme Point	**Co-Ordinates of the corner points of the feasible region (value of x and y)**	**Value of the objective function Z = 20x + 40y**
S	(0, 18)	₹ 720
R	(2, 6)	₹ 280
Q	(4, 2)	₹ 160
P	(12, 0)	₹ 240

The value of the objective function is minimum at the point Q (4, 2). Hence, the optimum solution in to purchase 4 units of product A and 2 units of product B in order to have minimum cost of ₹160.

Problem-18

The costs and selling prices per unit of two products manufacturing by a company are as under:

Product	*A (₹)*	*B (₹)*
Selling Price	*500*	*450*
Variable Costs:		
Direct Materials @ ₹ 25 per kg.	*100*	*100*
Direct Labour @ ₹ 20 per hour	*80*	*40*
Painting @ ₹ 30 per hour	*30*	*60*
Variable Overheads	*190*	*175*
Fixed Costs @ ₹ 17.50 / D.L.Hr.	*70*	*35*
Total Costs	*470*	*410*
Profit	*30*	*40*

In any month the maximum availability of inputs is limited to the following:

Direct Materials	*480 kg.*
Direct Labour Hours	*400 hours*
Painting Hours	*200 hours*

Required

(i) Formulate a linear programme to determine the production plan which maximizes the profits by using graphical approach.

(ii) State the optimal product mix and the monthly profit derived from your solution in (i) above.

(iii) If the company can sell the painting time at ₹ 40 per hour as a separate service, show what modification will be required in the formulation of the linear programming problem. (You are required to re-formulate the problem but not to solve)

Solution

Contribution Analysis:

Products	A	B
	(₹)	(₹)
Selling Price (A)	500	450
Variable Costs:		

Direct Materials	100	100
Direct Labour	80	40
Painting	30	60
Variable Overheads	190	175
Total Variable Costs (B)	400	375
Contribution (A − B)	100	75
Direct Material *per unit*	₹100 / ₹25 = 4 kg.	₹100 / ₹25 = 4 kg.
Direct Labour hour *per unit*	₹80 / ₹20 = 4 hrs.	₹40 / ₹20 = 2 hrs.
Painting hour *per unit*	₹30 / ₹30 = 1 hr.	₹60 / ₹30 = 2 hrs.

Let x be the units to be produced of product A and y be the units to be produced of product B.

LP Problem formulation:

Maximize

$$Z = 100x + 75y \quad \text{(Maximisation of contribution)}$$

Subject to the Constraints:

$$4x + 4y \leq 480 \quad \text{(Raw material constraint)}$$

Or $$x + y \leq 120$$

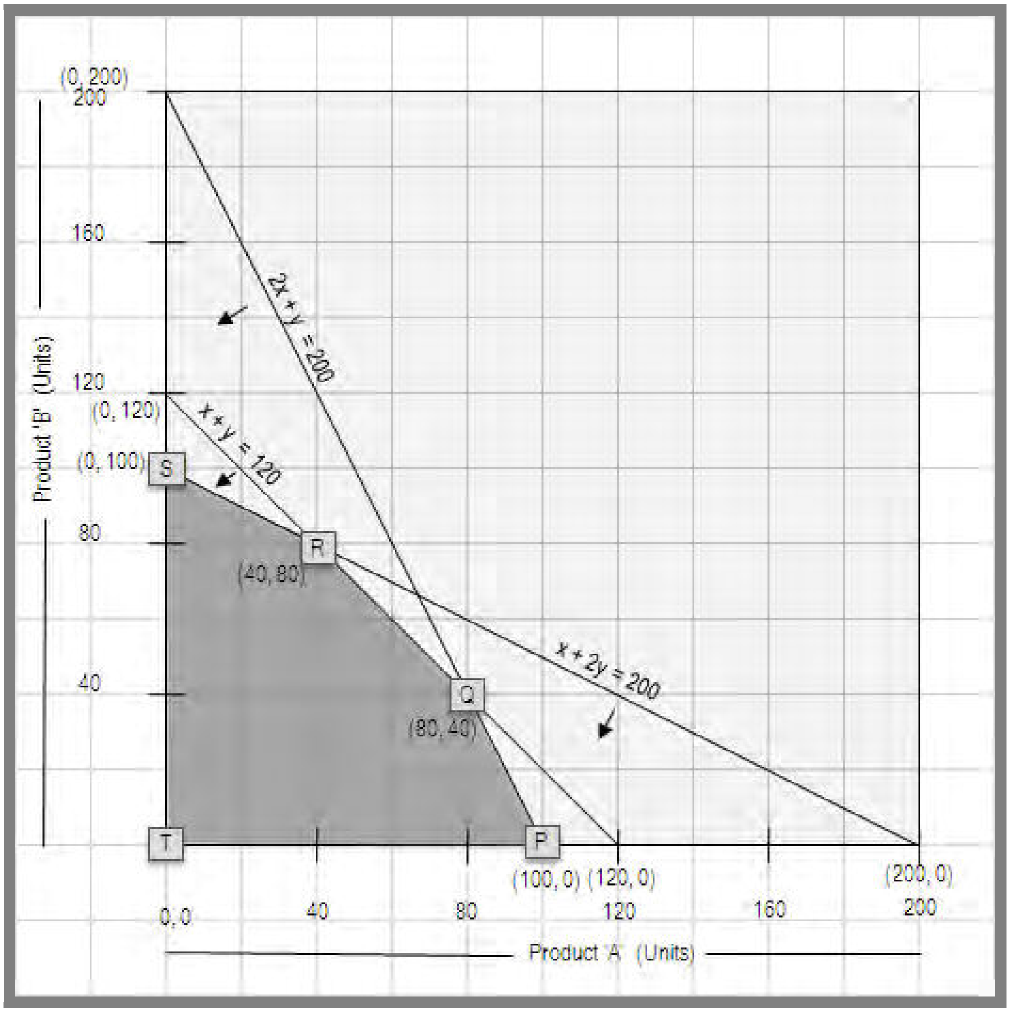
$$4x + 2y \leq 400 \quad \text{(Direct Labour hour constraint)}$$

Or $$2x + y \leq 200$$

$$x + 2y \leq 200 \quad \text{(Painting hour constraint)}$$

$$x, y \geq 0 \quad \text{(Non negativity constraint)}$$

The graphical representation will be as under:



Points to draw the lines and intersection points:

For	x + y	≤	120
If	y	=	0
	x	=	120
If	x	=	0
	y	=	120
For	2x + y	≤	200
If	y	=	0
	x	=	100

If	x	=	0
	y	=	200
For	x + 2y	≤	200
If	x	=	0
	y	=	100
If	y	=	0
	x	=	200
The point of intersection for the lines			
	x + y	=	120 and
	x + 2y	=	200 is given by Intersection Point R (40, 80)
The point of intersection for the lines			
	2x + y	=	200 and
	x + y	=	120 is given by Intersection Point Q (80, 40)

Evaluation of corner points:

Point	Products (Units)		Amount (₹)		Contribution (₹) (Z = 100 x + 75 y)
	A	B	A ₹100 *per unit*	B ₹75 *per unit*	
P	100	0	10,000	0	10,000
Q*	80	40	8,000	3,000	11,000
R	40	80	4,000	6,000	10,000
S	0	100	0	7,500	7,500
T	0	0	0	0	0

**Optimal product mix is Q*

Statement showing optimal profit:

Products	Units	Contribution (₹)
A	80	8,000
B	40	3,000
Total Contribution		11,000
Less: Fixed Cost (400 DL Hrs. × ₹17.50)		7,000
Optimal Profit		4,000

If the painting time can be sold at ₹ 40 per hour the opportunity cost is calculated as under:

Particulars	**A (₹)**	**B (₹)**
Income from Sale *per hour*	40	40
Less: Painting Variable Cost *per hour*	30	30
Opportunity Cost *per hour*	10	10
Painting Hours *per unit*	1	2
Opportunity Cost	10	20
Revised Contribution	90 (100 − 10)	55 (75 − 20)

Hence, modification is required in the objective function.

Re-formulated problem will be:

Maximize

$Z = 90x + 55y$ (Maximisation of contribution)

Subject to the Constraints:

$4x + 4y \leq 480$ (Raw material constraint)

Or $x + y \leq 120$

$4x + 2y \leq 400$ (Direct Labour hour constraint)

Or $2x + y \leq 200$

$x + 2y \leq 200$ (Painting hour constraint)

$x, y \geq 0$ (Non negativity constraint)

Simplex- Method

Problem-19

A manufacturer produces two products D_1 and D_2 using two machines R_1 and R_2 Products D_1 requires 2 hours on machine R_1 and 6 hours on machine R_2. Product D_2 utilises 5 hours of machine R_1 only. Total hours available per day on machine R_1 is 16 and R_2 is 30. Profit margin from D_1 and D_2 is ₹ 2 and ₹ 10 per unit respectively.

Required

Using simplex method find out the daily production mix to optimise profit.

Solution

The following table represents the data given in the problem:

	Machine R_1	Machine R_2	Profit/Unit (in ₹)
Product D_1	2 hours	6 hours	2
Product D_2	5 hours	Nil	10
Available Hours	16	30	

Let x_1 and x_2 represent the number of units of products D_1 and D_2 respectively then the mathematical formulation of the linear programming problem based on the above data will be as follows:

Maximize

$$Z = 2x_1 + 10x_2$$

Subject to the Constraints:

$$\begin{aligned} 2x_1 + 5x_2 &\leq 16 \\ 6x_1 + 0x_2 &\leq 30 \\ x_1, x_2 &\geq 0 \end{aligned}$$

Introduce slack variables in the above constrains, we get:

Maximize

$$Z = 2x_1 + 10x_2 + 0s_1 + 0s_2$$

Subject to:

$$\begin{aligned} 2x_1 + 5x_2 + s_1 &= 16 \\ 6x_1 + 0x_2 + s_2 &= 30 \\ x_1, x_2, s_1 \text{ and } s_2 &\geq 0 \end{aligned}$$

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			2	10	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables $b(=X_B)$	x_1	x_2	s_1	s_2	
0	s_1	16	2	**5**	1	0	← 3.2
0	s_2	30	6	0	0	1	–
		$Z_j = \sum C_{Bi}X_j$	0	0	0	0	
		$C_j - Z_j$	2	10↑	0	0	

SIMPLEX TABLEAU-II

$C_j \rightarrow$			2	10	0	0
C_B	Basic Variable (B)	Value of Basic Variables $b(=X_B)$	x_1	x_2	s_1	s_2
10	x_2	$\frac{16}{5}$	$\frac{2}{5}$	1	$\frac{1}{5}$	0
0	s_2	30	6	0	0	1
		$Z_j = \sum C_{Bi}X_j$	4	10	2	0
		$C_j - Z_j$	−2	0	−2	0

Since all numbers in the $C_j - Z_j$ row are either negative or zero, the optimum solution to the given problem has been obtained and is given by $x_1 = 0$ units and $x_2 = \frac{16}{5}$ units

Maximum Profit = ₹2 × 0 units + ₹10 × $\frac{16}{5}$ units = ₹ 32

Hence, the optimum solution is to produce 0 units of product D_1 and $\frac{16}{5}$ units of product D_2 to get maximum profit of ₹ 32

Problem-20

A company manufactures two products A and B, involving three departments - Machining, Fabrication and Assembly. The process time, profit/unit and total capacity of each department is given in the following table:

	Machining (hours)	*Fabrication (hours)*	*Assembly (hours)*	*Profit (₹)*
A	*1*	*5*	*3*	*80*
B	*2*	*4*	*1*	*100*
Capacity	*720*	*1,800*	*900*	

Required

Set up Linear Programming problem to maximize profits. What will be the product-mix at maximum profit level? What will be the profit? Solve by Simplex Method.

Solution

Let x and y denote the number of units produced for the product A & B respectively.

Maximize (Profit)

$$Z = 80x + 100y$$

Subject to the Constraints:

$$\begin{aligned} x + 2y &\le 720 && \text{(Machining Time)} \\ 5x + 4y &\le 1{,}800 && \text{(Fabrication Time)} \\ 3x + y &\le 900 && \text{(Assembly Time)} \\ x, y &\ge 0 \end{aligned}$$

By introducing slack variables $s_1 \ge 0$, $s_2 \ge 0$ and $s_3 \ge 0$ the linear programming problem in standard form becomes:

Maximize

$$Z = 80x + 100y + 0s_1 + 0s_2 + 0s_3$$

Subject to:

$$\begin{aligned} x + 2y + s_1 &= 720 && \text{(Machining Time)} \\ 5x + 4y + s_2 &= 1{,}800 && \text{(Fabrication Time)} \\ 3x + y + s_3 &= 900 && \text{(Assembly Time)} \\ x, y, s_1, s_2, s_3 &\ge 0 \end{aligned}$$

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			**80**	**100**	**0**	**0**	**0**	**Min. Ratio***
C_B	**Basic Variable (B)**	**Value of Basic Variables b (=X_B)**	**x**	**y**	**s_1**	**s_2**	**s_3**	
0	s_1	720	1	**2**	1	0	0	← 360
0	s_2	1,800	5	4	0	1	0	450
0	s_3	900	3	1	0	0	1	900
		$Z_j = \sum C_{Bi}X_j$	0	0	0	0	0	
		$C_j - Z_j$	80	100↑	0	0	0	

(*) Replacement Ratio

SIMPLEX TABLEAU-II

$C_j \rightarrow$			80	100	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables $b(=X_B)$	x	y	s_1	s_2	s_3	
100	y	360	$\frac{1}{2}$	1	$\frac{1}{2}$	0	0	720
0	s_2	360	**3**	0	-2	1	0	← 120
0	s_3	540	$\frac{5}{2}$	0	$-\frac{1}{2}$	0	1	216
		$Z_j = \sum C_{Bi}X_j$	50	100	50	0	0	
		$C_j - Z_j$	30↑	0	−50	0	0	

SIMPLEX TABLEAU-III

$C_j \rightarrow$			80	100	0	0	0
C_B	Basic Variable (B)	Value of Basic Variables $b(=X_B)$	x	y	s_1	s_2	s_3
100	y	300	0	1	$\frac{5}{6}$	$-\frac{1}{6}$	0
80	x	120	1	0	$-\frac{2}{3}$	$\frac{1}{3}$	0
0	s_3	240	0	0	$\frac{7}{6}$	$-\frac{5}{6}$	1
		$Z_j = \sum C_{Bi}X_j$	80	100	30	10	0
		$C_j - Z_j$	0	0	−30	−10	0

Since all numbers in the $C_j - Z_j$ row are either negative or zero, the optimum solution to the given problem has been obtained and is given by x = 120 units and y = 300 units

Maximum Profit = ₹80 × 120 units + ₹100 × 300 units

Hence, the optimum solution is to produce 120 units of product A and 300 units of product B to get maximum profit of ₹ 39,600

Problem-21

A factory produces 3 products X_1, X_2 and X_3. Each of these products is processed in two departments, machining and Assembly. The processing time in hours for each product in each department and the total available time in hours in the departments and contribution per unit are given below:

Product	Processing time (in hours)		Contribution ₹/unit
	Machining Department	Assembly Department	
X_1	4	3	8
X_2	4	2	6
X_3	6	4	5
Available time (hours)	384	288	

Exactly 30 units of X_3 must be produced.

Required

(i) Determine the optimal product mix using simplex method and find the optimal profit.

(ii) Comment on the solution, objective function and the constraints.

Solution

(i) Let x_1, x_2, and x_3 represent the number of units of products X_1, X_2 and X_3 respectively then the mathematical formulation of the linear programming problem based on the above data will be as follows:

Maximize

$$Z = 8x_1 + 6x_2 + 5x_3$$

Subject to the Constraints:

$$4x_1 + 4x_2 + 6x_3 \leq 384$$
$$3x_1 + 2x_2 + 4x_3 \leq 288$$
$$x_3 = 30$$
$$x_1, x_2, x_3 \geq 0$$

Or

Maximize

$$Z = 8x_1 + 6x_2 + 5 \times 30$$

Subject to the Constraints:

$$4x_1 + 4x_2 + 6 \times 30 \leq 384$$

$$3x_1 + 2x_2 + 4 \times 30 \leq 288$$
$$x_1, x_2 \geq 0$$

Or

Maximize

$$Z = 8x_1 + 6x_2 + 150$$

Subject to the Constraints:

$$4x_1 + 4x_2 \leq 204$$
$$3x_1 + 2x_2 \leq 168$$
$$x_1, x_2 \geq 0$$

By introducing slack variables in the above constrains, we get:

Maximize

$$Z = 8x_1 + 6x_2 + 150 + 0s_1 + 0s_2$$

Subject to:

$$4x_1 + 4x_2 + s_1 = 204$$
$$3x_1 + 2x_2 + s_2 = 168$$
$$x_1, x_2, s_1, s_2 \geq 0$$

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			8	6	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2	
0	s_1	204	4	4	1	0	←51
0	s_2	168	3	2	0	1	56
		$Z_j = \sum C_{Bi}X_j$	0	0	0	0	
		$C_j - Z_j$	8↑	6	0	0	

SIMPLEX TABLEAU-II

$C_j \rightarrow$			8	6	0	0
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2
8	x_1	51	1	1	1/4	0
0	s_2	15	0	−1	−3/4	1
		$Z_j = \sum C_{Bi}X_j$	8	8	2	0
		$C_j - Z_j$	0	−2	−2	0

Since all numbers in the $C_j – Z_j$ row are either negative or zero, the optimum solution to the given problem has been obtained and is given by x_1 = 51 units, x_2 = 0 units and x_3 = 30 units (already given).

Maximum Contribution = ₹8 × 51 units + ₹6 × 0 units + ₹5 × 30 units = ₹558

(ii) Solution, Objective Function and The Constraints

'When a *non basic variable* in the final tableau (showing optimal solution) to a problem has a *net zero contribution* then optimal solution to given problem is not one but *multiple*'

and

Multiple optimal solutions can occur when the *objective function parallel to a constraint*.

In the above case x_2 and s_1 are non basic variables in the optimal table (Simplex Tableau-II) and have $C_j - Z_j \neq 0$. Hence, LPP has no multiple optimal solutions. Accordingly *objective function* is also not parallel to *constraint*.

☞

This problem can also be solve by taking **'Artificial Variable'** for Equation x_3 = 30.

Problem-22

A factory engaged in the manufacturing of pistons, rings and valves for which the profits per unit are ₹ 10, 6 and 4 respectively wants to decide the most profitable mix. It takes one hour of preparatory work, ten hours of machining and two hours of packing and allied formalities for a piston. Corresponding time requirements for rings and valves are 1, 4 & 2 and 1, 5 & 6 hours respectively. The total number of hours available for preparatory work, machining and packing & allied formalities are 100, 600 and 300 respectively.

Required

Determine the most profitable mix, assuming that all produced can be sold.

✍ **Solution**

Hours required in manufacturing:

Nature of Work	Pistons	Rings	Valves	Total Hours Available
	Hrs. per Unit	Hrs. per Unit	Hrs. per Unit	
Preparatory	1	1	1	100
Machining	10	4	5	600
Packing & Allied	2	2	6	300

Profit per unit		
Pistons	Rings	Valves
₹10	₹6	₹4

Let x_1, x_2 and x_3 be the required quantities of pistons, rings and valves manufactured and sold to maximize the profit of the factory.

Maximise

$$Z = 10x_1 + 6x_2 + 4x_3$$

Subject to the Constraints:

$$x_1 + x_2 + x_3 \leq 100$$
$$10x_1 + 4x_2 + 5x_3 \leq 600$$
$$2x_1 + 2x_2 + 6x_3 \leq 300$$

Also $x_1, x_2, x_3 \geq 0$

Introduced slack variables in the above constraints to convert them into equalities:

Maximise

$$Z = 10x_1 + 6x_2 + 4x_3 + 0s_1 + 0s_2 + 0s_3$$

Subject to:

$$x_1 + x_2 + x_3 + s_1 = 100$$
$$10x_1 + 4x_2 + 5x_3 + s_2 = 600$$
$$2x_1 + 2x_2 + 6x_3 + s_3 = 300$$

Here $x_1, x_2, x_3, s_1, s_2, s_3 \geq 0$

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			10	6	4	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	x_3	s_1	s_2	s_3	
0	s_1	100	1	1	1	1	0	0	100
0	s_2	600	**10**	4	5	0	1	0	← 60
0	s_3	300	2	2	6	0	0	1	150
		$Z_j = \sum C_{Bi}X_j$	0	0	0	0	0	0	
		$C_j - Z_j$	10↑	6	4	0	0	0	

SIMPLEX TABLEAU-II

$C_j \rightarrow$			10	6	4	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	x_3	s_1	s_2	s_3	
0	s_1	40	0	$\frac{3}{5}$	$\frac{1}{2}$	1	$-\frac{1}{10}$	0	66.66.. ←
10	x_1	60	1	$\frac{2}{5}$	$\frac{1}{2}$	0	$\frac{1}{10}$	0	150
0	s_3	180	0	$\frac{6}{5}$	5	0	$-\frac{1}{5}$	1	150
		$Z_j = \sum C_{Bi}X_j$	10	4	5	0	1	0	
		$C_j - Z_j$	0	2↑	−1	0	−1	0	

SIMPLEX TABLEAU-III

$C_j \rightarrow$			10	6	4	0	0	0
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	x_3	s_1	s_2	s_3
6	x_2	$\frac{200}{3}$	0	1	$\frac{5}{6}$	$\frac{5}{3}$	$-\frac{1}{6}$	0
10	x_1	$\frac{100}{3}$	1	0	$\frac{1}{6}$	$-\frac{2}{3}$	$\frac{1}{6}$	0
0	s_3	100	0	0	4	−2	0	1
		$Z_j = \sum C_{Bi}X_j$	10	6	$\frac{20}{3}$	$\frac{10}{3}$	$\frac{2}{3}$	0
		$C_j - Z_j$	0	0	$-\frac{8}{3}$	$-\frac{10}{3}$	$-\frac{2}{3}$	0

Since all numbers in the $C_j - Z_j$ row are either negative or zero, the optimum solution to the given problem has been obtained and is given by $x_1 = \frac{100}{3}$ units, $x_2 = \frac{200}{3}$ and $x_3 = 0$ units

Maximum Profit = ₹10 × $\frac{100}{3}$ units + ₹6 × $\frac{200}{3}$ units + ₹4 × 0 = 733.33

Hence the most profitable mix includes the manufacture and sale of $\frac{100}{3}$ Pistons and $\frac{200}{3}$ Rings. The maximum profit in this case is ₹ 733.33.

Problem-23

Three grades of coal A, B and C contains phosphorus and ash as impurities. In a particular industrial process, fuel up to 100 ton (maximum) is required which could contain ash not more than 3% and phosphorus not more than 0.03%. It is desired to maximize the profit while satisfying these conditions. There is an unlimited supply of each grade. The percentage of impurities and the profits of each grades are as follows:

Coal	*Phosphorus (%)*	*Ash (%)*	*Profit in ₹ (Per ton)*
A	*0.02*	*3.0*	*12.00*
B	*0.04*	*2.0*	*15.00*
C	*0.03*	*5.0*	*14.00*

Required

Formulate the Linear Programming (LP) model to solve it by using simplex method to determine optimal product mix and profit.

Solution

Let x_1, x_2 and x_3 respectively be the amounts in tons of grades A, B & C used. The constraints are:

(i) Phosphorus content must not exceed 0.03%

$$0.02x_1 + 0.04x_2 + 0.03x_3 \leq 0.03\,(x_1 + x_2 + x_3)$$

Or $$-x_1 + x_2 \leq 0$$

(ii) Ash content must not exceed 3%

$$3x_1 + 2x_2 + 5x_3 \leq 3\,(x_1 + x_2 + x_3)$$

Or $$-x_2 + 2x_3 \leq 0$$

(iii) Total quantity of fuel required is not more than 100 tons.

$$x_1 + x_2 + x_3 \leq 100$$

The Mathematical formulation of the problem is:

Maximize

$$Z = 12x_1 + 15x_2 + 14x_3$$

Subject to the Constraints:

$$-x_1 + x_2 \leq 0$$

$$-x_2 + 2x_3 \leq 0$$

$$x_1 + x_2 + x_3 \leq 100$$
$$x_1, x_2, x_3 \geq 0$$

Introducing Slack Variables s_1, s_2, s_3:

Maximize

$$Z = 12x_1 + 15x_2 + 14x_3 + 0s_1 + 0s_2 + 0s_3$$

Subject to:

$$-x_1 + x_2 + s_1 \leq 0$$
$$-x_2 + 2x_3 + s_2 \leq 0$$
$$x_1 + x_2 + x_3 + s_3 \leq 100$$
$$x_1, x_2, x_3, s_1, s_2, s_3 \geq 0$$

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			12	15	14	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	x_3	s_1	s_2	s_3	
0	s_1	0	−1	**1**	0	1	0	0	←0
0	s_2	0	0	−1	2	0	1	0	–
0	s_3	100	1	1	1	0	0	1	100
		$Z_j = \sum C_{Bi}X_j$	0	0	0	0	0	0	
		$C_j - Z_j$	12	15↑	14	0	0	0	

SIMPLEX TABLEAU-II

$C_j \rightarrow$			12	15	14	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	x_3	s_1	s_2	s_3	
15	x_2	0	−1	1	0	1	0	0	–
0	s_2	0	−1	0	2	1	1	0	–
0	s_3	100	**2**	0	1	−1	0	1	←50
		$Z_j = \sum C_{Bi}X_j$	−15	15	0	15	0	0	
		$C_j - Z_j$	27↑	0	14	−15	0	0	

SIMPLEX TABLEAU-III

$C_j \rightarrow$			12	15	14	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables $b(=X_B)$	x_1	x_2	x_3	s_1	s_2	s_3	
15	x_2	50	0	1	$\frac{1}{2}$	$\frac{1}{2}$	0	$\frac{1}{2}$	100
0	s_2	50	0	0	$\boldsymbol{\frac{5}{2}}$	$\frac{1}{2}$	1	$\frac{1}{2}$	←20
12	x_1	50	1	0	$\frac{1}{2}$	$-\frac{1}{2}$	0	$\frac{1}{2}$	100
		$Z_j = \sum C_{Bi}X_j$	12	15	$\frac{27}{2}$	$\frac{3}{2}$	0	$\frac{27}{2}$	
		$C_j - Z_j$	0	0	$\frac{1}{2}$ ↑	$-\frac{3}{2}$	0	$-\frac{27}{2}$	

SIMPLEX TABLEAU-IV

$C_j \rightarrow$			12	15	14	0	0	0
C_B	Basic Variable (B)	Value of Basic Variables $b(=X_B)$	x_1	x_2	x_3	s_1	s_2	s_3
15	x_2	40	0	1	0	$\frac{2}{5}$	$-\frac{1}{5}$	$\frac{2}{5}$
14	x_3	20	0	0	1	$\frac{1}{5}$	$\frac{2}{5}$	$\frac{1}{5}$
12	x_1	40	1	0	0	$-\frac{3}{5}$	$-\frac{1}{5}$	$\frac{2}{5}$
		$Z_j = \sum C_{Bi}X_j$	12	15	14	$\frac{8}{5}$	$\frac{1}{5}$	$\frac{68}{5}$
		$C_j - Z_j$	0	0	0	$-\frac{8}{5}$	$-\frac{1}{5}$	$-\frac{68}{5}$

Since all numbers in the $C_j - Z_j$ row are either negative or zero, the optimum solution to the given problem has been obtained. The optimum solution is $x_1 = 40$, $x_2 = 40$ and $x_3 = 20$ with maximum Z = ₹1,360.

Hence, the optimum product mix is 40 tons of grade A, 40 tons of grade B and 20 tons of grade C to get maximum profit of ₹ 1,360.

Problem-24

A gear manufacturing company makes two types of gears - A and B. Both gears are processed on 3 machines. Hobbing M/c, Shaping M/c and Grinding M/c. The time required by each gear and total time available per week on each M/c is as follows:

Machine	*Gear (A) (Hours)*	*Gear (B) (Hours)*	*Available Hours*
Hobbing M/c………..	*3*	*3*	*36*
Shaping M/c………..	*5*	*2*	*60*
Grinding M/c………..	*2*	*6*	*60*
Other Data:			
Selling Price (₹)……	*820*	*960*	
Variable Cost (₹)…..	*780*	*900*	

Required

Determine the optimum production plan and the maximum contribution for the next week by simplex method. The initial tables given below:

$C_j \rightarrow$			***40***	***60***	***0***	***0***	***0***
C_B	***Basic Variable (B)***	***Value of Basic Variables b(=X_B)***	***x_1***	***x_2***	***s_1***	***s_2***	***s_3***
0	*s_1*	*36*	*3*	*3*	*1*	*0*	*0*
0	*s_2*	*60*	*5*	*2*	*0*	*1*	*0*
0	*s_3*	*60*	*2*	*6*	*0*	*0*	*1*

Solution

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			**40**	**60**	**0**	**0**	**0**	**Min. Ratio**
C_B	**Basic Variable (B)**	**Value of Basic Variables b(=X_B)**	**x_1**	**x_2**	**s_1**	**s_2**	**s_3**	
0	s_1	36	3	3	1	0	0	12
0	s_2	60	5	2	0	1	0	30
0	s_3	60	2	**6**	0	0	1	←10
		$Z_j = \sum C_{Bi} X_j$	0	0	0	0	0	
		$C_j - Z_j$	40	60↑	0	0	0	

SIMPLEX TABLEAU-II

$C_j \rightarrow$			40	60	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2	s_3	
0	s_1	6	**2**	0	1	0	$-\frac{1}{2}$	←3
0	s_2	40	$\frac{13}{3}$	0	0	1	$-\frac{1}{3}$	$\frac{120}{13}$
60	x_2	10	$\frac{1}{3}$	1	0	0	$\frac{1}{6}$	30
		$Z_j = \sum C_{Bi}X_j$	20	60	0	0	10	
		$C_j - Z_j$	20↑	0	0	0	−10	

SIMPLEX TABLEAU-III

$C_j \rightarrow$			40	60	0	0	0
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2	s_3
40	x_1	3	1	0	$\frac{1}{2}$	0	$-\frac{1}{4}$
0	s_2	27	0	0	$-\frac{13}{6}$	1	$\frac{3}{4}$
60	x_2	9	0	1	$-\frac{1}{6}$	0	$\frac{1}{4}$
		$Z_j = \sum C_{Bi}X_j$	40	60	10	0	5
		$C_j - Z_j$	0	0	−10	0	− 5

Since all $C_j - Z_j$ are negative or zero, this is the optimum solution with, $x_1 = 3$ & $x_2 = 9$ and optimum Z = ₹660.

Problem-25

Maximize

$$Z = 62{,}000x_1 + 1{,}24{,}000x_2$$

Subject to the Constraints:

$$3x_1 + 4x_2 \leq 260$$
$$x_1 \geq 2$$
$$x_2 \geq 3$$
$$x_1, x_2 \geq 0$$

Required

Solve above linear programming problem by Simplex Method.

Solution

Introduced Slack, Surplus and Artificial Variables:

Maximize

$$Z = 62{,}000x_1 + 1{,}24{,}000x_2 + 0s_1 + 0s_2 + 0s_3 - MA_1 - MA_2$$

Subject to:

$$3x_1 + 4x_2 + s_1 = 260$$
$$x_1 - s_2 + A_1 = 2$$
$$x_2 - s_3 + A_2 = 3$$
$$x_1, x_2, s_1, s_2, s_3, A_1, A_2 \geq 0$$

We shall prepare the simplex tableau as follows:

SIMPLEX TABLEAU-I

$C_j \rightarrow$			**62,000**	**1,24,000**	**0**	**0**	**0**	**−M**	**−M**	**Min. Ratio**
C_B	**Basic Variable (B)**	**Value of Basic Variables b(=X_B)**	x_1	x_2	s_1	s_2	s_3	A_1	A_2	
0	s_1	260	3	4	1	0	0	0	0	65
−M	A_1	2	1	0	0	−1	0	1	0	−
−M	A_2	3	0	**1**	0	0	−1	0	1	←3
		$Z_j = \sum C_{Bi}X_j$	−M	−M	0	M	M	−M	−M	
		$C_j - Z_j$	62,000+M	1,24,000+M↑	0	−M	−M	0	0	

SIMPLEX TABLEAU-II

$C_j \rightarrow$			62,000	1,24,000	0	0	0	−M	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2	s_3	A_1	
0	s_1	248	3	0	1	0	4	0	82.66
−M	A_1	2	**1**	0	0	−1	0	1	← 2
1,24,000	x_2	3	0	1	0	0	−1	0	−
		$Z_j = \sum C_{Bi}X_j$	−M	1,24,000	0	M	−1,24,000	−M	
		$C_j - Z_j$	62,000+M↑	0	0	−M	1,24,000	0	

SIMPLEX TABLEAU-III

$C_j \rightarrow$			62,000	1,24,000	0	0	0	Min. Ratio
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2	s_3	
0	s_1	242	0	0	1	3	4	← 60.5
62,000	x_1	2	1	0	0	−1	0	−
1,24,000	x_2	3	0	1	0	0	−1	−
$Z_j = \sum C_{Bi}X_j$			62,000	1,24,000	0	− 62,000	−1,24,000	
$C_j - Z_j$			0	0	0	62,000	1,24,000↑	

SIMPLEX TABLEAU-IV

$C_j \rightarrow$			62,000	1,24,000	0	0	0
C_B	Basic Variable (B)	Value of Basic Variables b(=X_B)	x_1	x_2	s_1	s_2	s_3
0	s_3	60.5	0	0	$\frac{1}{4}$	$\frac{3}{4}$	1
62,000	x_1	2	1	0	0	-1	0

1,24,000	x_2	63.5	0	1	$\frac{1}{4}$	$\frac{3}{4}$	0
		$Z_j = \sum C_{Bi}X_j$	62,000	1,24,000	31,000	31,000	0
		$C_j - Z_j$	0	0	− 31,000	− 31,000	0

Since all entries in '$C_j - Z_j$' row are either zero or negative in table IV, the current solution is the optimum one and is given by:

x_1=2, x_2=63.5, Maximum Z= 79,98,000

Primal & Dual

Problem-26

Minimize

$$Z = 2x_1 - 3x_2 + 4x_3$$

Subject to the Constraints:

$$\begin{aligned} 3x_1 + 2x_2 + 4x_3 &\geq 9 \\ 2x_1 + 3x_2 + 2x_3 &\geq 5 \\ 7x_1 - 2x_2 - 4x_3 &\leq 10 \\ 6x_1 - 3x_2 + 4x_3 &\geq 4 \\ 2x_1 + 5x_2 - 3x_3 &= 3 \\ x_1, x_2, x_3 &\geq 0 \end{aligned}$$

Required

Find the dual problem for the above problem.

Solution

Primal:

Minimize

$$Z = 2x_1 - 3x_2 + 4x_3$$

Subject to the Constraints

$$\begin{aligned} 3x_1 + 2x_2 + 4x_3 &\geq 9 \\ 2x_1 + 3x_2 + 2x_3 &\geq 5 \\ -7x_1 + 2x_2 + 4x_3 &\geq -10 \end{aligned}$$

$$6x_1 - 3x_2 + 4x_3 \geq 4$$
$$2x_1 + 5x_2 - 3x_3 \geq 3$$
$$-2x_1 - 5x_2 + 3x_3 \geq -3$$
$$x_1, x_2, x_3 \geq 0$$

Dual:

Maximize

$$Z = 9y_1 + 5y_2 - 10y_3 + 4y_4 + 3y_5 - 3y_6$$

Subject to the Constraints:

$$3y_1 + 2y_2 - 7y_3 + 6y_4 + 2y_5 - 2y_6 \leq 2$$
$$2y_1 + 3y_2 + 2y_3 - 3y_4 + 5y_5 - 5y_6 \leq -3$$
$$4y_1 + 2y_2 + 4y_3 + 4y_4 - 3y_5 + 3y_6 \leq 4$$
$$y_1, y_2, y_3, y_4, y_5, y_6 \geq 0$$

By substituting $y_5 - y_6 = y_7$ the dual can alternatively be expressed as:

Maximize $Z = 9y_1 + 5y_2 - 10y_3 + 4y_4 + 3y_7$

Subject to the Constraints:

$$3y_1 + 2y_2 - 7y_3 + 6y_4 + 2y_7 \leq 2$$
$$-2y_1 - 3y_2 - 2y_3 + 3y_4 - 5y_7 \geq 3$$
$$4y_1 + 2y_2 + 4y_3 + 4y_4 - 3y_7 \leq 4$$
$$y_1, y_2, y_3, y_4 \geq 0,\ y_7 \text{ unrestricted in sign.}$$

Problem-27

Maximise

$$Z = 100x_1 + 90x_2 + 40x_3 + 60x_4$$

Subject to

$$6x_1 + 4x_2 + 8x_3 + 4x_4 \leq 140$$
$$10x_1 + 10x_2 + 2x_3 + 6x_4 \leq 120$$
$$10x_1 + 12x_2 + 6x_3 + 2x_4 \leq 50$$
$$x_1, x_2, x_3, x_4 \geq 0$$

Required

Formulate the dual for the above problem. Only formulation is required. Please do not solve.

Solution

Dual:

Minimize

$$Z = 140u_1 + 120u_2 + 50u_3$$

Subject to the Constraints:

$$6u_1 + 10u_2 + 10u_3 \geq 100$$
$$4u_1 + 10u_2 + 12u_3 \geq 90$$
$$8u_1 + 2u_2 + 6u_3 \geq 40$$
$$4u_1 + 6u_2 + 2u_3 \geq 60$$
$$u_1, u_2, u_3 \geq 0$$

SECTION - C

Simplex Method – Miscellaneous Concepts

(Slack/ Surplus Variable, Shadow Price, Feasible/ Alternate Solution/ Optimal Solution)

Problem-1

The following information is given relating to the simplex method of a linear program with the usual notations.

Objective function:

$$Z = x_1 + 5x_2 \quad \rightarrow (1)$$

Subject to:

$$6x_1 + 8x_2 \leq 12 \quad \rightarrow (2)$$
$$5x_1 + 15x_2 \geq 10 \quad \rightarrow (3)$$
$$x_1, x_2 \geq 10 \quad \rightarrow (4)$$

Let s_1 be the variable introduced to restate (2) as an equality and let s_2 and A_2 be variables to restate (3) as an equality.

Required

If the objective is to maximize Z,

(i) What will be the coefficients of s_1, s_2 and A_2 in equation (1) and (3) restated as equality?

(ii) Identify the slack and surplus variables.

(iii) Which variables will form part of the initial solution? Why?

(iv) If the objective is to minimize Z what will be your answer to (i) above?

Solution

(i) Working

Introducing Slack/ Surplus/ Artificial Variables

In Case of Maximization…

$$Z = x_1 + 5x_2 + 0s_1 + 0s_2 - MA_2 \quad \ldots (1)$$

Subject to:

$$6x_1 + 8x_2 + s_1 = 12 \quad \ldots (2)$$
$$5x_1 + 15x_2 - s_2 + A_2 = 10 \quad \ldots (3)$$
$$x_1, x_2, s_1, s_2, A_2 \geq 0 \quad \ldots (4)$$

For Equation (1)

Coefficients of $\mathbf{s_1}$, $\mathbf{s_2}$, and $\mathbf{A_2}$ are **0**, **0** and **– M** respectively.

For Equation (3)

Coefficients of $\mathbf{s_1}$, $\mathbf{s_2}$, and $\mathbf{A_2}$ are **0**, **–1** and **1** respectively.

(ii) $\mathbf{s_1}$ is **Slack Variable** and $\mathbf{s_2}$ is **Surplus Variable**.

(iii) In any Maximisation problem, this tableau must satisfy the following requirements:

- All the Slack Variables (and thus Surplus Variables as well) must form part of the initial solution mix (basis).
- The table must contain as many rows as there are constraints.
- The elements in the columns of variables appearing in the basis must form a unit vector.

If s_2 is included in the basis, the elements of the s_2 will be 0 and –1 and thus not a unit vector. This is contrary to the non-negativity restriction i.e. all variables must have a positive value. This problem is solved by adding an Artificial Variable (denoted by A_i) to the equation, that is, a variable that has a positive value. Artificial variables do not represent any quantity relating to the decision problem and must not be present in the final solution (if at all they do, it represents a situation of infeasibility). Accordingly, in the initial tableau we will place $\mathbf{A_2}$ along with $\mathbf{s_1}$ to eliminate the impact of them first.

(iv) Working

Introducing Slack/ Surplus/ Artificial Variables

In Case of Minimization…

$$Z = x_1 + 5x_2 + 0s_1 + 0s_2 + MA_2 \qquad \ldots (1)$$

Subject to:

$$6x_1 + 8x_2 + s_1 = 12 \qquad \ldots (2)$$

$$5x_1 + 15x_2 - s_2 + A_2 = 10 \qquad \ldots (3)$$

$$x_1, x_2, s_1, s_2, A_2 \geq 0 \qquad \ldots (4)$$

For Equation (1)

Coefficients of $\mathbf{s_1}$, $\mathbf{s_2}$, and $\mathbf{A_2}$ are **0**, **0** and **M** respectively.

For Equation (3)

Coefficients of $\mathbf{s_1}$, $\mathbf{s_2}$, and $\mathbf{A_2}$ are **0**, **–1** and **1** respectively.

Problem-2

Given below is an iteration in a simplex table for a maximization objective linear programming product mix problem for products X_1, X_2 and X_3.

C_j→			6	4	10	0	0	0
	Basic Variable	Quantity	X_1	X_2	X_3	S_1	S_2	S_3
0	S_1	400	0	4/3	0	1	-1/3	0
6	X_1	400	1	2/3	2	0	1/3	0
0	S_3	400	0	5/3	0	0	-2/3	1
Z_j		2,400	6	4	12	0	2	0
$C_j - Z_j$			0	0	-2	0	-2	0

Answer the following questions:

(i) Is the above solution feasible?

(ii) Perform one more iteration with X_2 entering the solution to get a solution with the same value for the objective function.

(iii) Indicate the shadow prices.

(iv) If customer is prepared to pay higher price for product X_3 then by how much should the price be increased so that the company's profit remains unchanged?

(v) From the given table, derive any one original constraint inequality with the coefficients of variables in their simplest whole number forms.

Solution

Workings

C_j→			6	4	10	0	0	0	Min. Ratio
C_B	Basic Variable	Quantity	X_1	X_2	X_3	S_1	S_2	S_3	
0	S_1	400	0	4/3	0	1	–1/3	0	300
6	X_1	400	1	2/3	2	0	1/3	0	600
0	S_3	400	0	5/3	0	0	–2/3	1	←240
		$Z_j = \sum C_{Bi}X_j$	6	4	12	0	2	0	
		$C_j - Z_j$	0	0↑	–2	0	–2	0	

(i) Yes, because the given solution has no artificial variables in the basic column.

(ii) Perform one more iteration with X_2:

$C_j \rightarrow$			6	4	10	0	0	0
C_B	Basic Variable	Quantity	X_1	X_2	X_3	S_1	S_2	S_3
0	S_1	80	0	0	0	1	1/5	–4/5
6	X_1	240	1	0	2	0	3/5	–2/5
4	X_2	240	0	1	0	0	–2/5	3/5
		$Z_j = \sum C_{Bi}X_j$	6	4	12	0	2	0
		$C_j - Z_j$	0	0	–2	0	–2	0

(iii) Shadow Price is ₹0, ₹2 and ₹0 (or any other given monetary unit) for Constraint 1, Constraint 2 and Constraint 3 respectively and same has been obtained from row $C_j - Z_j$.

(iv) $C_j - Z_j$ for X_3 being –2, production of each unit of X_3 would cause a reduction of ₹2 (or any other given monetary unit). Thus, the price for X_3 should be increased by at least two rupee *per unit* to ensure no reduction of profits.

(v) Original Constraint Inequality *with the coefficient of variables:*

Let us consider the given iteration is the 2nd one. The first iteration (I_1) must have had S_2 instead of X_1. Row X_1 of I_2 has been computed by dividing the S_2 row of I_1 by 3. S_2 of I_1 (in Identity Matrix) would have been 1. Now it is 1/3. Working backwards, we multiply row X_1 of I_2 by 3 to get Row S_2 of I_1.

Original Row S_2 [X_1 of I_2 × 3]:

$$(1X_1 + 2/3X_2 + 2X_3) \times 3 \quad \leq \quad 400 \times 3$$

Or

$$\mathbf{3X_1 + 2X_2 + 6X_3 \quad \leq \quad 1{,}200}$$

Similarly **Original Row S_1** [S_1 of I_2 + X_1 of I_2]:

$$(0X_1 + 4/3X_2 + 0X_3) + (1X_1 + 2/3X_2 + 2X_3) \quad \leq \quad 400 + 400$$

Or

$$\mathbf{X_1 + 2X_2 + 2X_3 \quad \leq \quad 800}$$

Similarly **Original Row S_3** [S_3 of I_2 + 2 × X_1 of I_2]:

$$0X_1 + 5/3X_2 + 0X_3 + (1X_1 + 2/3X_2 + 2X_3) \times 2 \quad \leq \quad 400 + 400 \times 2$$

Or

$$\mathbf{2X_1 + 3X_2 + 4X_3 \quad \leq \quad 1,200}$$

☞

> Original Constraint Inequality (with the coefficient of variables) can also be traced through algebraic method by solving through ***system of equations***.

Problem-3

Given below is an iteration in a simplex table for a maximization objective linear programming product mix problem for products x, y and z. Each of these products is processed in three machines KA-07, KB-27 & KC-49 and each machine has limited available hours.

C_j →			***30***	***40***	***20***	***0***	***0***	***0***
C_B	***Basic Variable (B)***	***Value of Basic Variables b (=X_B)***	***x***	***y***	***z***	***s_1***	***s_2***	***s_3***
30	*x*	*250*	*1*	*0*	*-26/16*	*10/16*	*-12/16*	*0*
40	*y*	*625*	*0*	*1*	*31/16*	*-7/16*	*10/16*	*0*
0	*s_3*	*125*	*0*	*0*	*11/16*	*-3/16*	*1/8*	*1*

s_1, s_2 and s_3 are slack variables for machine KA-07, KB-27 and KC-49 respectively.

Answer the following questions, giving reasons in brief:

(i) *Does the table above give an 'Optimal Solution'?*

(ii) *Are there more than one 'Optimal Solution' / 'Alternate Optimal Solution'?*

(iii) *Is this solution 'Feasible'?*

(iv) *Is this solution 'Degenerate'?*

(v) *Write down the 'Objective Function' of the problem.*

(vi) *Write the 'Optimal Product Mix' and 'Profit' shown by the above solution.*

(vii) *Which of these machines is being used to the full capacity when producing according to this solution?*

(viii) *How much would you be prepared to pay for another hour of capacity each on machine KA-07, machine KB-27, and machine KC-49?*

(ix) *If the company wishes to expand the production capacity, which of the three resources should be given priority?*

(x) *What happens if 16 machine hours are lost due to some mechanical problem in machine KB-27?*

(xi) *A customer would like to have one unit of product z and is willing to pay higher price for z in order to get it. How much should the price be increased so that the company's profit remains unchanged?*

(xii) *A new product is proposed to be introduced which would require processing time of 4 hours on machine KA-07, 2 hours on machine KB-27 and 4 hours on machine KC-49. It would yield a profit of ₹12 per unit. Do you think it is advisable to introduce this product?*

Solution

(i) Yes, the given solution is optimal because all $C_j - Z_j$ are less than, or equal to, zero.

$C_j \rightarrow$			**30**	**40**	**20**	**0**	**0**	**0**
C_B	**Basic Variable (B)**	**Value of Basic Variables b (=X_B)**	**x**	**y**	**z**	**s_1**	**s_2**	**s_3**
30	x	250	1	0	-26/16	10/16	-12/16	0
40	y	625	0	1	31/16	-7/16	10/16	0
0	s_3	125	0	0	11/16	-3/16	1/8	1
		$Z_j = \sum C_{Bi}X_j$	30	40	115/4	5/4	5/2	0
		$C_j - Z_j$	0	0	-35/4	-5/4	-5/2	0

(ii) No, because for each of the **non - basic variables** z, s_1 and s_2, the $C_j - Z_j$ is strictly negative. Alternate optimal solution (s) exist when either of non-basic variables has a zero $C_j - Z_j$.

Non Basic Variables	**z**	**s_1**	**s_2**
$C_j - Z_j$	-35/4	-5/4	-5/2

(iii) Yes, because the given solution has no artificial variable in the basis.

(iv) No, solution is not degenerate as none of the basic variables has zero quantity.

Basic Variables	**x**	**y**	**s_3**
Quantity	250	625	125

(A solution degenerates if the Quantity of one or more basic variables is zero)

(v) Maximize Z = 30x + 40y + 20z

(vi) According to the given solution, 250 units of x and 625 units of y are being produced. The total profit is ₹32,500 (250 units × ₹30 + 625 units × ₹40).

(vii) Machine KA-07 and KB-27 are being used to the full capacity because, the slack variable s_1 and s_2 corresponding to them has a zero value in the solution.

(viii) The shadow price of hours on machine KA-07, machine KB-27 and machine KC-49 are being ₹5/4, ₹5/2 and ₹0, respectively, these are the maximum prices one would be prepared to pay for another hour of capacity for these three machines.

(ix) Machine KB-27 may be given priority as its shadow price is the highest.

(x) When 16 hours are lost, then production of x would increase by 12 units and that of y would decrease by 10 units and the total profit decrease by ₹40.

(xi) $C_j - Z_j$ for z being -35/4, production of each unit of z would cause a reduction of 35/4 rupee. Thus, the price for z should be increased by at least 35/4 rupee to ensure no reduction of profits.

(xii) Shadow prices of times on machines KA-07, KB-27 and KC-49 are ₹5/4, ₹5/2 and ₹0. Production of a unit of the proposed new product would, therefore, reduce profit by ₹10 [(4 hrs. × ₹5/4) + (2 hrs. × ₹5/2) + (4 hrs. × ₹0)]. Since the product would yield a profit of ₹12, it would result in a net increase in profit at a rate of ₹2 per unit. It is advisable, therefore to introduce it.

11 The Transportation Problem

Basic Concepts

Alternate Solution	The Δ_{ij} matrix or $C_{ij} - (u_i + v_j)$ matrix, where C_{ij} is the cost matrix and $(u_i + v_j)$ is the cell evaluation matrix for unallocated cell. The Δ_{ij} matrix has one or more 'Zero' elements, indicating that, if that cell is brought into the solution, the optional cost will not change though the allocation changes. Thus, a 'Zero' element in the Δ_{ij} matrix reveals the possibility of an alternative solution.
Cell Evaluations	The allocations are m+n-1 in number and independent. For each allocated cell, cell value equals to $C_{ij} = u_i + v_j$ where u_i = row value; v_j = column value. One row where maximum allocation is made, u value is made zero and ui and vj for all rows and columns are calculated. For each unallocated cell, cell value equals to Cost of cell – $(u_i + v_j)$
Feasible Solution	A necessary and sufficient condition for the existence of a feasible solution to the transportation problem is that $$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$ Where a_i = quantity of product available at origin i b_j = quantity of product available at origin j In other words, the total capacity (or supply) must equal total requirement (or demand).
North - West Corner Rule	This method simply consists of making allocations to each row in turn, apportioning as much as possible to its first cell

	and proceeding in this manner to its following cells until the row total in exhausted.
Optimality Test	Once the initial basic feasible solution is done, we have to do the optimality test. If it satisfy the condition that number of allocation is equal to (m+n-1) where m= number of rows, n= number of columns. If allocation is less than (m+n-1), then the problem shows degenerate situation. In that case we have to allocate an infinitely small quantity (e) in least cost and independent cell.
Steps - North-West Corner Rule	Step-1: Before allocation ensure that the total of demand & supply of availability and requirement are equal. If not then make same equal by introducing dummy availability or requirement. Step-2: The first allocation is made in the cell occupying the upper left hand corner of the matrix. The assignment is made in such a way that either the resource availability is exhausted or the demand at the first destination is satisfied. Step-3(a): If the resource availability of the row one is exhausted first, we move down the second row and first column to make another allocation which either exhausts the resource availability of row two or satisfies the remaining destination demand of column one. Step-3(b): If the first allocation completely satisfies the destination demand of column one, we move to column two in row one, and make a second allocation which either exhausts the remaining resource availability of row one or satisfies the destination requirement under column two. Step-4: The above procedure is repeated until all the row availability and column requirements are satisfied.
Steps - The Least Cost Method	Step-1: Before starting the process of allocation ensure that the total of availability and demand is equal. The least cost method starts by making the first allocation in the cell whose shipping cost (or transportation cost) per unit is lowest. Step-2: This lowest cost cell is loaded or filled as much as possible in view of the origin capacity of its row and the destination requirements of its column. Step-3: We move to the next lowest cost cell and make an allocation in view of the remaining capacity and requirement of its row and column. In case there is a tie for the lowest cost cell during any allocation, we can exercise our judgment and we arbitrarily choose cell for allocation.

	Step-4: The above procedure is repeated till all row requirements are satisfied.
Steps - Vogel's Approximation Method (VAM)	Step-1: Before allocation ensure that the total of demand & supply of availability and requirement are equal. If not then make same equal by introducing dummy availability or requirement. Step-2: For each row of the transportation table identify the smallest and next smallest costs. Find the difference between the two costs and display it to the right of that row as "Difference" (Diff.). Likewise, find such a difference for each column and display it below that column. In case two cells contain the same least cost then the difference will be taken as 'zero'. Step-3: From amongst these row and column differences, select the one with the largest difference. Allocate the maximum possible to the least cost cell in the selected column or row. If there occurs a tie amongst the largest differences, the choice may be made for a row or column which has least cost. In case there is a tie in cost cell also, choice may be made for a row or column by which maximum requirement is exhausted. Match that column or row containing this cell whose totals have been exhausted so that this column or row is ignored in further consideration. Step-4: Re-compute the column and row differences for the reduced transportation table and go to step 2. Repeat the procedure until all the column and row totals are exhausted.
Transportation Problem	This type of problem deals with optimization of transportation cost in a distribution scenario involving 'm' factories (sources) to 'n' warehouses (destination) where cost of shipping from i^{th} factory to j^{th} warehouse is given and goods produced at different factories and requirement at different warehouses are given.
Prohibited Routes	Sometimes in a given transportation problem, some routes may not be available. There could be several reasons for this such as bad road conditions or strike etc. In such situations, there is a restriction on the route available for transportation. To handle such type of a situation, a very large cost (or a negative profit for the maximization problem) represented by ∞ or 'M' is assigned to each of such routes which are not available. Due to assignment of very large cost, such routes would automatically be eliminated in the final solution. The problem is the solved in its usual way.

SECTION - A

Transportation – Methods

Question-1

State the methods in which initial feasible solution can be arrived at in a transportation problem.

Answer

The methods by which initial feasible solution can be arrived at in a transportation model are as under:

(i) North-West Corner Method

(ii) Least Cost Method

(iii) Vogel's Approximation Method (VAM)

Question-2

Will the solution for a minimization problem obtained by Vogel's Approximation Method and Least Cost Method be the same? Why?

Answer

The initial solution need not be the same under both methods.

Vogel's Approximation Method (VAM) uses the differences between the minimum and the next minimum costs for each row and column. This is the penalty or opportunity cost of not utilising the next best alternative. The highest penalty is given the 1st preference. This need not be the lowest cost.

For example if a row has minimum cost as 2, and the next minimum as 3, penalty is 1; whereas if another row has minimum 4 and next minimum 6, penalty is 2, and this row is given preference. But Least Cost Method gives preference to the lowest cost cell, irrespective of the next cost. Solution obtained using Vogel's Approximation Method is more optimal than Least Cost Method.

Initial solution will be same only when the maximum penalty and the minimum cost coincide.

Question-3

Write a short note on *alternate solution in "transportation problem"*.

Answer

The Δ_{ij} matrix or C_{ij} – (u_i + v_j) matrix, where C_{ij} is the cost matrix and (u_i + v_j) is the cell evaluation matrix for unallocated cell. The Δ_{ij} matrix has one or more 'Zero' elements, indicating that, if that cell is brought into the solution, the optimum cost will not change though the allocation changes.

Thus, a 'Zero' element in the Δ_{ij} matrix reveals the possibility of an alternative solution.

Question-4

Explain the term degeneracy in a transportation problem.

Answer

A transportation problem's solution has m+n-1 basic variables, (where 'm' and 'n' are the number of rows and columns respectively) which means that the number of occupied cells in the initial basic solution are one less than the number of rows and number of columns.

When the number of occupied cells in a initial basic solution are less than m+n-1, the solution is called a degenerate solution.

Such a situation is handled by introducing an infinitesimally small allocation *'e'* in the least cost and independent cell.

If the number of occupied cells < m+n-1 by one, then only one *'e'* needs to be introduced. If the number of occupied cells is less by more than one, to the extent of shortage, *'e''s* will have to be introduced till the condition that number of occupied cells = m+n-1. For example if number of occupied cells in an initial basic solution are 7 and we have m+n-1 (= 9), then, we have to introduce two quantities of *'e'*, say e_1 and e_2 in two of the least cost independent cells.

Degeneracy occurs because in any particular allocation (earlier than the last allocation), the row and column totals get simultaneously fulfilled. (In the last allocation, it is always that row and column get fulfilled). Then, we have degeneracy by one number, i.e. number of occupied cells +1 equals m+n-1. We need to put one *'e'.* In the subsequent allocation, if again row and column totals get fulfilled simultaneously, again there will be a shortage of occupied cells and another *'e'* will be required.

SECTION - B

Minimization Problem

Problem-1

A product is manufactured by four factories A, B, C and D. The Unit production costs are ₹ 2, ₹ 3, ₹ 1 and ₹ 5 respectively. Their daily production capacities are 50, 70, 30 and 50 units respectively. These factories supply the product to four stores P, Q, R and S. The demand made by these stores are 25, 35, 105 and 20 Units transportation cost in rupees from each factory to each store is given in the following table;

Stores

Factories	*P*	*Q*	*R*	*S*
A	*2*	*4*	*6*	*11*
B	*10*	*8*	*7*	*5*
C	*13*	*3*	*9*	*12*
D	*4*	*6*	*8*	*3*

Required

Determine the extent of deliveries from each of the factories to each of the stores so that the total cost (production and transportation together) is minimum.

Solution

The new transportation costs table, which consists of both production and transportation costs, is given in following table.

Stores

Factories	P	Q	R	S	Supply
A	4 (2 + 2)	6 (4 + 2)	8 (6 + 2)	13 (11 + 2)	50
B	13 (10 + 3)	11 (8 + 3)	10 (7 + 3)	8 (5 + 3)	70
C	14 (13 + 1)	4 (3 + 1)	10 (9 + 1)	13 (12 + 1)	30
D	9 (4 + 5)	11 (6 + 5)	13 (8 + 5)	8 (3 + 5)	50
Demand	25	35	105	20	185 / 200

Since the total supply of 200 units exceeds the total demand of 185 units by 15 units of product, therefore a dummy destination (store) is added to absorb the excess supply. The associated cost coefficients in dummy store are taken as zero as the surplus quantity remains lying in the respective factories and is, in fact, not shipped at all. The modified table is given below. The problem now becomes a balanced transportation one and it is a minimization problem. We shall now apply Vogel's Approximation method to find an initial solution.

	P	Q	R	S	Dummy	Supply	Difference
A	4 [25]	6 [5]	8 [20]	13	0	50/25/20/0	4 2 2 2 5
B	13	11	10 [70]	8	0	70/0	8 2 2 2 2 2
C	14	4 [30]	10	13	0	30/0	4 6 - - - -
D	9	11	13 [15]	8 [20]	0 [15]	50/35/15/0	8 1 1 3 3 5
Demand	25/0	35/5/0	105/85/15/0	20/0	15/0	200	
Difference	5	2	2	0	0		
	5	2	2	0	-		
	5	5	2	0	-		
	-	5	2	0	-		
	-	-	2	0	-		

The initial solution is shown in above table. It can be seen that 15 units are allocated to dummy store from factory D. This means that the company may cut down the production by 15 units at the factory where it is uneconomical. We will now test the optimality of the solution. The total number of allocations is 8 which is equal to the required m+n-1 (=8) allocation. Introduce (u_i)'s, (v_j)'s, i= (1,2,- - - - -,4) and j= (1,2,- - - -,5), $\Delta_{ij} = C_{ij} - (u_i+v_j)$ for allocated cells. We assume that $u_4 = 0$ and remaining u_j's, v_j's and Δ_{ij}'s are calculated below-

$(u_i + v_j)$ Matrix for Allocated / Unallocated Cells

						u_i
	4	6	8	3	-5	–5
	6	8	10	5	-3	-3
	2	4	6	1	-7	-7
	9	11	13	8	0	0
v_j	9	11	13	8	0	

Note

($u_i + v_j$) matrix for allocated cells has been indicated in the shaded cells and the value of un-shaded cells represent ($u_i + v_j$) matrix for unallocated cells.

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

			10	5
7	3		3	3
12		4	12	7
0	0			

Since opportunity cost in all the unoccupied cells is positive, therefore initial solution is an optimal solution. The total cost (transportation and production together) associated with this solution is-

Factory	Store	Units	Cost (₹)	Value (₹)
A	P	25	4	100
A	Q	5	6	30
A	R	20	8	160
B	R	70	10	700
C	Q	30	4	120
D	R	15	13	195
D	S	20	8	160
D	Dummy	15	0	0
			Total Cost	1,465

Problem-2

A compressed Natural Gas (CNG) company has three plants producing gas and four outlets. The cost of transporting gas from different production plants to the outlets, production capacity of each plant and requirement at different outlets is shown in the following cost-matrix table:

Plants	*Outlets*				*Capacity of Production*
	A	***B***	***C***	***D***	
X	*4*	*6*	*8*	*6*	*700*
Y	*3*	*5*	*2*	*5*	*400*
Z	*3*	*9*	*6*	*5*	*600*
Requirement	*400*	*450*	*350*	*500*	*1,700*

The cost in the cost-matrix is given in thousand of rupees.

Required

Determine a transportation schedule so that the cost is minimized.

Solution

The given problem is a balanced minimization transportation problem. The objective of the company is to minimize the cost. Let us find the initial feasible solution using Vogel's Approximation method (VAM).

	A	B	C	D	Capacity	Difference
X	4	6 $\boxed{400}$	8	6 $\boxed{300}$	700/300/0	2 2 0 0
Y	3	5 $\boxed{50}$	2 $\boxed{350}$	5	400/50/0	1 2 0 0
Z	3 $\boxed{400}$	9	6	5 $\boxed{200}$	600/200/0	2 2 4 -
Req.	400/0	450/400/0	350/0	500/300/0	1,700	
Difference	0	1	4	0		
	0	1	-	0		
	-	1	-	0		
	-	1	-	1		

The initial feasible solution obtained by VAM is given below-

	A	B	C	D	Capacity
X	4	6 [400]	8	6 [300]	700
Y	3	5 [50]	2 [350]	5	400
Z	3 [400]	9	6	5 [200]	600
Req.	400	450	350	500	1,700

Since the number of allocations m+n-1 (= 6), let us test the above solution for optimality. Introduce u_i (i = 1, 2, 3) and v_j (j = 1, 2, 3, 4) such that $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for allocated cells. We assume $u_1 = 0$, and rest of the u_i's, v_j's and Δ_{ij}'s are calculated as below-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

					u_i
	4	6	3	6	0
	3	5	2	5	-1
	3	5	2	5	-1
v_j	4	6	3	6	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

0		5	
0			0
	4	4	

On calculating Δ_{ij}'s for non-allocated cells, we found that all the $\Delta_{ij} \geq 0$, hence the initial solution obtained above is optimal.

The optimal allocations are given below-

Plants	Outlet	Units	Cost (₹)	Total Cost (₹)
X	B	400	6	2,400
X	D	300	6	1,800
Y	B	50	5	250
Y	C	350	2	700
Z	A	400	3	1,200
Z	D	200	5	1,000
			Total	7,350

The minimum cost equals to 7,350 thousand rupees.

Since some of the Δ_{ij}'s are equal to 0, the above solution is not unique. Alternative solutions exist.

Problem-3

Consider the following data for the transportation problem:

Factory	***Destination***			***Supply to be exhausted***
	(1)	***(2)***	***(3)***	
A	*5*	*1*	*7*	*10*
B	*6*	*4*	*6*	*80*
C	*3*	*2*	*5*	*15*
Demand	*75*	*20*	*50*	

Since there is not enough supply, some of the demands at the three destinations may not be satisfied. For the unsatisfied demands, let the penalty costs be rupees 1, 2 and 3 for destinations (1), (2) and (3) respectively.

Required

Find the optimal allocation that minimizes the transportation and penalty costs.

Solution

The initial solution is obtained below by Vogel's Approximation method (VAM).

Since demand 145 (75 + 20 + 50) is greater than supply 105 (10 + 80 + 15) by 40 units, the given problem is an unbalanced one. We introduce a dummy factory with a supply of 40 units. It is given that for the unsatisfied demands, the penalty cost is rupees 1, 2, and 3 for destinations (1), (2) and (3) respectively. Hence, the transportation problem becomes-

Factory	Destination			Supply to be Exhausted
	(1)	(2)	(3)	
A	5	1	7	10
B	6	4	6	80
C	3	2	5	15
Dummy	1	2	3	40
Demand	75	20	50	145

	1	2	3	Supply	Difference
A	5	1 $\boxed{10}$	7	10/0	4 - -
B	6 $\boxed{20}$	4 $\boxed{10}$	6 $\boxed{50}$	80/70/50/0	2 2 2
C	3 $\boxed{15}$	2	5	15/0	1 1 1
Dummy	1 $\boxed{40}$	2	3	40/0	1 1 -
Demand	75/35/20/0	20/10/0	50/0	145	
Difference	2	1	2		
	2	0	2		
	3	2	1		

The initial solution is given in the table below-

	1	2	3	Supply
A	5	1 $\boxed{10}$	7	10
B	6 $\boxed{20}$	4 $\boxed{10}$	6 $\boxed{50}$	80
C	3 $\boxed{15}$	2	5	15
Dummy	1 $\boxed{40}$	2	3	40
Demand	75	20	50	145

The number of allocations is 6 which is equal to the required m + n - 1 (= 6) allocations. Also, these allocations are in dependent. Hence, both the conditions are satisfied.

We now apply the optimality test to find whether the initial solution found above is optimal or not.

Let us now introduce u_i [i = (1, 2, 3, 4)] and v_j [j = (1, 2, 3)] such that $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for allocated cells. We assume that $u_2 = 0$ and remaining u_i's, v_j's and Δ_{ij}'s are calculated as below-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

				u_i
	3	1	3	-3
	6	4	6	0
	3	1	3	-3
	1	-1	1	-5
v_j	6	4	6	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

2		4
	1	2
	3	2

Since all Δ_{ij}'s for non basic cells are positive, therefore, the solution obtained above is an optimal one. The allocation of factories to destinations and their cost is given below-

Factory	Destination	Units	Cost (₹)	Total Cost (₹)	Type
A	(2)	10	1	10	Transportation Cost
B	(1)	20	6	120	
B	(2)	10	4	40	
B	(3)	50	6	300	
C	(1)	15	3	45	
Dummy	(1)	40	1	40	Penalty Cost
			Total	555	

Problem-4

The initial allocation of a transportation problem, along with the unit cost of transportation from each origin to destination is given below.

						Requirement
	11	2 $\boxed{8}$	8	6 $\boxed{6}$	2 $\boxed{4}$	18
	9 $\boxed{10}$	9	12	9	6	10
	7	6	3 $\boxed{8}$	7	7	8
	9 $\boxed{2}$	3	5	6 $\boxed{2}$	11	4
Availability	12	8	8	8	4	40

Required

Arrive at the minimum transportation cost by the Vogel's Approximation method and check for optimality. (Hint: Students may consider u1 = 0 at Row 1 for initial cell evaluation)

Solution

The concept tested in this problem is Degeneracy with respect to the transportation problem. Total of rows and columns = 9 (4 + 5). Hence, the number of allocations should be 8 (i.e. 9 -1). As the actual number of allocation is 7, an infinitely small quantity 'e' allocation is called for. To resolve this, an independent cell with least cost should be chosen. R_4C_2 has the least cost (cost = 3), but this is not independent. The next least cost cell R_4C_3 (cost = 5) is independent.

						Requirement
	11	2 $\boxed{8}$	8	6 $\boxed{6}$	2 $\boxed{4}$	18
	9 $\boxed{10}$	9	12	9	6	10
	7	6	3 $\boxed{8}$	7	7	8
	9 $\boxed{2}$	3	5 $\boxed{e}$	6 $\boxed{2}$	11	4
Availability	12	8	8	8	4	40

Now total number of allocations become equal to m + n -1 i.e. 8. This solution is tested for optimality.

(u_i + v_j) Matrix for Allocated / Unallocated Cells

						u_i
	9	2	5	6	2	0
	9	2	5	6	2	0
	7	0	3	4	0	-2
	9	2	5	6	2	0
v_j	9	2	5	6	2	

Δ_{ij} Matrix

2		3		
	7	7	3	4
0	6		3	7
	1			9

Since all the evaluation are 0 or +ve, the optimal solution is obtained. Since, in the above matrix cell R_3C_1 has zero value hence, alternative solution is possible.

The optimal allocation and cost is as follows:

Allocations	Units	Cost per unit (₹)	Total Cost (₹)
R_1C_2	8	2	16
R_1C_4	6	6	36
R_1C_5	4	2	8
R_2C_1	10	9	90
R_3C_3	8	3	24
R_4C_1	2	9	18
R_4C_3	e	5	0
R_4C_4	2	6	12
		Total	204

Problem-5

Goods manufactured at 3 plants, A, B and C are required to be transported to sales outlets X, Y and Z. The unit costs of transporting the goods from the plants to the outlets are given below-

Plants / *Sales Outlets*	*A*	*B*	*C*	*Total Demand*
X	*3*	*9*	*6*	*20*
Y	*4*	*4*	*6*	*40*
Z	*8*	*3*	*5*	*60*
Total Supply	*40*	*50*	*30*	*120*

Required

(i) *Compute the initial allocation by North-West Corner Rule.*

(ii) *Compute the initial allocation by Vogel's approximation method and check whether it is optimal.*

(iii) *State your analysis on the optimality of allocation under North-West corner Rule and Vogel's Approximation method.*

Solution

The given transportation problem is a balanced minimization transportation problem. Let us find the initial basic feasible solution using the following methods:

(i) North-West Corner Method

	A	**B**	**C**	Demand
X	3 [20]	9	6	20/0
Y	4 [20]	4 [20]	6	40/20/0
Z	8	3 [30]	5 [30]	60/30/0
Supply	40/20/0	50/30/0	30/0	120

Since, initial solution obtained is equal to m + n -1 i.e. 5. Now we test this initial solution for optimality as under-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

				u_i
	3	3	5	0
	4	4	6	1
	3	3	5	0
v_j	3	3	5	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

	6	1
		0
5		

Since, all the values in the above Δ_{ij} Matrix is ≥ 0, hence, the above allocation is optimal. However, an alternative solution is also possible.

Units	Cost per unit (₹)	Total Cost (₹)
20	3	60
20	4	80
20	4	80
30	3	90
30	5	150
	Total	460

(ii) Initial Solution by VAM

	A	B	C	Supply	Difference
X	3 [20]	9	6	20/0	3 - -
Y	4 [20]	4	6 [20]	40/20/0	0 0 2
Z	8	3 [50]	5 [10]	60/10/0	2 2 2
Demand	40/20/0	50/0	30/20/0	120	

Difference	1	1	1
	4	1	1
	-	1	1

Since, initial solution obtained is equal to m + n -1 i.e. 5. Now we test this initial solution for optimality as under-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

				u_i
	3	3	5	0
	4	4	6	1
	3	3	5	0
v_j	3	3	5	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

	6	1
	0	
5		

Since, all the values in the above Δ_{ij} Matrix is ≥ 0, hence, the above allocation is optimal. However, an alternative solution is also possible.

Units	Cost per unit (₹)	Total Cost (₹)
20	3	60
20	4	80
50	3	150
20	6	120
10	5	50
	Total	460

(iii)

The both solutions obtained from North-West Corner method and Vogel's Approximation method is optimal. Under North-West Corner method the allocation at cell R2C3 can alternatively allocated to cell R2C2. Under VAM method also the allocation at cell R2C2 can be allocated to cell R2C3. The both method has the same optimal solution and total cost.

Problem-6

The following table gives the unit transportation costs and the quantities demanded/supplied at different locations for a minimization problem:

Supply \ *Demand*	C_1	C_2	C_3	C_4	*Total Units*
R_1	*100*	*120*	*200*	*110*	*20,000*
R_2	*160*	*80*	*140*	*120*	*38,000*
R_3	*180*	*140*	*60*	*100*	*16,000*
Total Units	*10,000*	*18,000*	*22,000*	*24,000*	

Required

Find out which cell gets the 3rd allocation in the initial basic feasible solution under each of the following methods and to give the cell reference, cost per unit of that cell and the quantity allocated to that cell :

(i) North West Corner Rule

(ii) Vogel's Approximation Method

(iii) Least Cost Method

Solution

Sl. No	Method	Cell Reference	Cost / unit	Quantity
		I	II	III
(i)	North West Corner Rule (W.N.-1)	R_2 C_2	80	8,000
(ii)	Vogel's Method (W.N.-2)	R_2 C_3 or R_1 C_1	140 100	6,000 10,000
(iii)	Least Cost Method (W.N.-3)	R_1 C_1	100	10,000

Working Notes

W.N.-1

North-West Corner Rule-

Units in '000

Supply	**Demand**				Total Units
	C_1	**C_2**	**C_3**	**C_4**	
R_1	100 $\boxed{10}$	120 $\boxed{10}$	200	110	20/10/0
R_2	160	**80** $\boxed{8}$	140	120	38/30
R_3	180	140	60	100	16
Total Units	10/0	18/8/0	22	24	

Allocation	Cell	Cost per unit	Demand	Supply	Allocation
1st	R_1C_1	100	20,000	10,000	10,000
2nd	R_1C_2	120	10,000	18,000	10,000
3rd	**R_2C_2**	**80**	38,000	8,000	**8,000**

W.N.-2

Vogel's Approximation Method-

Units in '000

Supply	**Demand**				Total Units	Difference
	C_1	**C_2**	**C_3**	**C_4**		
R_1	100 $\boxed{10}$	120	200	110	20/10	10 10 10
R_2	160	80	**140** $\boxed{6}$	120	38/32	40 40 40
R_3	180	140	60 $\boxed{16}$	100	16/0	40 - -

Total Units	10/0	18	22/6/0	24
Difference	60	40	80	10
	60	40	60	10
	-	40	**60**	10

Allocation	Cell	Cost per unit	Demand	Supply	Allocation
1st	R_3C_3	60	16,000	22,000	16,000
2nd	R_1C_1	100	20,000	10,000	10,000
3rd	**R_2C_3**	**140**	38,000	6,000	**6,000**

Or

Units in '000

Supply	Demand				Total Units	Difference
	C_1	**C_2**	**C_3**	**C_4**		
R_1	**100** [**10**]	120	200	110	20/10	10 10 10
R_2	160	80	140 [6]	120	38/32	40 40 40
R_3	180	140	60 [16]	100	16/0	40 - -
Total Units	10/0	18	22/6/0	24		
Difference	60	40	80	10		
	60	40	60	10		
	60	40	-	10		

Allocation	Cell	Cost per unit	Demand	Supply	Allocation
1st	R_3C_3	60	16,000	22,000	16,000
2nd	R_2C_3	140	38,000	6,000	6,000
3rd	**R_1C_1**	**100**	20,000	10,000	**10,000**

W.N.-3

Least Cost Method-

Units in '000

Supply	Demand				Total Units
	C_1	C_2	C_3	C_4	
R_1	**100** $\boxed{10}$	120	200	110	20/10
R_2	160	80 $\boxed{18}$	140	120	38/20
R_3	180	140	60	100	16/0
Total Units	10/0	18/0	22	24	

Allocation	Cell	Cost per unit	Demand	Supply	Allocation
1st	R_3C_3	60	16,000	22,000	16,000
2nd	R_2C_2	80	38,000	18,000	18,000
3rd	**R_1C_1**	**100**	20,000	10,000	**10,000**

Problem-7

Four student A, B, C and D were asked to work out the initial solution of the following matrix showing unit transportation costs from plants to sales outlets, with a minimization objective and unbalanced quantities of supply and demand. A introduced a dummy row D on top (above S_1 position), while others introduced the dummy row D at the bottom (below S_3 position). A and B were asked to do the North West Corner Rule, while C did Least Cost Method and D did Vogel's method.

Plants / ***Sales outlets***	***P_1***	***P_2***	***P_3***	***Demand***
S_1	*9*	*27*	*18*	*80*
S_2	*12*	*12*	*18*	*120*
S_3	*24*	*10*	*15*	*140*
Supply	*120*	*150*	*90*	

Using the usual notation of cell reference (e.g. S_2 P_3 refers to the cell at the intersection of the S_2 row and P_3 column), what would be the 3rd allocation step in the initial allocation by each student?

Required

Advised to use the following format for your answers.

Student	*Allocation Details at Step III*		
	Cell Reference	*Quantity Allocated units)*	*Unit Cost at that cell*
A			
B			
C			
D			

Solution

Allocation Details at Step III

Student	Cell Reference	Quantity Allocated (units)	Unit Cost at that Cell (₹)
A	S_2P_1	20	12
B	S_2P_2	80	12
C	S_3P_2	130 *Or* 140	10
D	S_2P_1	40	12

Workings

Initial Allocation by Student 'A' (North-West Corner Rule) ---

	P_1	P_2	P_3	Demand
Dummy	0 $\boxed{20}$	0	0	20/0
S_1	9 $\boxed{80}$	27	18	80/0
S_2	12 $\boxed{20}$	12	18	120/100
S_3	24	10	15	140
Supply	120/100/20/0	150	90	360

1st Allocation → **Dummy, P_1 → 20 units**

2nd Allocation → **S_1P_1 → 80 units**

3rd Allocation → **S_2P_1 → 20 units**

Initial Allocation by Student 'B' (North-West Corner Rule) ---

	P_1	**P_2**	**P_3**	Demand
S_1	9 $\boxed{80}$	27	18	80/0
S_2	12 $\boxed{40}$	12 $\boxed{80}$	18	120/80/0
S_3	24	10	15	140
Dummy	0	0	0	20
Supply	120/40/0	150/70	90	360

1st Allocation → **S_1P_1 → 80 units**

2nd Allocation → **S_2P_1 → 40 units**

3rd Allocation → **S_2P_2 → 80 units**

Initial Allocation by Student 'C' (Least Cost Method) ---

	P_1	**P_2**	**P_3**	Demand
S_1	9 $\boxed{80}$	27	18	80/0
S_2	12	12	18	120
S_3	24	10 $\boxed{130}$	15	140/10
Dummy	0	0 $\boxed{20}$	0	20/0
Supply	120/40	150/130/0	90	360

1st Allocation → **Dummy, P_2 → 20 units**

2nd Allocation → **S_1P_1 → 80 units**

3rd Allocation → **S_3P_2 → 130 units**

Or

	P_1	P_2	P_3	Demand
S_1	9 $\boxed{80}$	27	18	80/0
S_2	12	12	18	120
S_3	24	10 $\boxed{140}$	15	140/0
Dummy	0 $\boxed{20}$	0	0	20/0
Supply	120/100/20	150/10	90	360

1st Allocation → **Dummy, P_1 → 20 units**

2nd Allocation → **S_1P_1 → 80 units**

3rd Allocation → **S_3P_2 → 140 units**

Or

	P_1	P_2	P_3	Demand
S_1	9 $\boxed{80}$	27	18	80/0
S_2	12	12	18	120
S_3	24	10 $\boxed{140}$	15	140/0
Dummy	0	0	0 $\boxed{20}$	20/0
Supply	120/40	150/10	90/70	360

1st Allocation → **Dummy, P_3 → 20 units**

2rd Allocation → **S_1P_1 → 80 units**

3nd Allocation → **S_3P_2 → 140 units**

Initial Allocation by student 'D' (Vogel's Method) ---

	P_1	P_2	P_3	Demand	Difference
S_1	9 $\boxed{80}$	27	18	80/0	9 9 -
S_2	12 $\boxed{40}$	12	18	120/80	0 0 0
S_3	24	10	15	140	5 5 5
Dummy	0	0	0 $\boxed{20}$	20/0	0 - -
Supply	120/40/0	150	90/70	360	
Difference	9	10	15		
	3	2	3		
	12	2	3		

1st Allocation → **Dummy, P_3 → 20 units**

2nd Allocation → **S_1P_1 → 80 units**

3rd Allocation → **S_2P_1 → 40 units**

Maximization Problem

Problem-8

The unit profit matrix based on four factories and three sales depots of a company and unbalanced quantities of demand and supply are tabulated below: The main object of the company is to maximize profit. Assume that there is no profit in case of surplus production.

Factories	*Sales Depots*			*Supply (Nos.)*
	S1	*S2*	*S3*	
F1	*6*	*6*	*1*	*10*
F2	*-2*	*-2*	*-4*	*150*
F3	*3*	*2*	*2*	*50*
F4	*8*	*5*	*3*	*100*
Demand (Nos.)	*80*	*120*	*150*	

Required

Formulate the above as a usual transportation minimization problem and find the initial solution by using Vogel's Approximation Method (VAM).

Solution

Since, Demand and Supply for the product is not equal, hence, it should be made equal by introducing *dummy row* with a supply of 40 units. The matrix will be as follows-

	S_1	S_2	S_3	Supply
F1	6	6	1	10
F2	–2	–2	–4	150
F3	3	2	2	50
F4	8	5	3	100
Dummy	0	0	0	40
Demand	80	120	150	350

To make the above matrix into a *minimization* matrix, all the cell value shall be deducted the highest cell value i.e. 8. The minimized transportation matrix will be as follows-

	S_1	S_2	S_3	Supply
F1	2	2	7	10
F2	10	10	12	150
F3	5	6	6	50
F4	0	3	5	100
Dummy	8	8	8	40
Demand	80	120	150	350

The Initial solution by Vogel's Approximation Method (VAM)-

	S_1	S_2	S_3	Supply	Diff.
F1	2	2 $\boxed{10}$	7	10/0	0 5 - - -
F2	10	10 $\boxed{90}$	12 $\boxed{60}$	150/60/0	0 2 2 2 2
F3	5	6	6 $\boxed{50}$	50/0	1 0 0 0 -
F4	0 $\boxed{80}$	3 $\boxed{20}$	5	100/20/0	3 2 2 - -
Dummy	8	8	8 $\boxed{40}$	40/0	0 0 0 0 0

Demand	80/0	120/110/90/0	150/100/60/0	350
Diff.	2	1	1	
	-	1	1	
	-	3	1	
	-	2	2	
	-	2	4	

Alternative Solution to Initial Solution by VAM

	S1	S2	S3	Supply	Diff.
F1	2	2 [10]	7	10/0	0 5 - - -
F2	10	10 [40]	12 [110]	150/110/0	0 2 2 2 2
F3	5	6 [50]	6	50/0	1 0 0 0 -
F4	0 [80]	3 [20]	5	100/20/0	3 2 2 - -
Dummy	8	8	8 [40]	40/0	0 0 0 0 0
Demand	80/0	120/110/90/40/0	150/110/0	350	
Diff.	2	1	1		
	-	1	1		
	-	3	1		
	-	2	2		
	-	2	4		

☞

The above solution can also be solved by making the profit matrix into loss in first step and then introduction of dummy row, the initial solution under VAM will be same.

Problem-9

Following is the profit matrix based on four factories and three sales depots of the company:

Factory	*Sales Depot*			*Availability*
	S_1	*S_2*	*S_3*	
F_1	*6*	*6*	*1*	*10*
F_2	*-2*	*-2*	*-4*	*150*
F_3	*3*	*2*	*2*	*50*
F_4	*8*	*5*	*3*	*100*
Requirement	*80*	*120*	*150*	*350 / 310*

Required

Determine the most profitable distribution schedule and the corresponding profit, assuming no profit in case of surplus production.

Solution

The given transportation problem is an unbalanced one and it is a maximisation problem. As a first step, we will balance this transportation problem, by adding a dummy factory, assuming no profit in case of surplus production.

Factory	**Sales Depot**			Availability
	S_1	**S_2**	**S_3**	
F_1	6	6	1	10
F_2	-2	-2	-4	150
F_3	3	2	2	50
F_4	8	5	3	100
Dummy	0	0	0	40
Requirement	80	120	150	350 / 350

We shall now convert the above transportation problem (a profit matrix) into a loss matrix by subtracting all the elements from the highest value in the table i.e. 8. Therefore, we shall apply the VAM to find initial solution.

Factory	Sales Depot			Availability	Difference
	S_1	S_2	S_3		
F_1	2	2 [10]	7	10/0	0 5 - - -
F_2	10	10 [90]	12 [60]	150/60/0	0 2 2 2 2
F_3	5	6	6 [50]	50/0	1 0 0 0 0
F_4	0 [80]	3 [20]	5	100/20/0	3 2 2 - -
Dummy	8	8	8 [40]	40/0	0 0 0 0 -
Demand	80/0	120/110/90/0	150/110/60/0	350/350	
Difference	2	1	1		
	-	1	1		
	-	3	1		
	-	2	2		
	-	2	4		

Since, number of allocation is equal to 7 which is equal to m + n -1. We will test the optimality of the above initial solution.

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

				u_i
	-1	2	4	4
	7	10	12	12
	1	4	6	6
	0	3	5	5
	3	6	8	8
v_j	-5	-2	0	

Now we calculate $\Delta_{ij} = C_{ij} – (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

3		3
3		
4	2	
		0
5	2	

Since all Δ_{ij} 's for non basic cells are positive, the solution as calculated in the above table is optimal solution. The distribution schedule from factories to sales depots along with profit is given below-

Factory	Sales Depot	Units	Profit per unit (₹)	Total Profit (₹)
F_1	S_2	10	6	60
F_2	S_2	90	-2	-180
F_2	S_3	60	-4	-240
F_3	S_3	50	2	100
F_4	S_1	80	8	640
F_4	S_2	20	5	100
			Total	480

Problem-10

A leading firm has three auditors. Each auditor can work up to 160 hours during the next month, during which time three projects must be completed. Project 1 will take 130 hours, Project 2 will take 140 hours, the Project 3 will take 160 hours. The amount per hour that can be billed for assigning each auditor to each project is given in Table 1:

Table 1

Auditor	*Project*		
	1	*2*	*3*
	(₹)	*(₹)*	*(₹)*
A	*1,200*	*1,500*	*1,900*
B	*1,400*	*1,300*	*1,200*
C	*1,600*	*1,400*	*1,500*

Required

Formulate this as a transportation problem and find the optimal solution. Also find out the maximum total billings during the next month.

Solution

The given information can be tabulated in following transportation problem-

	1	2	3	Time Available (Hrs.)
A	1,200	1,500	1,900	160
B	1,400	1,300	1,200	160
C	1,600	1,400	1,500	160
Time Required	130	140	160	430/480

The given problem is an unbalanced transportation problem. Introducing a dummy project to balance it, we get-

	1	2	3	Dummy	Time Available (Hrs.)
A	1,200	1,500	1,900	0	160
B	1,400	1,300	1,200	0	160
C	1,600	1,400	1,500	0	160
Time Required	130	140	160	50	480/480

The objective here is to maximize total billing amount of the auditors. For achieving this objective, let us convert this maximization problem into a minimization problem by subtracting all the elements of the above payoff matrix from the highest payoff i.e. ₹ 1,900.

	1	2	3	Dummy	Time Available (Hrs.)
A	700	400	0	1,900	160
B	500	600	700	1,900	160
C	300	500	400	1,900	160
Time Required	130	140	160	50	480/480

Now, let us apply Vogel's Approximation Method to the above matrix for finding the initial feasible solution.

Figures in ₹'00

	1	2	3	Dummy	Time Available	Difference
A	7	4	0 [160]	19	160/0	4 - - -
B	5	6 [110]	7	19 [50]	160/50/0	1 1 13 13
C	3 [130]	5 [30]	4	19	160/30/0	1 2 14 -
Time Req.	130/0	140/110/0	160/0	50/0	480/480	
Difference	2	1	4	0		
	2	1	-	0		
	-	1	-	0		
	-	1	-	0		

The initial solution is given below. It can be seen that it is a degenerate solution since the number of allocation is 5. In order to apply optimality test, the total number of allocations should be 6 (= m + n -1). To make the initial solution a non-degenerate, we introduce a very small quantity in the least cost independent cell which is cell R_3C_3.

Figures in ₹'00

	1	2	3	Dummy	Time Available
A	7	4	0 [160]	19	160/0
B	5	6 [110]	7	19 [50]	160/50/0
C	3 [130]	5 [30]	4 [e]	19	160/30/0
Time Req.	130/0	140/110/0	160/0	50/0	

Introduce u_i's and v_j's such that $\Delta_{ij} = C_{ij} – (u_i + v_j)$ (for i = 1 to 3; j = 1,2,3, Dummy). To determine the values of u_i's and v_j's we assume that $u_3 = 0$, values of other variables i.e. u_i's and v_j's are calculated as follows-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

					u_i
	-1	1	0	14	-4
	4	6	5	19	1
	3	5	4	18	0
v_j	3	5	4	18	

Δ_{ij} Matrix

8	3		5
1		2	
			1

Since all Δ_{ij} cells value are positive, therefore the initial solution obtained above is optimal. The allocation of projects to auditors and their billing amount is given below-

Auditor	Project	Working Hours	Rate *per hour* (₹)	Billing Amount (₹)
A	3	160	1,900	3,04,000
B	2	110	1,300	1,43,000
C	1	130	1,600	2,08,000
C	2	30	1,400	42,000
			Total Billing	6,97,000

Hence, the maximum total billing during the next month will be ₹6,97,000/-

Problem-11

SBC Partners a leading CA firm has three managers. Each manager can work up to 176 hours during the next month, during which time three assignments must be completed. Transfer Pricing Assignment will take 143 hours, Corporate Valuation will take 154 hours, and Statutory Audit will take 176 hours. The amount per hour that can be billed for assigning each manager to each assignment is given below:

Manager	*Assignment*		
	Transfer Pricing (₹)	*Corporate Valuation (₹)*	*Statutory Audit (₹)*
S	*1,800*	*2,250*	*2,850*
D	*2,100*	*1,950*	*1,800*
K	*2,400*	*2,100*	*2,250*

Required

Formulate this as a transportation problem and find the optimal solution. Also find out the maximum total billings during the next month.

Note: A manager may be involved in more than one assignment.

Solution

The given information can be tabulated in following transportation problem-

Manager	Assignment			Time Available (Hours)
	Transfer Pricing (₹)	Corporate Valuation (₹)	Statutory Audit (₹)	
S	1,800	2,250	2,850	176
D	2,100	1,950	1,800	176
K	2,400	2,100	2,250	176
Time Required (Hours)	143	154	176	

The given problem is an unbalanced transportation problem. Introducing a dummy assignment to balance it, we get-

Manager	Assignment				Time Available (Hours)
	Transfer Pricing (₹)	Corporate Valuation (₹)	Statutory Audit (₹)	Dummy (₹)	
S	1,800	2,250	2,850	0	176
D	2,100	1,950	1,800	0	176
K	2,400	2,100	2,250	0	176
Time Required (Hours)	143	154	176	55	528

The objective here is to maximize total billing amount of the auditors. For achieving this objective, let us convert this maximization problem into a minimization problem by subtracting all the elements of the above payoff matrix from the highest payoff i.e. ₹2,850.

Manager	Assignment				Time Available (Hours)
	Transfer Pricing (₹)	Corporate Valuation (₹)	Statutory Audit (₹)	Dummy (₹)	
S	1,050	600	0	2,850	176
D	750	900	1,050	2,850	176
K	450	750	600	2,850	176
Time Required (Hours)	143	154	176	55	528

Now, let us apply VAM method to the above matrix for finding the initial feasible solution.

Manager	Assignment				Time Avail. (Hours)	Difference
	Transfer Pricing (₹)	Corp. Valuation (₹)	Stat. Audit (₹)	Dummy (₹)		
S	1,050	600	0 $\boxed{176}$	2,850	176/0	600 - -
D	750	900 $\boxed{121}$	1,050	2,850 $\boxed{55}$	176/55/0	150, 150 1,950
K	450 $\boxed{143}$	750 $\boxed{33}$	600	2,850	176/33/0	150, 300, 2,100
Time Required	143/0	154/121/0	176/0	55/0	528	
Difference	300 300 -	150 150 150	600 -- -	0 0 0		

The initial solution is given below. It can be seen that it is a degenerate solution since the number of allocation is 5. In order to apply optimality test, the total number of allocations should be 6 (m + n -1). To make the initial solution a non-degenerate, we introduce a very small quantity in the least cost independent cell which is cell of K, Statutory Audit.

Manager	Assignment			
	Transfer Pricing (₹)	Corp. Valuation (₹)	Stat. Audit (₹)	Dummy (₹)
S	1,050	600	0 $\boxed{176}$	2,850
D	750	900 $\boxed{121}$	1,050	2,850 $\boxed{55}$
K	450 $\boxed{143}$	750 $\boxed{33}$	600 $\boxed{e}$	2,850

Let us test the above solution for optimality-

(u_i + v_j) Matrix for Allocated / Unallocated Cells

					u_i
	-150	150	0	2,100	-600
	600	900	750	2,850	150
	450	750	600	2,700	0
v_j	450	750	600	2,700	

Now we calculate $\Delta_{ij} = C_{ij} – (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

1,200	450		750
150		300	
			150

Since, all allocations in $\Delta_{ij} = C_{ij} –(u_i+v_j)$are non negative, the allocation is optimal. The allocation of assignments to managers and their billing amount is given below:

Manager	Assignment	Billing Amount
S	Statutory Audit	₹5,01,600 (176 hrs. x ₹2,850)
D	Corporate Valuation	₹2,35,950 (121 hrs. x ₹1,950)
K	Transfer Pricing	₹3,43,200 (143 hrs. x ₹2,400)
K	Corporate Valuation	₹69,300 (33 hrs. x ₹2,100)
	Total Billing	₹11,50,050

Problem-12

A company has three factory and four customers. The company furnishes the following schedule of profit per unit on transportation of goods to the customers in rupees:

Factory	***Customers***				***Supply***
	A	***B***	***C***	***D***	
P	*40*	*25*	*22*	*33*	*100*
Q	*44*	*35*	*30*	*30*	*30*
R	*38*	*38*	*28*	*30*	*70*
Demand	*40*	*20*	*60*	*30*	*150 / 200*

Required

Solve the transportation problem to maximize the profit and determine the resultant optimal profit.

Solution

Convert the given profit matrix into a loss matrix by subtracting each element of the matrix from the highest value viz.44.The resulting loss matrix is as follows:

Loss Matrix

Factory	**Customers**				Supply
	A	**B**	**C**	**D**	
P	4	19	22	11	100
Q	0	9	14	14	30
R	6	6	16	14	70
Demand	40	20	60	30	150 / 200

The loss matrix, obtained as above is an unbalanced one, We introduce a dummy column to make it a balanced one.

Factory	Customers					Supply
	A	B	C	D	Dummy	
P	4	19	22	11	0	100
Q	0	9	14	14	0	30
R	6	6	16	14	0	70
Demand	40	20	60	30	50	200 / 200

By using Vogel's approximation method, the following initial feasible solution is found-

	A	B	C	D	Dummy	Supply	Difference
P	4 [10]	19	22 [60]	11 [30]	0 [e]	100/90/60/0	4 7 7
Q	0 [30]	9	14	14	0	30/0	0 9 -
R	6	6 [20]	16	14	0 [50]	70/20/0	6 0 0
Demand	40/10/0	20/0	60/0	30/0	50/0	200 / 200	
Difference	4	3	2	3	0		
	4	3	2	3	-		
	2	13	6	3	-		

Since the number of allocation's in the initial feasible solution are 6 and for applying optimality test they should be equal to 7 (m+n-1), therefore we enter a very small assignment equal to *'e'* in the minimum cost so that no loop is formed. Now we test the above solution for optimality.

(u_i + v_j) Matrix for Allocated / Unallocated Cells

						u_i
	4	6	22	11	0	0
	0	2	18	7	-4	-4
	4	6	22	11	0	0
v_j	4	6	22	11	0	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below:

Δ_{ij} Matrix

	13			
	7	-4	7	4
2		-6	3	

Since, there are two negative cell values in the above Δ_{ij} Matrix, so we have to do re allocation by making a loop and allocate at the cell which has the worst negative value. The re-allocation will be as follows-

10		60 -50	30	e +50
30				
	20	+50		50 -50

Revised allocations (improved initial solution) are as follows-

10		10	30	50
30				
	20	50		

Now we test this allocation (improved initial solution) for optimality-

(u_i + v_j) Matrix for Allocated / Unallocated Cells

						u_i
	4	12	22	11	0	0
	0	8	18	7	-4	-4
	-2	6	16	5	-6	-6
v_j	4	12	22	11	0	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below:

Δ_{ij} Matrix

	7			
	1	-4	7	4
8			9	6

Again, in the above Δ_{ij} Matrix one cell value is negative, so we have to do reallocation by making a loop and make allocation in the negative value cell.

10 +10		10 -10	30	50
30 -10		+10		
	20	50		

Revised allocations (improved initial solution) are as follows-

20			30	50
20		10		
	20	50		

Now we test this allocation (improved initial solution) for optimality-

(u_i + v_j) Matrix for Allocated / Unallocated Cells

						u_i
	4	8	18	11	0	0
	0	4	14	7	-4	-4
	2	6	16	9	-2	-2
v_j	4	8	18	11	0	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

	11	4		
	5		7	4
4			5	2

Now all the cells value are non-negative, hence the above solution is optimal.

Factory	Customer	Units	Profit/ unit (₹)	Total Profit (₹)
P	A	20	40	800
P	D	30	33	990
Q	A	20	44	880
Q	C	10	30	300
R	B	20	38	760
R	C	50	28	1,400
			Total	5,130

Transportation/ Assignment Problem

Problem-13

The cost per unit of transporting goods from the factories X, Y, Z to destinations. A, B and C, and the quantities demanded and supplied are tabulated below. As the company is working out the optimum logistics, the Govt.; has announced a fall in oil prices. The revised unit costs are exactly half the costs given in the table.

Destinations / Factories	***A***	***B***	***C***	***Supply***
X	*15*	*9*	*6*	*10*
Y	*21*	*12*	*6*	*10*
Z	*6*	*18*	*9*	*10*
Demand	*10*	*10*	*10*	*30*

Required

You are required to evaluate the minimum transportation cost.

Solution

The problem may be treated as an assignment problem. The solution will be the same even if prices are halved. Only at the last stage, calculate the minimum cost and divide it by 2 to account for fall in oil prices.

Factories \ Destinations	A	B	C
X	15	9	6
Y	21	12	6
Z	6	18	9

Subtracting minimum row value from the all values of the respective row-

Factories \ Destinations	A	B	C
X	9	3	0
Y	15	6	0
Z	0	12	3

Now subtract minimum column value with the all values of the respective column-

Factories \ Destinations	A	B	C
X	9	$\boxed{0}$	0
Y	15	3	$\boxed{0}$
Z	$\boxed{0}$	9	3

Minimum number of lines covering all zeroes are 3 which is equal to order of matrix. The allocation and minimum transportation cost is as follows-

Factory	Destination	Cost per unit (₹)	Units	Cost (₹)	Revised Cost (₹)
X	B	9	10	90	45
Y	C	6	10	60	30
Z	A	6	10	60	30
				Total	105

Minimum cost equals to ₹105.

Alternatively

Vogel's Approximation Method (VAM)-

	A	B	C	Supply	Diff.
X	15	9 [10]	6	10/0	3 3
Y	21	12	6 [10]	10/0	6 6
Z	6 [10]	18	9	10/0	3 -
Demand	10/0	10/0	10/0	30	
Diff.	9	3	0		
	-	3	0		

The number of allocations are 3 which is less than m+n -1 i.e. 5, so it becomes a degeneracy case. This degenerate situation will be made good by introducing two infinitesimally small allocations 'e_1' and 'e_2' in independent lowest cost cells R_1C_3 and R_3C_3 respectively. The initial basic solution will be as follows-

	A	B	C	Supply
X	15	9 [10]	6 [e_1]	10/0
Y	21	12	6 [10]	10/0
Z	6 [10]	18	9 [e_2]	10/0
Demand	10/0	10/0	10/0	30

Now we test the above initial solution for optimality.

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

				u_i
	9	9	6	6
	9	9	6	6
	6	12	9	9
v_j	3	3	0	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

6		
12	3	
	6	

All $\Delta_{ij} > 0$, Hence this is the optimal solution.

Factory	Destination	Cost per unit (₹)	Units	Cost (₹)	Revised Cost (₹)
X	B	9	10	90	45
X	C	6	e_1	0	0
Y	C	6	10	60	30
Z	A	6	10	60	30
Z	C	9	e_2	0	0
				Total	105

Total minimum transportation cost is ₹ 105.

Change in Resource Capacities AND/ OR Destination Requirements

Problem-14

A manufacturer of jeans is interested in developing an advertising campaign that will reach four different age groups. Advertising campaigns can be conducted through TV, Radio and Magazines. The following table gives the estimated cost in rupees per exposure for each age group according to the medium employed. In addition, Maximum exposure levels possible in each of the media, namely TV, Radio and Magazines are 40, 30 and 20 million respectively. Also the minimum desired exposures within each age group, namely 13-18,19-25,26-35,36 & older, are 30, 25,15 and 10 millions. The objective is to minimize the cost of attaining the minimum exposure level in each age group.

Media	***Age Group***			
	13- 18	***19- 25***	***26- 35***	***36 & older***
TV	*12*	*7*	*10*	*10*
Radio	*10*	*9*	*12*	*10*
Magazines	*14*	*12*	*9*	*12*

Required

(i) *Formulate the above as a transportation problem, and find the optimal solution.*

(ii) *Solve this problem if the policy is to provide at least 4 million exposures through TV in the 13-18 age group and at least 8 million exposures through TV in the age group 19-25.*

Solution

(i)

As a first step, let us formulate the given problem as a transportation problem:

Media	Age Group				Max. Exposures*
	13-18	**19-25**	**26-35**	**36 & Old**	
TV	12	7	10	10	40
Radio	10	9	12	10	30
Magazines	14	12	9	12	20
Min. Exposures*	30	25	15	10	

(*) *in millions*

It is apparent from the above table that this transportation problem is an unbalanced one. It is balanced by introducing a dummy age category before applying Vogel's Approximation Method.

Media	Age Group					Max. Exposures	Difference
	13-18	**19-25**	**26-35**	**36 & Old**	**Dummy**		
TV	12	7 [25]	10 [5]	10 [10]	0	40/15/10/0	7 3 0 0 0
Radio	10 [30]	9	12	10	0	30/0	9 1 0 0 -
Mag.	14	12	9 [10]	12	0 [10]	20/10/0	9 3 3 - -
Min. Exposure	30/0	25/0	15/5/0	10/0	10/0	90	

Difference	2	2	1	0	0
	2	2	1	0	-
	2	-	1	0	-
	2	-	2	0	-
	-	-	10	10	-

The solution given by VAM is degenerate since there are only six assignments. Let us put an 'e' in the least cost independent cell to check for optimality.

Media	Age Group					Max. Exposures
	13-18	19-25	26-35	36 & Old	Dummy	
TV	12	7 [25]	10 [5]	10 [10]	0	40/15/10/0
Radio	10 [30]	9	12	10	0 [e]	30/0
Mag.	14	12	9 [10]	12	0 [10]	20/10/0
Min. Exposure	30/0	25/0	15/5/0	10/0	10/0	90

(u_i + v_j) Matrix for Allocated / Unallocated Cells

						u_i
	11	7	10	10	1	0
	10	6	9	9	0	-1
	10	6	9	9	0	-1
v_j	11	7	10	10	1	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

1				-1
	3	3	1	
4	6		3	

Since one of the Δ_{ij} is negative, the solution given above is not optimal. Let us include the cell with negative Δ_{ij} as a basic cell and try to improve the solution. The reallocated solution is given below which is tested for optimality-

	25	5 -5	10	+5
30				e
		10 +5		10 -5

Re-allocated Solution

	25		10	5
30				e
		15		5

(u_i + v_j) Matrix for Allocated / Unallocated Cells

						u_i
	10	7	9	10	0	0
	10	7	9	10	0	0
	10	7	9	10	0	0
v_j	10	7	9	10	0	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

2		1		
	2	3	0	
4	5		2	

Since all the entries in the above Δ_{ij} Matrix table are non-negative, this solution is optimal.

Media	Age Group	Exposures (in million)	Cost per Exposure (₹)	Total Cost (₹ in million)
TV	19-25	25	7	175
TV	36 & older	10	10	100
Radio	13-18	30	10	300
Magazines	26-35	15	9	135
			Total Cost	710

Since one of Δ_{ij} in the second solution is zero, this solution is not unique, alternate solution also exists.

(ii)

Media	Age Group					Max. Exposures
	13-18	**19-25**	**26-35**	**36 & Old**	**Dummy**	
TV	12 $\boxed{4}$	7 $\boxed{25}$	10	10 $\boxed{10}$	0 $\boxed{1}$	40
Radio	10 $\boxed{26}$	9	12	10	0 $\boxed{4}$	30
Magazine	14	12	9 $\boxed{15}$	12	0 $\boxed{5}$	20
Min. Exposure	30	25	15	10	10	90

Total Cost *for this allocation*

Media	Age group	Exposures (₹ in million)	Cost per Exposure (₹)	Total Cost (₹ in million)
TV	13-18	4	12	48
TV	19-25	25	7	175
TV	36 & older	10	10	100
Radio	13-18	26	10	260
Magazines	26-35	15	9	135
			Total Cost	718

Problem-15

The following table shows all the necessary information on the available supply to each warehouse, the requirement of each market and the unit transportation cost from each warehouse to each market:

Warehouse	*Market*				*Supply*
	I	*II*	*III*	*IV*	
A	*5*	*2*	*4*	*3*	*22*
B	*4*	*8*	*1*	*6*	*15*
C	*4*	*6*	*7*	*5*	*8*
Requirement	*7*	*12*	*17*	*9*	*45\ 45*

The shipping clerk has worked out the following schedule from his experience:

12 units from A to II
1 unit from A to III
9 units from A to IV
15 units from B to III
7 units from C to I and
1 unit from C to III

Required

(i) Check and see if the clerk has the optimal schedule;

(ii) Find the optimal schedule and minimum total shipping cost; and

(iii) If the clerk is approached by a carrier of route C to II, Who offers to reduce his rate in the hope of getting some business, by how much should the rate be reduced before the clerk should consider giving him an order ?

Solution

(i)

The Initial basic solution worked out by the shipping clerk is as follows-

Warehouse	Market				Supply
	I	II	III	IV	
A	5	2 $\boxed{12}$	4 $\boxed{1}$	3 $\boxed{9}$	22

B	4	8	1 [15]	6	15
C	4 [7]	6	7 [1]	5	8
Req.	7	12	17	9	45

The initial solution is tested for optimality. The total number of independent allocations is 6 which is equal to the desired (m +n –1) allocations. We introduce u_i's (i = 1, 2, 3) and v_j's (j = 1, 2, 3, 4) such $\Delta_{ij} = C_{ij} - (u_i + v_j)$. Let us assume $u_1 = 0$, remaining u_i's and v_j's are calculated as below-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

					u_i
	1	2	4	3	0
	-2	-1	1	0	-3
	4	5	7	6	3
v_j	1	2	4	3	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

4			
6	9		6
	1		-1

Since one of the Δ_{ij}'s is negative, the schedule worked out by the clerk is not the optimal solution.

(ii)

Introduce in the cell with negative Δ_{ij} [R_3C_4], an assignment. The reallocation is done as follows-

	12	1 +1	9 -1
		15	
7		1 -1	+1

Revised Allocation Table

	12	2	8
		15	
7			1

Now we test the above improved initial solution for optimality-

($u_i + v_j$) Matrix for Allocated / Unallocated Cells

					u_i
	2	2	4	3	0
	-1	-1	1	0	-3
	4	4	6	5	2
v_j	2	2	4	3	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

3			
5	9		6
	2	1	

Since all Δ_{ij} for non basic cells are positive, the solution as calculated in the above table is the optimal solution. The supply of units from each warehouse to markets, along with the transportation cost is given below-

Warehouse	Market	Units	Cost per unit (₹)	Total Cost (₹)
A	II	12	2	24
A	III	2	4	8
A	IV	8	3	24
B	III	15	1	15
C	I	7	4	28
C	IV	1	5	5
			Minimum Total Shipping Cost	104

(iii)

If the clerk wants to consider the carrier of route C to II for giving an order, then his transportation cost must be less than the cost of carrier of routes C to I and C to IV i.e. his transportation cost should be at the most ₹ 3 per unit. If the carrier C to II brings down his cost to ₹ 3, he will get an order for 1 unit, and the schedule will be-

Warehouse	Market	Units	Cost per unit (₹)	Total Cost (₹)
A	II	11	2	22
A	III	2	4	8
A	IV	9	3	27
B	III	15	1	15
C	I	7	4	28
C	II	1	3	3
			Minimum Total Shipping Cost	103

The total shipping cost will be ₹103.

☞

Alternative Way for *better understanding* of concept

Issue:

If the clerk is approached by a carrier of route C to II, Who offers to reduce his rate in the hope of **getting some business**, by how much should the rate be reduced before the clerk should consider giving him an order ?

Resolution:

If the clerk wants to consider the carrier of route C to II for giving **some business (minimum ONE unit)**, then Revised Schedule will be

Warehouse	Market	Units
A	II	11
A	III	2
A	IV	9
B	III	15
C	I	7
C	**II**	**1**

But Minimum Shipping Cost Should be **less than** ₹104 (existing situation).

Statement Showing **Cost** *per unit* **C, II**

Warehouse	Market	Units	Cost per unit (Rs.)	Total Cost (₹)
A	II	11	2	22
A	III	2	4	8
A	IV	9	3	27
B	III	15	1	15
C	I	7	4	28
C	II	1	Less Than 4*	Less Than 4*
Minimum Total Shipping Cost (Less Than)				104

** Balancing Figure*

Accordingly Carrier should reduce its rate to less than ₹4 or to ₹**3** so that he/ she can get at least some business i.e. ONE unit.

Problem-16

The following table shows all the necessary information on the available supply from each warehouse, the requirement of each market and the unit transportation cost in rupees from each warehouse to each market.

Warehouses	***Markets***				***Supply***
	I	***II***	***III***	***IV***	
A	*5*	*2*	*4*	*3*	*22*
B	*4*	*8*	*1*	*6*	*15*
C	*4*	*6*	*7*	*5*	*8*
Requirement	*7*	*12*	*17*	*9*	*45/45*

The shipping clerk has worked out the following schedule from experience:

12 units from A to II, 1 unit from A to III, 9 units from A to IV, 15 units from B to III, 7 units from C to I and I unit from C to III.

Required

(i) *Check if the clerk has made the 'Optimal Schedule'.*

(ii) *Find the 'Optimal Schedule' and 'Minimum Total Shipping Cost'.*

(iii) *Carrier of route C to II offers to transport entire supply of warehouse C at a reduced price. By how much must the rate be reduced by the Carrier before the clerk should consider giving him business?*

(iv) *If the supply from warehouse B reduces to 11 units and simultaneously the requirement of market III reduces to 13 units, find the 'Optimal Transportation Schedule'.*

(v) *Further, if supply from warehouse A also reduces to 19 units and simultaneously the requirement of III reduces further to 10 units, will the optimal solution of part (iv) change?*

Solution

(i) The Initial basic solution worked out by the shipping clerk is as follows-

Warehouse	**Market**				Supply
	I	**II**	**III**	**IV**	
A	5	2 $\boxed{12}$	4 $\boxed{1}$	3 $\boxed{9}$	22
B	4	8	1 $\boxed{15}$	6	15
C	4 $\boxed{7}$	6	7 $\boxed{1}$	5	8
Req.	7	12	17	9	45

The initial solution is tested for optimality. The total number of independent allocations is 6 which is equal to the desired (m +n –1) allocations. We introduce u_i's (i = 1, 2, 3) and v_j's (j = 1, 2, 3, 4). Let us assume u_1 = 0, remaining u_i's and v_j's are calculated as below-

(u_i + v_j) Matrix for Allocated / Unallocated Cells

					u_i
	1	2	4	3	0
	-2	-1	1	0	-3
	4	5	7	6	3
v_j	1	2	4	3	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

4			
6	9		6
	1		-1

Since one of the Δ_{ij}'s is negative, the schedule worked out by the clerk is not the optimal solution.

(ii) Introduce in the cell with negative Δ_{ij} [R_3C_4], an assignment. The reallocation is done as follows-

	12	1 +1	9 -1
		15	
7		1 -1	+1

Revised Allocation Table

	12	2	8
		15	
7			1

Now we test the above improved initial solution for optimality-

(u_i + v_j) Matrix for Allocated / Unallocated Cells

					u_i
	2	2	4	3	0
	-1	-1	1	0	-3
	4	4	6	5	2
v_j	2	2	4	3	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

3			
5	9		6
	2	1	

Since all Δ_{ij} for non basic cells are positive, the solution as calculated in the above table is the optimal solution. The supply of units from each warehouse to markets, along with the transportation cost is given below-

Warehouse	Market	Units	Cost per unit (₹)	Total Cost (₹)
A	II	12	2	24
A	III	2	4	8
A	IV	8	3	24
B	III	15	1	15
C	I	7	4	28
C	IV	1	5	5
			Minimum Total Shipping Cost	104

(iii) If the clerk wants to consider the carrier of route C to II only, instead of 7 units to I and 1 unit to IV, it will involve shifting of 7 units from (A, II) to (A, I) and 1 unit to (A, IV) which results in the following table-

Warehouse	Market				Supply
	I	II	III	IV	
A	5 $\boxed{7}$	2 $\boxed{4}$	4 $\boxed{2}$	3 $\boxed{9}$	22

B	4	8	1 $\boxed{15}$	6	15
C	4	6 $\boxed{8}$	7	5	8
Req.	7	12	17	9	45

The transportation cost will become-

Warehouse	Market	Units	Cost per unit (₹)	Total Cost (₹)
A	I	7	5	35
A	II	4	2	8
A	III	2	4	8
A	IV	9	3	27
B	III	15	1	15
C	II	8	6	48
			Minimum Total Shipping Cost	141

The total shipping cost will be ₹141.

Additional Transportation Cost ₹37.

The carrier of C to II must reduce the cost by ₹4.63 (₹37/8) so that the total cost of transportation remains the same and clerk can give him business.

(iv) Revised transportation table is shown below-

Warehouse	**Market**				Supply
	I	**II**	**III**	**IV**	
A	5	2 $\boxed{12}$	4 $\boxed{2}$	3 $\boxed{8}$	22
B	4	8	1 $\boxed{11}$	6	15/11
C	4 $\boxed{7}$	6	7	5 $\boxed{1}$	8
Req.	7	12	17/13	9	45

Since the <u>alterations are restricted to allocated cells only</u>, the present alterations do not disturb the optimal allocation schedule.

(v) In this situation, <u>alterations are not restricted to allocated cells</u> since allocation in cell (A, III) is **2** units only while reduction in requirement of Market III as well as supply of

Warehouse A is **3** units. Therefore, it is essential to make alterations in allocations, check solution for optimality test and iterate if required.

Advanced Problem in Transportation

Problem-17

A project consists of four (4) major jobs, for which four (4) contractors have submitted tenders. The tender amounts, in thousands of rupees, are given in the each cell. The initial solution of the problem obtained by using Vogel's Approximation Method is given in the Table below:

Contractors	Job P	Job Q	Job R	Job S
A	112.50	100.00	127.50	167.50 $\boxed{1}$
B	142.50	105.00 $\boxed{1}$	157.50	137.50
C	122.50	130.00	120.00 $\boxed{1}$	160.00
D	102.50 $\boxed{1}$	112.50	150.00	137.50

Required

Find the assignment, which minimizes the total cost of the project. Each contractor has to be awarded one job only.

Solution

Once the initial basic feasible solution is done, we have to do the optimality test. If it satisfy the condition that number of allocation is equal to m+n-1 where m= number of rows, n= number of columns. If allocation is less than m+n-1, then the problem shows degenerate situation. In that case we have to allocate an infinitely small quantity (e) in least cost and independent cell. Independent cells in Transportation Problems mean the cells which do not form a closed loop with occupied cells.

The table obtained after using VAM contains 4 occupied cells against the required number of 4 + 4 – 1 = 7, hence the solution is degenerate.

To remove degeneracy, a letter 'e' is placed in three independent cells. The problem for test of optimality is reproduced in table below:

Contractors	Job P	Job Q	Job R	Job S
A	112.50 $\boxed{e}$	100.00 $\boxed{e}$	127.50	167.50 $\boxed{1}$
B	142.50	105.00 $\boxed{1}$	157.50	137.50
C	122.50 $\boxed{e}$	130.00	120.00 $\boxed{1}$	160.00
D	102.50 $\boxed{1}$	112.50	150.00	137.50

☞

Alternatively **'e'** can also be allocated to cell C_{42} instead of C_{11}.

Now total number of allocations become equal to m + n -1 i.e. 7. This solution is tested for optimality.

(u_i + v_j) Matrix for Allocated / Unallocated Cells

					u_i
	112.50	100.00	110.00	167.50	0
	117.50	105.00	115.00	172.50	5.00
	122.50	110.00	120.00	177.50	10.00
	102.50	90.00	100.00	157.50	-10.00
v_j	112.50	100.00	110.00	167.50	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

		17.50	
25.00		42.50	-35.00
	20.00		-17.50
	22.50	50.00	-20.00

Since all values of Δ_{ij} are not positive, the solution given above is not optimal. Let us include the cell with highest negative Δ_{ij} which is C_{24} as a basic cell and try to improve the solution. The reallocated solution is given below which is tested for optimality-

e	e +1		1 -1
	1 -1		**+1**
e		1	
1			

Revised allocations (improved initial solution) are as follows-

Contractors	Job P	Job Q	Job R	Job S
A	112.50 e	100.00 1	127.50	167.50
B	142.50	105.00 **e**	157.50	137.50 1
C	122.50 e	130.00	120.00 1	160.00
D	102.50 1	112.50	150.00	137.50

☞

Again there is a situation of degeneracy to remove this situation a new **'e'** has been allocated to least cost independent cell **C_{22}**.

(u_i + v_j) Matrix for Allocated / Unallocated Cells

					u_i
	112.50	100.00	110.00	132.50	0
	117.50	105.00	115.00	137.50	5.00
	122.50	110.00	120.00	142.50	10.00
	102.50	90.00	100.00	122.50	-10.00
v_j	112.50	100.00	110.00	132.50	

Now we calculate $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for non basic cells which are given in the table below-

Δ_{ij} Matrix

		17.50	35.00
25.00		42.50	
	20.00		17.50
	22.50	50.00	15.00

Since all the entries in the above Δ_{ij} Matrix table are non-negative, this solution is optimal. The optimal assignment is given below-

Contractor	Job	Cost of Project
A	Q	100.00
B	S	137.50
C	R	120.00
D	P	102.50
	Total	460.00

SECTION - C

Transportation– Basic Concepts

(Feasible Solution/ Degenerate Solution/ Optimal Solution/ Miscellaneous)

Problem-1

In a 3 x 4 transportation problem for minimizing costs, will the R_2C_1 cell (at the intersection of the 2^{nd} row and 1^{st} column) always figure in the initial solution by the North West Corner Rule? Why?

Solution

The Initial solution obtained by the North-West Corner Rule in transportation need not always contain the R_2C_1 cell. In the North-West Corner Rule the first allocation is made at R_1C_1 cell and then it only moves towards R_2C_1 cell when the resources at the first row i.e. R_1 is exhausted first than the resources of first column i.e. C_1. On the contrary if resources at first column i.e. C_1 is exhausted first then the next allocation will be at R_1C_2.

For example the resource availability at first row (R_1) is 1,500 units and the demand in first column (C_1) is 1,000 units. In this case resource availability of first row (R_1) will be exhausted to the extent of the demand in first column (C_1) first and then the remaining resource availability at first row (R_1) will be used to meet the demand of the second column (C_2). In this example cell R_2C_1 will not come in initial solution obtained by the North-West Corner Rule.

Problem-2

In a transportation problem for cost minimization, there are 4 rows indicating quantities demanded and this totals up to 1,200 units. There are 4 columns giving quantities supplied. This totals up to 1,400 units. What is the condition for a solution to be degenerate?

Solution

The condition for degeneracy is that the number of allocations in a solution is less than m+n-1.

The given problem is an unbalanced situation and hence a dummy row is to be added, since the column quantity is greater than that of the row quantity. The total number of rows and columns will be 9 i.e. (5 rows and 4 columns). Therefore, m+n-1 (= 8), i.e. if the number of allocations is less than 8, then degeneracy would occur.

Problem-3

XYZ Company has three plants and four warehouses. The supply and demand in units and the corresponding transportation costs are given. The table below shows the details taken from the solution procedure of the transportation problem:

Plants	**Warehouses**				*Supply*
	I	***II***	***III***	***IV***	
A	5	10	4 $\boxed{10}$	5	10
B	6 $\boxed{20}$	8	7	2 $\boxed{5}$	25
C	4 $\boxed{5}$	2 $\boxed{10}$	5 $\boxed{5}$	7	20
Demand	25	10	15	5	55

Required

(i) *Is this solution feasible?*

(ii) *Is this solution degenerate?*

(iii) *Is this solution optimum?*

Solution

(i) Is this solution feasible?

A necessary and sufficient condition for the existence of a feasible solution to the transportation problem is that

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Where

a_i = quantity of product available at origin i.

b_j = quantity of product available at origin j.

In other words, the total capacity (or supply) must equal total requirement (or demand)

As the supply 55 units (10+25+20) equals demand 55 units (25+10+15+5), a feasible solution to the problem exists.

(ii) Is this solution degenerate?

When the number of positive allocations at any stage of the feasible solution is less than the required number (rows + columns -1), the solution is said to be *degenerate solution*.

In given solution total allocated cells are 6 which are equal to 4+3-1 (rows + columns - 1). Therefore, the initial basic solution is not a degenerate solution.

(iii) Is this solution optimum?

Test of Optimality:

(u_i + v_j) Matrix for Allocated Cells

					u_i
			4		-1
	6			2	2
	4	2	5		0
v_j	4	2	5	0	

(u_i + v_j) Matrix for Unallocated Cells

					u_i
	3	1		-1	-1
		4	7		2
				0	0
v_j	4	2	5	0	

Δ_{ij}= C_{ij}— (u_i + v_j) Matrix

2	9		6
	4	0	
			7

Since, all cells values in Δ_{ij}= C_{ij}— (u_i + v_j) matrix are non- negative, hence the solution provided by XYZ Company is optimum.

It may be noted that zero opportunity cost in cell (B, III) indicates a case of alternative optimum solution.

Problem-4

The following matrix is a minimization problem for transportation cost. The unit transportation costs are given at the right hand corners of the cells and the Δ_{ij} values are encircled.

	D_1	D_2	D_3	Supply
F_1	$\boxed{3}$	$\boxed{4}$	$\boxed{4}$	500
F_2	8 $\boxed{9}$	300 $\boxed{6}$	8 $\boxed{7}$	300
F_3	0 $\boxed{4}$	8 $\boxed{6}$	200 $\boxed{5}$	200
Demand	300	400	300	1,000

Required

Find the optimum solution (s) and the minimum cost.

Solution

As we know Δ_{ij} values are given for unallocated cells. Hence, the remaining cells represent the allocated cells which is 5 and equal to m + n -1 (no. of columns + no of rows – 1).

Now we fill up the allocated cells with allocated units.

Allocation (other than Δ_{ij} cells)

Cell	Demand in Corresponding Column	Supply in Corresponding Row	Maximum Possible Allocation (Minimum of Demand and Supply)	Allocation
R_1C_1	300	500	300	300
R_1C_2	100 (400 – 300 in R_2C_2)	200 (500 – 300 in R_1C_1)	100	100
R_1C_3	100 (300 – 200 in R_3C_3)	100 (200 – 100 in R_1C_2)	100	100

	D_1	D_2	D_3	Supply
F_1	300 [3]	100 [4]	100 [4]	500
F_2	(8) [9]	300 [6]	(8) [7]	300
F_3	(0) [4]	(8) [6]	200 [5]	200
Demand	300	400	300	1,000

This solution is optimal since all Δ_{ij} values are either zero or positive. However alternative solution exists as at R_3C_1 the Δ_{ij} value is zero. For the other optimal solution, a loop is created as follows-

	D_1	D_2	D_3
F_1	300 -200	100	100 +200
F_2		300	
F_3	+200		200 -200

Re-allocation table is as below-

	D_1	D_2	D_3
F_1	100	100	300
F_2		300	
F_3	200		

Minimum Cost-

Allocation	Alternative-I	Alternative-II
R_1C_1	900 (3 x 300)	300 (3 x 100)
R_1C_2	400 (4 × 100)	400 (4 x 100)

R_1C_3	400 (4 x 100)	1,200 (4 x 300)
R_2C_2	1,800 (6 x 300)	1,800 (6 x 300)
R_3C_3	1,000 (5 x 200)	---
R_3C_1	---	800 (4 x 200)
Total	4,500	4,500

12 The Assignment Problem

Basic Concepts

Assignment Algorithm	The Assignment Problem is another special case of LPP. It occurs when m jobs are to be assigned to n facilities on a one-to-one basis with a view to optimising the resource required.
Steps for Solving the Assignment Problem	Assignment problem can be solved by applying the following steps: *Step-1:* Subtract the minimum element of each row from all the elements in that row. From each column of the matrix so obtained, subtract its minimum element. The resulting matrix is the starting matrix for the following procedure. *Step-2:* Draw the minimum number of horizontal and vertical lines that cover all the zeros. If this number of lines is n, order of the matrix, optimal assignment can be made by skipping steps 3 and 4 and proceeding with step 5. If, however, this number is less than n, go to the next step. *Step-3:* Here, we try to increase the number of zeros in the matrix. We select the smallest element out of these which do not lie on any line. Subtract this element from all such (uncovered) elements and add it to the elements which are placed at the intersections of the horizontal and vertical lines. Do not alter the elements through which only one line passes. *Step-4:* Repeat steps 1, 2 and 3 until we get the minimum number of lines equal to n. *Step-5(A):* Starting with first row, examine all rows of matrix in step 2 or 4 in turn until a row containing exactly one zero is found. Surround this zero by (□), indication of an assignment there. Draw a vertical line through the column containing this zero. This eliminates any confusion of making any further assignments in that column. Process all the rows in this way.

	Step-5(B): Apply the same treatment to columns also. Starting with the first column, examine all columns until a column containing exactly one zero is found. Mark (□) around this zero and draw a horizontal line through the row containing this marked zero. Repeat steps 5A and B, until one of the following situations arises: – No unmarked (□) or uncovered (by a line) zero is left, – There may be more than one unmarked zero in one column or row. In this case, put around one of the unmarked zero arbitrarily and pass 2 lines in the cells of the remaining zeros in its row and column. Repeat the process until no unmarked zero is left in the matrix.
Unbalanced Assignment Problems	Like the unbalanced transportation problems there could arise unbalanced assignment problems too. They are to be handled exactly in the same manner i.e., by introducing dummy jobs or dummy men, etc.

SECTION - A

Steps to Solve Assignment Problem

Question-1

Prescribe the steps to be followed to solve an assignment problem.

Answer

The assignment problem can be solved by applying the following steps-

Step-1:

Subtract the minimum element after row operation of each row from all the elements in that row. From each column of the matrix so obtained, subtract its minimum element. The resulting matrix is the starting matrix for the following procedure.

Step-2:

Draw the minimum number of horizontal and vertical lines that cover all the zeros. If this number of lines is *n*, order of the matrix, optimal assignment can be made by skipping steps 3 and 4 and proceeding with step 5. If, however, this number is less than *n*, go to the next step

Step-3:

Here, we try to increase the number of zeros in the matrix. We select the smallest element out of these which do not lie on any line. Subtract this element from all such (uncovered) elements and add it to the elements which are placed at the intersections of the horizontal and vertical lines. Do not alter the elements through which only one line passes.

Step-4:

Repeat steps 1, 2 and 3 until we get the minimum number of lines equal to *n.*

Step-5(A):

Starting with first row, examine all rows of matrix in step 2 or 4 in turn until a row containing exactly one zero is found. Surround this zero by (☐), indication of an assignment there. Draw a vertical line through the column containing this zero. This eliminates any confusion of making any further assignments in that column. Process all the rows in this way.

Step5 (B): Apply the same treatment to columns also. Starting with the first column, examine all columns until a column containing exactly one zero is found. Mark (☐) around this zero and draw a horizontal line through the row containing this marked zero. Repeat steps 5A and B, until one of the following situations arises:

– No unmarked (□) or uncovered (by a line) zero is left,

– There may be more than one unmarked zero in one column or row. In this case, put around one of the unmarked zero arbitrarily and pass 2 lines in the cells of the remaining zeros in its row and column. Repeat the process until no unmarked zero is left in the matrix.

SECTION - B

Minimization Problem

Problem-1

An Electronic Data Processing (EDP) centre has three expert Software professionals. The Centre wants three application software programs to be developed. The head of EDP Centre estimates the computer time in minutes required by the experts for development of Application Software Programs as follows-

Software Programs	***Computer Time (in minutes) Required by Software Professionals***		
	A	***B***	***C***
1	*100*	*85*	*70*
2	*50*	*70*	*110*
3	*110*	*120*	*130*

Required

Assign the software professionals to the application software programs to ensure minimum usage of computer time.

Solution

The given problem is a balanced minimization assignment problem.

The minimum time elements in row 1, 2 and 3 are 70, 50 and 110 respectively. Subtract these elements from all elements in their respective row. The reduced matrix is shown below-

	A	**B**	**C**
1	30	15	0
2	0	20	60
3	0	10	20

The minimum time elements in columns A, B and C are 0, 10, and 0 respectively. Subtract these elements from all the elements in their respective columns to get the reduced time matrix as shown below-

	A	B	C
1	30	5	$\boxed{0}$
2	$\boxed{0}$	10	60
3	0	$\boxed{0}$	20

The minimum number of horizontal and vertical lines to cover all zeros is 3, which is equal to the order of the matrix.

The Pattern of assignments among software professionals and programs with their respective time (in minutes) is given below-

Program	Software Professionals	Time (in Minutes)
1	C	70
2	A	50
3	B	120
Total		240

Problem-2

A project consists of four (4) major jobs, for which four (4) contractors have submitted tenders. The tender amounts, in thousands of rupees, are given below-

Contractors	*Job A*	*Job B*	*Job C*	*Job D*
1	*120*	*100*	*80*	*90*
2	*80*	*90*	*110*	*70*
3	*110*	*140*	*120*	*100*
4	*90*	*90*	*80*	*90*

Required

Find the assignment, which minimizes the total cost of the project. Each contractor has to be assigned one job.

Solution

The given problem is a balanced minimization problem. Subtracting the minimum element of each row from all its elements in turn, the given problem reduces to-

Contractors	Job A	Job B	Job C	Job D
1	40	20	0	10
2	10	20	40	0
3	10	40	20	0
4	10	10	0	10

Now subtract the minimum element of each column from all its elements in turn. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

Contractors	Job A	Job B	Job C	Job D
1	30	10	$\boxed{0}$	10
2	$\boxed{0}$	10	40	0
3	0	30	20	$\boxed{0}$
4	0	$\boxed{0}$	0	10

Since the minimum number of lines to cover all zeros is equal to 4(order of the matrix), this matrix will give optimal solution. The optimal assignment is made in the matrix below-

Contractors	Job A	Job B	Job C	Job D
1	30	10	$\boxed{0}$	10
2	$\boxed{0}$	10	40	$\cancel{0}$
3	$\cancel{0}$	30	20	$\boxed{0}$
4	$\cancel{0}$	$\boxed{0}$	$\cancel{0}$	10

The optimal assignment is-

Contractor	Job	Cost ('000 ₹)
1	C	80
2	A	80
3	D	100
4	B	90

Hence, total minimum cost of the project will be ₹3,50,000.

Problem-3

A Marketing Manager has 4 subordinates and 4 tasks. The subordinates differ in efficiency. The tasks also differ in their intrinsic difficulty. His estimates of the time each subordinate would take to perform each task is given in the matrix below.

	I	*II*	*III*	*IV*
1	*16*	*52*	*34*	*22*
2	*26*	*56*	*8*	*52*
3	*76*	*38*	*36*	*30*
4	*38*	*52*	*48*	*20*

Required

How should the task be allocated one to one man so that the total man-hours are minimised?

Solution

Step 1

Subtract the smallest element of each row from every element of the corresponding row.

	I	II	III	IV
1	0	36	18	6
2	18	48	0	44
3	46	8	6	0
4	18	32	28	0

Step 2

Subtract the smallest element of each column from every element in that column.

	I	II	III	IV
1	0	28	18	6
2	18	40	0	44
3	46	0	6	0
4	18	24	28	0

Step 3

Drew minimum number of horizontal and vertical lines to cover all the zeros

	I	II	III	IV
1	$\boxed{0}$	28	18	6
2	18	40	$\boxed{0}$	44
3	46	$\boxed{0}$	6	0
4	18	24	28	$\boxed{0}$

Since, No. of lines are equal to order of matrix, hence, solution is optimal.

1	I	16 hrs.
2	III	8 hrs.
3	II	38 hrs.
4	IV	20 hrs.
	Total	82 hrs.

Minimum time taken is 82 hrs.

Problem-4

Five swimmers are eligible to compete in a relay team which is to consist of four swimmers swimming four different swimming styles ; back stroke breast stroke, free style and butterfly. The time taken for the five swimmers – Anand, Bhaskar, Chandru, Dorai and Easwar- to cover a distance of 100 meters in various swimming styles are given below in minutes : seconds. Anand swims the back stroke in 1:09, the breast stroke in 1:15 and has never competed in the free style or butterfly. Bhaskar is a free style specialist averaging 1:01 for the 100 metres but can also swim the breast stroke in 1:16 and butterfly in 1:20. Chandru swims all styles – back storke 1:10, butterfly 1:12, free style 1:05 and breast stroke 1:20. Dorai swims only the butterfly 1:11 while Easwar swims the back stroke 1:20, the breast stroke 1:16, the free style 1:06 and the butterfly 1:10.

Required

Which swimmers should be assigned to which swimming style? Who will be in the relay?

Solution

Let us first create the assignment matrix with time expressed in seconds. Also it is an unbalanced assignment problem hence a dummy style is added to balance it.

	Back Stroke	Breast Stroke	Free Style	Butterfly	Dummy
Anand	69	75	-	-	0
Bhaskar	-	76	61	80	0
Chandru	70	80	65	72	0
Dorai	-	-	-	71	0
Easwar	80	76	66	70	0

Step 1

As there is a zero in each row, we go straight to the column reduction-

	Back Stroke	Breast Stroke	Free Style	Butterfly	Dummy
Anand	$\boxed{0}$	0	-	-	0
Bhaskar	-	1	$\boxed{0}$	10	0
Chandru	1	5	4	2	$\boxed{0}$
Dorai	-	-	-	1	0
Easwar	11	1	5	$\boxed{0}$	0

Step 2

The minimum number of lines to cover all zeros is 4, which is less than 5, the order of the square matrix. Hence, the above matrix will not provide the optimal solution. Thus we try to increase the number of zeros. Select the minimum uncovered element by these lines (which is 1). Subtract it from all the uncovered elements and add it to the elements lying on the intersection of lines, as drawn above. The revised matrix will be-

	Back Stroke	Breast Stroke	Free Style	Butterfly	Dummy
Anand	0	$\boxed{0}$	-	-	1
Bhaskar	-	1	$\boxed{0}$	11	1
Chandru	$\boxed{0}$	4	3	2	0
Dorai	-	-	-	1	$\boxed{0}$
Easwar	10	0	4	$\boxed{0}$	0

As the minimum number of lines to cover all zeros is 5, which is equal to the order of the square matrix, the above matrix will provide the optimal solution. The assignment is made below-

Swimmer	Swimming Style	Time (Seconds)
Anand	Breast Stroke	75
Bhaskar	Free Style	61
Chandru	Back Stroke	70
Dorai	Dummy (not participate)	-
Easwar	Butterfly	70
Total Minimum Time *in the relay*		276

Dorai will be out of the relay.

Problem-5

ABC company is engaged in manufacturing 5 brands of packet snacks. It is having five manufacturing setups, each capable of manufacturing any of its brands, one at a time. The cost to make a brand on these setups vary according to following table-

	S_1	S_2	S_3	S_4	S_5
B_1	4	6	7	5	11
B_2	7	3	6	9	5
B_3	8	5	4	6	9
B_4	9	12	7	11	10
B_5	7	5	9	8	11

Required

Assuming five setups are S_1, S_2, S_3, S_4, and S_5 and five brands are B_1, B_2, B_3, B_4, and B_5, Find the optimum assignment of the products on these setups resulting in the minimum cost.

Solution

This is an assignment problem whose objective is to assign on manufacturing set up to one brand so that the total cost of production is minimum. To determine the appropriate assignment, let us apply the assignment algorithm.

Subtract the minimum element of each row from all elements of that row to get the following matrix-

Brands	Manufacturing Setups				
	S_1	S_2	S_3	S_4	S_5
B_1	0	2	3	1	7
B_2	4	0	3	6	2
B_3	4	1	0	2	5
B_4	2	5	0	4	3
B_5	2	0	4	3	6

Now subtract the minimum elements of each column from all elements of that column-

Brands	Manufacturing Setups				
	S_1	S_2	S_3	S_4	S_5
B_1	$\boxed{0}$	2	3	0	5
B_2	4	0	3	5	$\boxed{0}$
B_3	4	1	$\boxed{0}$	1	3
B_4	2	5	0	3	1
B_5	2	$\boxed{0}$	4	2	4

The minimum number of lines drawn to cover all zeros is equal to 4 which is one less than the order of the matrix (= 5), the above table will not yield the optimal assignment. For obtaining the optimal assignment, we increase the number of zeroes by subtracting the minimum uncovered element from all uncovered elements and adding it to elements lying at the intersection of two lines, we get the following matrix-

Brands	Manufacturing Setups				
	S_1	S_2	S_3	S_4	S_5
B_1	$\boxed{0}$	3	4	0	5
B_2	4	1	4	5	$\boxed{0}$
B_3	3	1	0	$\boxed{0}$	2
B_4	1	5	$\boxed{0}$	2	0
B_5	1	$\boxed{0}$	4	1	3

Since the minimum number of lines required to cover all zeros is five, the above table will give the optimal solution. The required assignment is made as below-

Brand	Setup	Cost
B_1	S_1	4
B_2	S_5	5
B_3	S_4	6
B_4	S_3	7
B_5	S_2	5
	Total	27

Problem-6

A Production supervisor is considering, how he should assign five jobs that are to be performed, to five mechanists working under him. He wants to assign the jobs to the mechanists in such a manner that the aggregate cost to perform the jobs is the least. He has following information about the wages paid to the mechanists for performing these jobs-

Mechanist	*Job1*	*Job 2*	*Job 3*	*Job 4*	*Job 5*
A	*10*	*3*	*3*	*2*	*8*
B	*9*	*7*	*8*	*2*	*7*
C	*7*	*5*	*6*	*2*	*4*
D	*3*	*5*	*8*	*2*	*4*
E	*9*	*10*	*9*	*6*	*10*

Required

Assign the jobs to the mechanists so that the aggregate cost is the least.

Solution

The given problem is a balanced minimization problem.

Subtracting minimum element of each row from all the elements of that row, the given problem reduces to-

Mechanist	Job1	Job 2	Job 3	Job 4	Job 5
A	8	1	1	0	6
B	7	5	6	0	5
C	5	3	4	0	2
D	1	3	6	0	2
E	3	4	3	0	4

Subtract the minimum element of each column from all the elements of that column. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

Mechanist	Job1	Job 2	Job 3	Job 4	Job 5
A	7	$\boxed{0}$	0	0	4
B	6	4	5	$\boxed{0}$	3
C	4	2	3	0	$\boxed{0}$
D	$\boxed{0}$	2	5	0	0
E	2	3	2	0	2

Since the minimum number of lines covering all zeros is equal to 4 which is less than the number of columns / rows (=5), the above table will not provide optimal solution. Subtract the minimum uncovered element (=2) from all uncovered elements and add to the elements lying on the intersection of two lines, we get the following matrix-

Mechanist	Job1	Job 2	Job 3	Job 4	Job 5
A	7	$\boxed{0}$	0	2	6
B	4	2	3	$\boxed{0}$	3
C	2	0	1	0	$\boxed{0}$
D	$\boxed{0}$	2	5	2	2
E	0	1	$\boxed{0}$	0	2

Since the minimum number of horizontal and vertical lines to cover all zeros is equal to five which is equal to the order of the matrix, the above table will give the optimal solution. The optimal assignment is made below-

Mechanist	Job1	Job 2	Job 3	Job 4	Job 5
A	7	$\boxed{0}$	~~0~~	2	6
B	4	2	3	$\boxed{0}$	3
C	2	~~0~~	1	~~0~~	$\boxed{0}$
D	$\boxed{0}$	2	5	2	2
E	~~0~~	1	$\boxed{0}$	~~0~~	2

The optimal assignment is given below-

Mechanist	Job	Wages
A	2	3
B	4	2
C	5	4
D	1	3
E	3	9
	Total	21

The total least cost associated with the optimal mechanist-job assignment equals to 21.

Problem-7

A factory is going to modify of a plant layout to install four new machines M_1, M_2, M_3 and M_4. There are 5 vacant places J, K, L, M and N available. Because of limited space machine M_2 cannot be placed at L and M_3 cannot be placed at J. The cost of locating machine to place in Rupees is shown below:

(₹)

	J	K	L	M	N
M_1	18	22	30	20	22
M_2	24	18	--	20	18
M_3	--	22	28	22	14
M_4	28	16	24	14	16

Required

Determine the optimal assignment schedule in such a manner that the total costs are kept at a minimum.

Solution

Dummy machine (M_5) is inserted to make it a balanced cost matrix and assume its installation cost to be zero. Cost of install at cell M_3 (J) and M_2 (L) is very high marked as M.

	J	K	L	M	N
M_1	18	22	30	20	22
M_2	24	18	M	20	18

M_3	M	22	28	22	14
M_4	28	16	24	14	16
M_5 (Dummy)	0	0	0	0	0

Step 1

Subtract the minimum element of each row from each element of that row-

	J	**K**	**L**	**M**	**N**
M_1	0	4	12	2	4
M_2	6	0	M	2	0
M_3	M	8	14	8	0
M_4	14	2	10	0	2
M_5 (Dummy)	0	0	0	0	0

Step 2

Subtract the minimum element of each column from each element of that column-

	J	**K**	**L**	**M**	**N**
M_1	0	4	12	2	4
M_2	6	0	M	2	0
M_3	M	8	14	8	0
M_4	14	2	10	0	2
M_5 (Dummy)	0	0	0	0	0

Step 3

Draw lines to connect the zeros as under-

	J	**K**	**L**	**M**	**N**
M_1	$\boxed{0}$	4	12	2	4
M_2	6	$\boxed{0}$	M	2	0
M_3	M	8	14	8	$\boxed{0}$
M_4	14	2	10	$\boxed{0}$	2
M_5 (Dummy)	0	0	$\boxed{0}$	0	0

There are five lines which are equal to the order of the matrix. Hence the solution is optimal. We may proceed to make the assignment as under-

	J	K	L	M	N
M_1	$\boxed{0}$	4	12	2	4
M_2	6	$\boxed{0}$	M	2	$\cancel{0}$
M_3	M	8	14	8	$\boxed{0}$
M_4	14	2	10	$\boxed{0}$	2
M_5 (Dummy)	$\cancel{0}$	$\cancel{0}$	$\boxed{0}$	$\cancel{0}$	$\cancel{0}$

The following is the assignment which keeps the total cost at minimum-

Machines	Location	Costs (₹)
M_1	J	18
M_2	K	18
M_3	N	14
M_4	M	14
M_5 (Dummy)	L	0
	Total	64

Problem-8

A private firm employs typists on hourly piece rate basis for their daily work. Five typists are working in that firm and their charges and speeds are different. On the basis of some earlier understanding, only one job is given to one typist and the typist is paid for full hours even when he or she works for a fraction of an hour.

Typist	*Rate per hour (₹)*	*No. of pages typed per hour*
A	*5*	*12*
B	*6*	*14*
C	*3*	*8*
D	*4*	*10*
E	*4*	*11*

Job	*No. of pages*
P	*199*
Q	*175*
R	*145*
S	*298*
T	*178*

Required

Find the least cost allocation for the above data.

Solution

The following matrix gives the cost incurred if the typist (i = A, B, C, D, E) executes the job (j = P, Q, R, S, T).

Typist	Job P	Job Q	Job R	Job S	Job T
A	85	75	65	125	75
B	90	78	66	132	78
C	75	66	57	114	69
D	80	72	60	120	72
E	76	64	56	112	68

Subtracting the minimum element of each row from all its elements in turn, the above matrix reduces to-

Typist	Job P	Job Q	Job R	Job S	Job T
A	20	10	0	60	10
B	24	12	0	66	12
C	18	9	0	57	12
D	20	12	0	60	12
E	20	8	0	56	12

Now subtract the minimum element of each column from all its elements in turn, and draw minimum number of lines horizontal or vertical so as to cover all zeros. All zeros can be covered by four lines as given below-

Typist	Job P	Job Q	Job R	Job S	Job T
A	2	2	0	4	$\boxed{0}$
B	6	4	$\boxed{0}$	10	2
C	$\boxed{0}$	1	0	1	2
D	2	4	0	4	2
E	2	$\boxed{0}$	0	0	2

Since there are only 4 lines (<5) to cover all zeros, optimal assignment cannot be made. The minimum uncovered element is 1.

We subtract the value 1 from all uncovered elements, add this value to all intersections of two lines values and leave the other elements undisturbed. The revised matrix so obtained is given below-

Typist	Job P	Job Q	Job R	Job S	Job T
A	3	2	1	4	$\boxed{0}$
B	6	3	$\boxed{0}$	9	1
C	$\boxed{0}$	0	0	0	1
D	2	3	0	3	1
E	3	$\boxed{0}$	1	0	2

Since the minimum no. of lines required to cover all the zeros is only 4 (< 5), optimal assignment cannot be made at this stage also.

The minimum uncovered element is 2. Repeating the usual process again, we get the following matrix-

Typist	Job P	Job Q	Job R	Job S	Job T
A	1	0	1	2	$\boxed{0}$
B	4	1	$\boxed{0}$	7	1
C	0	$\boxed{0}$	2	0	3
D	$\boxed{0}$	1	0	1	1
E	3	0	3	$\boxed{0}$	4

Since the minimum number of lines to cover all zeros is equal to 5, this matrix will give optimal solution. The optimal assignment is made in the matrix below-

Typist	Job P	Job Q	Job R	Job S	Job T
A	1	$\cancel{0}$	1	2	$\boxed{0}$
B	4	1	$\boxed{0}$	7	1
C	$\cancel{0}$	$\boxed{0}$	2	$\cancel{0}$	3
D	$\boxed{0}$	1	$\cancel{0}$	1	1
E	3	$\cancel{0}$	3	$\boxed{0}$	4

Typist	Job	Cost (₹)
A	T	75
B	R	66
C	Q	66
D	P	80
E	S	112
	Total	399

Note

In this case the above solution is not unique. Alternate solution also exists.

Problem-9

A car hiring company has one car at each of the five depots A, B C, D and E. A customer in each of the five towns V, W, X, Y and Z requires a car. The distance in kms, between depots (origin) and the town (destination) are given in the following table-

Town	***Depots***				
	A	***B***	***C***	***D***	***E***
V	*3*	*5*	*10*	*15*	*8*
W	*4*	*7*	*15*	*18*	*8*
X	*8*	*12*	*20*	*20*	*12*
Y	*5*	*5*	*8*	*10*	*6*
Z	*10*	*10*	*15*	*25*	*10*

Required

Find out as to which car should be assigned to which customer so that the total distance travelled is a minimum. How much is the total travelled distance?

Solution

The given problem is a balance minimization assignment problem. Let us apply the assignment algorithm to find the optimal assignment. Subtracting the smallest element of each row from all the elements of that row, we get the following table-

Town	Depots				
	A	B	C	D	E
V	0	2	7	12	5
W	0	3	11	14	4
X	0	4	12	12	4
Y	0	0	3	5	1
Z	0	0	5	15	0

Subtracting the smallest element of each column from all the elements of that column, wet get the following-

Town	Depots				
	A	B	C	D	E
V	$\boxed{0}$	2	4	7	5
W	0	3	8	9	4
X	0	4	9	7	4
Y	0	0	$\boxed{0}$	0	1
Z	0	0	2	10	$\boxed{0}$

Draw the minimum number of lines to cover all zeros. Since the number of lines (=3) is not equal to the order of the matrix (which is 5), the above matrix will not give the optimal solution. Subtract the minimum uncovered element (=2) from all uncovered elements and add it to the elements lying on the intersection of two lines, we get the following matrix-

Town	Depots				
	A	B	C	D	E
V	0	$\boxed{0}$	2	5	3
W	$\boxed{0}$	1	6	7	2
X	0	2	7	5	2
Y	2	0	$\boxed{0}$	0	1
Z	2	0	2	10	$\boxed{0}$

Against, the minimum number of lines of cover all zeros is 4, which is less than the order of the matrix. Subtract the uncovered element (=2) from all the uncovered element and add it to the elements lying on the intersection of two lines, we get-

Town	Depots				
	A	B	C	D	E
V	0	$\boxed{0}$	0	3	1
W	$\boxed{0}$	1	4	5	0
X	0	2	5	3	0
Y	4	2	$\boxed{0}$	0	1
Z	4	2	2	10	$\boxed{0}$

Since the minimum number of lines to cover all zeros is 4 which is less than the order of the matrix, hence, the above matrix will not give the optimal solution. Subtracting the uncovered element (=1) from all the uncovered elements and adding it to the elements lying on the intersection of two lines, we get-

Town	Depots				
	A	B	C	D	E
V	1	0	$\boxed{0}$	3	2
W	0	$\boxed{0}$	3	4	0
X	$\boxed{0}$	1	4	2	0
Y	5	2	0	$\boxed{0}$	2
Z	4	1	1	9	$\boxed{0}$

Since the minimum number of lines of cover all zeros is 5 which is equal to the order of the matrix, the above table will give the optimal assignment. The optimal assignment is made below-

This optimal assignment is-

Customer at Town	Car at Depot	Distance (Km.)
V	C	10
W	B	7
X	A	8
Y	D	10
Z	E	10
	Total	45

Hence the minimum total travelled distance equals to 45 kms.

Maximization Problem

Problem-10

A company has four zones open and four marketing managers available for assignment. The zones are not equal in sales potentials. It is estimated that a typical marketing manager operating in each zone would bring in the following Annual sales:

Zones	*(₹)*
East……………………………………………….	*2,40,000*
West……………………………………………….	*1,92,000*
North……………………………………………..	*1,44,000*
South……………………………………………..	*1,20,000*

The four marketing manages are also different in ability. It is estimated that working under the same conditions, their yearly sales would be proportionately as under:

Manager M……………………………………….	*8*
Manager N……………………………………….	*7*
Manager O……………………………………….	*5*
Manager P……………………………………….	*4*

Required

If the criterion is maximum expected total sales, find the optimum assignment and the maximum sales.

Solution

Sum of the proportion is 24 (8 + 7 + 5 + 4). Assuming ₹1,000 as one unit, the effective matrix is as follows-

Effective Matrix

Manager	**Zones**			
	East	**West**	**North**	**South**
M	80 [(8/24) × 240]	64 [(8/24) × 192]	48 [(8/24) × 144]	40 [(8/24) × 120]
N	70 [(7/24) × 240]	56 [(7/24) × 192]	42 [(7/24) × 144]	35 [(7/24) × 120]
O	50 [(5/24) × 240]	40 [(5/24) × 192]	30 [(5/24) × 144]	25 [(5/24) × 120]
P	40 [(4/24) × 240]	32 [(4/24) × 192]	24 [(4/24) × 144]	20 [(4/24) × 120]

Convert the maximization problem to minimization problem. The resultant loss matrix is as follows-

Loss Matrix

Manager	East	West	North	South
M	0	16	32	40
N	10	24	38	45
O	30	40	50	55
P	40	48	56	60

Row Operation

Manager	East	West	North	South
M	0	16	32	40
N	0	14	28	35
O	0	10	20	25
P	0	8	16	20

Column Operation

Manager	East	West	North	South
M	$\boxed{0}$	8	16	20
N	0	6	12	15
O	0	2	4	5
P	0	$\boxed{0}$	0	0

No. of lines are 2 which is less than the order of matrix, hence, this is not an optimal solution. Lowest uncovered element 2 shall be deducted from all uncovered cells value and added to the value at intersections.

Manager	East	West	North	South
M	$\boxed{0}$	6	14	18
N	0	4	10	13
O	0	$\boxed{0}$	2	3
P	2	0	$\boxed{0}$	0

Again no. of lines covering zeros are not equal to the order of matrix, therefore, lowest uncovered element 2 shall be deducted from all uncovered cells value and added with value at intersections.

Manager	East	West	North	South
M	$\boxed{0}$	6	12	16
N	0	4	8	11
O	0	$\boxed{0}$	0	1
P	4	2	$\boxed{0}$	0

Once again no. of lines covering zeros are not equal to the order of matrix, therefore, lowest uncovered element 4 shall be deducted from all uncovered cells value and added with value at intersections.

Manager	East	West	North	South
M	$\boxed{0}$	2	8	12
N	0	$\boxed{0}$	4	7
O	4	0	$\boxed{0}$	1
P	8	2	0	$\boxed{0}$

Now the number of lines covering zeros are equal to the order of matrix, hence, this is the optimal solution.

Assignment	Sales (₹)
M - East	80,000
N - West	56,000
O - North	30,000
P - South	20,000
Total	1,86,000

Problem-11

Five lathes are to be allotted to five operators (one for each). The following table gives weekly output figures (in pieces)-

Operator	*Weekly Output in Lathe*				
	L_1	*L_2*	*L_3*	*L_4*	*L_5*
P	*20*	*22*	*27*	*32*	*36*
Q	*19*	*23*	*29*	*34*	*40*
R	*23*	*28*	*35*	*39*	*34*
S	*21*	*24*	*31*	*37*	*42*
T	*24*	*28*	*31*	*36*	*41*

Profit per piece is ₹ 25.

Required

Find the maximum profit per week.

Solution

The given assignment problem is a maximization problem. Let us convert it into an opportunity loss matrix by subtracting all the elements of the given table from the highest element of the table that is 42.

Operator	Weekly Output in Lathe				
	L_1	L_2	L_3	L_4	L_5
P	22	20	15	10	6
Q	23	19	13	8	2
R	19	14	7	3	8
S	21	18	11	5	0
T	18	14	11	6	1

The assignment procedure is now applies to above problem. Subtract the minimum element of each row from all the elements of that row, and repeat this step with all the rows of the table.

Operator	Weekly output in lathe				
	L_1	L_2	L_3	L_4	L_5
P	16	14	9	4	0
Q	21	17	11	6	0
R	16	11	4	0	5
S	21	18	11	5	0
T	17	13	10	5	0

Repeat the above step with the columns of the table also. Subtract the minimum element of each column from all the elements of that column.

Operator	Weekly Output in Lathe				
	L_1	L_2	L_3	L_4	L_5
P	$\boxed{0}$	3	5	4	0
Q	5	6	7	6	$\boxed{0}$
R	0	$\boxed{0}$	0	0	5
S	5	7	7	5	0
T	1	2	6	5	0

Since the minimum number of lines to cover all zeros is 3 which is less than 5 (order of the square matrix), the above matrix will not give the optimal solution. Hence we try to increase the number of zeros. Subtract the least uncovered element which is 2 from all uncovered elements and add it to all the elements lying on the intersection of two lines. We get the following matrix-

Operator	Weekly Output in Lathe				
	L_1	L_2	L_3	L_4	L_5
P	$\boxed{0}$	1	3	2	0
Q	5	4	5	4	$\boxed{0}$
R	2	0	$\boxed{0}$	0	7
S	5	5	5	3	0
T	1	$\boxed{0}$	4	3	0

Again, the minimum number of lines drawn to cover all zeros is 4. Repeating the above steps once again, we get the following table-

Operator	Weekly Output in Lathe				
	L_1	L_2	L_3	L_4	L_5
P	$\boxed{0}$	2	3	2	1
Q	4	4	4	3	$\boxed{0}$
R	2	1	$\boxed{0}$	0	8
S	4	5	4	2	0
T	0	$\boxed{0}$	3	2	0

The minimum number of lines to cover all zeros is 4 which is less than 5. Repeating the above step once again, we thus get-

Operator	Weekly Output in Lathe				
	L_1	L_2	L_3	L_4	L_5
P	$\boxed{0}$	0	1	0	1
Q	4	2	2	1	$\boxed{0}$
R	4	1	$\boxed{0}$	0	10
S	4	3	2	$\boxed{0}$	0
T	2	$\boxed{0}$	3	2	2

The minimum number of lines to cover all zeros is 5. Hence the above matrix will give the optimal solution. The optimal assignment is made as below-

Operator	Lathe Machine	Weekly Output
P	L_1	20
Q	L_5	40
R	L_3	35
S	L_4	37
T	L_2	28
	Total	160

The maximum profit per week is ₹4,000 (₹ 25 × 160).

Problem-12

An organization producing 4 different products, viz., WW, WX, WY, and WZ having 4 operators, viz., A,B, C and D who are capable of producing any of the four products, works effectively 7 hours a day. The time (in minutes) required for each operator for producing each of the products are given in the cells of the following matrix along with profit (Rs. per unit):

Operator	*Product*			
	WW	*WX*	*WY*	*WZ*
A	*3.0*	*5.0*	*7.0*	*6.0*
B	*3.5*	*2.5*	*1.5*	*2.0*
C	*3.0*	*3.5*	*5.0*	*5.0*
D	*10.0*	*5.0*	*7.5*	*7.5*
Profit	*1.5*	*1.0*	*2.0*	*0.5*

Required

Find out the assignment of operators to product which will maximize the profit.

Solution

Given that the unit (factory) works effectively for 7 hours and the processing time (in minutes) for each of the four products by different operators, we obtain the production and profit matrices as follows:

Production Matrix

Operator	Product			
	WW	WX	WY	WZ
A	140	84	60	70
B	120	168	280	210
C	140	120	84	84
D	42	84	56	56

Profit Matrix:

Operator	Product			
	WW	WX	WY	WZ
A	210	84	120	35
B	180	168	560	105
C	210	120	168	42
D	63	84	112	28

Subtract all the elements from the highest value and obtain the following matrix:

Operator	Product			
	WW	WX	WY	WZ
A	350	476	440	525
B	380	392	0	455
C	350	440	392	518
D	497	476	448	532

Subtracting row minimum, we obtain:

Operator	Product			
	WW	WX	WY	WZ
A	0	126	90	175

B	380	392	0	455
C	0	90	42	168
D	49	28	0	84

Subtracting column minimum and after assignment, we get:

Operator	**Product**			
	WW	**WX**	**WY**	**WZ**
A	$\boxed{0}$	98	90	91
B	380	364	$\boxed{0}$	371
C	0	62	42	84
D	49	$\boxed{0}$	0	0

Since required number of assignments could not be made, proceed further:

Operator	**Product**			
	WW	**WX**	**WY**	**WZ**
A	$\boxed{0}$	36	90	29
B	380	302	$\boxed{0}$	309
C	0	$\boxed{0}$	42	22
D	111	0	62	$\boxed{0}$

The optimum solution is:

Operator	**Product**	**Profit (Rs.)**
A	WW	210
B	WY	560
C	WX	120
D	WZ	28
	Total Profit	918

Problem-13

Imagine yourself to be the Executive Director of a 5-Star Hotel which has four banquet halls that can be used for all functions including weddings. The halls were all about the same size and the facilities in each hall differed. During a heavy marriage season, 4 parties approached you to reserve a hall for the marriage to be celebrated on the same day. These marriage parties were told that the first choice among these 4 halls would cost ₹ 25,000 for the day.

They were also required to indicate the second, third and fourth preferences and the price that they would be willing to pay. Marriage party A & D indicated that they won't be interested in Halls 3 & 4. Other particulars are given in the following table-

Revenue/Hall

Marriage Party	*Hall 1*	*Hall 2*	*Hall 3*	*Hall 4*
A	*₹ 25,000*	*₹ 22,500*	*X*	*X*
B	*₹ 20,000*	*₹ 25,000*	*₹ 20,000*	*₹ 12,500*
C	*₹ 17,500*	*₹ 25,000*	*₹ 15,000*	*₹ 20,000*
D	*₹ 25,000*	*₹ 20,000*	*X*	*X*

Where X indicates that the party does not want that hall.

Required

Decide on an allocation that will maximize the revenue to your hotel.

Solution

The objective of the given problem is to identify the preferences of marriage parties about halls so that hotel management could maximize its profit.

To solve this problem first convert it to a minimization problem by subtracting all the elements of the given matrix from its highest element. The matrix so obtained which is known as loss matrix is given below-

Loss Matrix/Hall

Marriage Party	1	2	3	4
A	0	2,500	X	X
B	5,000	0	5,000	12,500
C	7,500	0	10,000	5,000
D	0	5,000	X	X

Now we can apply the assignment algorithm to find optimal solution. Subtracting the minimum element of each column from all elements of that column-

Loss Matrix/Hall

Marriage Party	1	2	3	4
A	$\boxed{0}$	2,500	X	X
B	5,000	0	$\boxed{0}$	7,500
C	7,500	0	5,000	$\boxed{0}$
D	0	5,000	X	X

The minimum number of lines to cover all zeros is 3 which is less than the order of the square matrix (i.e.4), the above matrix will not give the optimal solution. Subtracting the minimum uncovered element (2,500) from all uncovered elements and add it to the elements lying on the intersection of two lines, we get the following matrix-

Loss Matrix/Hall

Marriage Party	1	2	3	4
A	0	0	X	X
B	7,500	0	0	7,500
C	10,000	0	5,000	0
D	0	2,500	X	X

Since the minimum number of lines to cover all zeros is 4 which is equal to the order of the matrix, the above matrix will give the optimal solution which is given below-

Loss Matrix/Hall

Marriage Party	1	2	3	4
A	0	0	X	X
B	7,500	0	0	7,500
C	10,000	0	5,000	0
D	0	2,500	X	X

Optimal Schedule is-

Marriage Party	Hall	Revenue (₹)
A	2	22,500
B	3	20,000
C	4	20,000
D	1	25,000
Total		87,500

The Travelling Salesman's Problem

Problem-14

A salesman has to visit five cities. He wishes to start from a particular city, visit each city once and then return to his starting point. Cost (in ₹ '000) of travelling from one city to another is given below:

	P	*Q*	*R*	*S*	*T*
P	*-*	*5*	*14*	*20*	*2*
Q	*17*	*-*	*8*	*23*	*5*
R	*23*	*20*	*-*	*11*	*20*
S	*35*	*11*	*17*	*-*	*14*
T	*2*	*8*	*5*	*23*	*-*

Required

Find out the 'Least Cost Route'.

Solution

Row Operation-

	P	Q	R	S	T
P	-	3	12	18	0
Q	12	-	3	18	0
R	12	9	-	0	9
S	24	0	6	-	3
T	0	6	3	21	-

Column Operation-

	P	Q	R	S	T
P	-	3	9	18	0
Q	12	-	0	18	0
R	12	9	-	0	9
S	24	0	3	-	3
T	0	6	0	21	-

We know check if optimal assignment can be made in below table or not. Proceeding, we get following table-

	P	Q	R	S	T
P	-	3	9	18	$\boxed{0}$
Q	12	-	$\boxed{0}$	18	0
R	12	9	-	$\boxed{0}$	9
S	24	$\boxed{0}$	3	-	3
T	$\boxed{0}$	6	0	21	-

The above solution is optimum solution with two routes-

P to T to P and

Q to R to S to Q

Above table provides the optimum solution but do not satisfy travelling condition. To solve this problem we have to bring next minimum element in the matrix i.e.3. Now the possible *new assignments* are

P to Q instead of P to T,

S to R instead of S to Q and

S to T instead of S to Q.

Let us consider each of the new assignment independently.

Situation-1

We make 'assignment' in cell (P, Q) instead of 'assignment' in cell (P, T). The resulting table is shown below-

	P	Q	R	S	T
P	-	$\boxed{3}$	9	18	0
Q	12	-	$\boxed{0}$	18	0
R	12	9	-	$\boxed{0}$	9
S	24	0	3	-	$\boxed{3}$
T	$\boxed{0}$	6	0	21	-

The feasible solution is P to Q to R to S to T to P and it involves a cost of ₹40,000 (₹5,000 + ₹8,000 + ₹11,000 + ₹14,000 + ₹2,000).

Situation-2

We make 'assignment' in cell (S, R) instead of 'assignment' in cell (S, Q). The resulting table is shown below-

	P	Q	R	S	T
P	-	$\boxed{3}$	9	18	0
Q	12	-	0	18	$\boxed{0}$
R	12	9	-	$\boxed{0}$	9
S	24	0	$\boxed{3}$	-	3
T	$\boxed{0}$	6	0	21	-

The resulting solution is P to Q to T to P, R to S to R, which is not feasible as it does not satisfy the travelling condition.

Situation-3

We make 'assignment' in cell (S, T) instead of 'assignment' in cell (S, Q). The resulting table is shown below-

	P	Q	R	S	T
P	-	$\boxed{3}$	9	18	0
Q	12	-	$\boxed{0}$	18	0
R	12	9	-	$\boxed{0}$	9
S	24	0	3	-	$\boxed{3}$
T	$\boxed{0}$	6	0	21	-

The resulting table is same as in Situation 1 which gives the feasible solution P to Q to R to S to T to P with cost of ₹40,000.

Hence least cost route is P to Q to R to S to T to P with cost of ₹40,000.

☞

Refer Problem No.15 for **alternative way**.

Problem-15

A salesman has to visit five cities. He wishes to start from a particular city, visit each city once and then return to his starting point. Cost (in ₹ '000) of travelling from one city to another is given below-

From / To	*P*	*Q*	*R*	*S*	*T*
P	*-*	*6*	*12*	*4*	*6*
Q	*6*	*-*	*10*	*4*	*6*
R	*12*	*10*	*-*	*12*	*8*
S	*4*	*4*	*12*	*-*	*12*
T	*6*	*6*	*8*	*12*	*-*

Required

Find out the least cost route.

Solution

Row Operation

Cities	P	Q	R	S	T
P	-	2	8	0	2
Q	2	-	6	0	2
R	4	2	-	4	0
S	0	0	8	-	8
T	0	0	2	6	-

Column Operation

Cities	P	Q	R	S	T
P	-	2	6	$\boxed{0}$	2
Q	2	-	4	0	2
R	4	2	-	4	$\boxed{0}$
S	$\boxed{0}$	0	6	-	8
T	0	0	$\boxed{0}$	6	-

Since the minimum number of lines covering all zeros is equal to 4 which is less than the number of columns / rows (=5), the above table will not provide optimal solution. Subtract the minimum uncovered element (=2) from all uncovered elements and add to the elements lying on the intersection of two lines, we get the following matrix-

Cities	P	Q	R	S	T
P	-	$\boxed{0}$	4	0	2
Q	0	-	2	$\boxed{0}$	2
R	2	0	-	4	$\boxed{0}$
S	$\boxed{0}$	0	6	-	10
T	0	0	$\boxed{0}$	8	-

Or

Cities	P	Q	R	S	T
P	-	0	4	$\boxed{0}$	2
Q	$\boxed{0}$	-	2	0	2
R	2	0	-	4	$\boxed{0}$
S	0	$\boxed{0}$	6	-	10
T	0	0	$\boxed{0}$	8	-

The routes and their associated costs are as follows:

From	To	Cost (₹)
P	Q	6,000
Q	S	4,000
R	T	8,000
S	P	4,000
T	R	8,000
	Total	30,000

P → Q → S → P route does not cover the destination R and T so, these routes are not optimal and alternative route should be find out.

Let us find out alternative routes from the obtained reduced matrix.

Cities	P	Q	R	S	T
P	-	0	4	0	2
Q	0	-	2	0	2
R	2	0	-	4	0
S	0	0	6	-	10
T	0	0	0	8	-

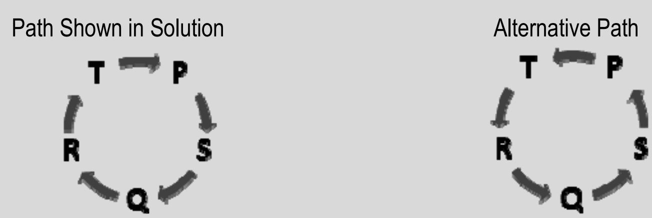
From	Possible Routes	Route Selected	Reasoning
P	P → Q, P → S	P → S	P → Q has already been rejected.
Q	Q → P, Q → S, Q → R, Q → T	Q → R	Q → P does not cover the other cities. Q → S has already been rejected. So we need to move towards next lowest cost destination i.e. '2'. There are two possibilities i.e. Q → R or Q → T. Q→ T is not possible as destination T has already been selected.

R	R → Q, R → T	R → T	R → T has already been selected.
S	S → P, S → Q.	S → Q	S → P has already been rejected.
T	T → P, T → Q T → R	T → P	Destination Q and R have already been selected.

The possible least cost route is P → S → Q → R → T → P

From	To	Cost (₹)
P	S	4,000
S	Q	4,000
Q	R	10,000
R	T	8,000
T	P	6,000
	Total	32,000

☞



Possible Least Cost is ₹ 32,000 in both of the cases.

Problem-16

The cost matrix giving selling costs per unit of a product by salesman A, B, C and D in regions R_1, R_2, R_3 and R_4 is given below:

	A	*B*	*C*	*D*
R_1	4	12	16	8
R_2	20	28	32	24
R_3	36	44	48	40
R_4	52	60	64	56

Required

(i) *Assign one salesman to one region to minimise the selling cost.*

(ii) *If the selling price of the product is ₹ 200 per unit and variable cost excluding the selling cost given in the table is ₹ 100 per unit, find the assignment that would maximise the contribution.*

(iii) *What other conclusion can you make from the above?*

Solution

(i) Subtracting minimum element of each row-

	A	B	C	D
R_1	0	8	12	4
R_2	0	8	12	4
R_3	0	8	12	4
R_4	0	8	12	4

Subtracting minimum element of each column-

	A	B	C	D
R_1	$\boxed{0}$	0	0	0
R_2	0	$\boxed{0}$	0	0
R_3	0	0	$\boxed{0}$	0
R_4	0	0	0	$\boxed{0}$

Minimum no. of lines to cover all zeros are 4 (equal to order of matrix). Hence optional assignment is possible.

Minimum Cost = $AR_1 + BR_2 + CR_3 + DR_4$

= 4 + 28 + 48 + 56

= 136

Since all are zeros, there are 24 solutions (4 × 3 × 2 × 1) to this assignment problem.

(ii) Given - Sales Price ₹200, Variable Cost Excluding Selling Cost ₹100

The contribution matrix is given below-

	A	B	C	D
R_1	96	88	84	92
R_2	80	72	68	76
R_3	64	56	52	60
R_4	48	40	36	44

Subtracting all the cells value with the highest cell value i.e. 96 to make it loss matrix-

	A	B	C	D
R_1	0	8	12	4
R_2	16	24	28	20
R_3	32	40	44	36
R_4	48	56	60	52

Subtracting minimum term of each row-

	A	B	C	D
R_1	0	8	12	4
R_2	0	8	12	4
R_3	0	8	12	4
R_4	0	8	12	4

This is the same as the earlier matrix.

Maximum Contribution $= AR_1 + BR_2 + CR_3 + DR_4$

$= ₹96 + ₹72 + ₹52 + ₹44$

$= ₹264$

(iii) **(a)** The relative cost of assigning person i to region r do not change by addition or subtraction of a constant from either a row, or column or all elements of the matrix.

(b) Minimising cost is the same as maximizing contribution. Hence, the assignment solution will be the same, applying point (i) above.

(c) Many zero's represent many feasible least cost assignment. Here, all zeros mean maximum permutation of a 4×4 matrix, viz. 24 solutions $(4 \times 3 \times 2 \times 1)$ are possible.

Miscellaneous Problems

Problem-17

A manager was asked to assign tasks to operators (one task per operator only) so as to minimize the time taken. He was given the matrix showing the hours taken by the operators for the tasks.

First, he preformed the row minimum operation. Secondly, he did the column minimum operation. Then, he realized that there were 4 tasks and 5 operators. At the third step he introduced the dummy row and continued with his fourth step of drawing lines to cover zeros. He drew 2 vertical lines (under operator III and operator IV) and two horizontal lines (aside task T_4 and dummy task T_5). At step 5, he performed the necessary operation with the uncovered element, since the number of lines was less than the order of the matrix. After this, his matrix appeared as follows:

Operators

Tasks	I	II	III	IV	V
T_1	4	2	5	0	0
T_2	6	3	3	0	3
T_3	4	0	0	0	1
T_4	0	0	5	3	0
T_5 (Dummy)	0	0	3	3	0

Required

(i) What was the matrix after step II? Based on such matrix, ascertain (ii) and (iii) given below.

(ii) What was the most difficult task for operators I, II and V?

(iii) Who was the most efficient operators?

(iv) If you are not told anything about the manager's errors, which operator would be denied any task? Why?

✍ Solution

Matrix after **Step V** is as follows-

	I	II	III	IV	V
T_1	4	2	5	0	0
T_2	6	3	3	0	3
T_3	4	0	0	0	1
T_4	0	0	5	3	0
T_5 (Dummy)	0	0	3	3	0

Junction values at T_5 (Dummy) is 3, it implies 3 was the minimum uncovered element.

Now we do the reverse steps.

Previous step was i.e. **Step IV:**

	I	II	III	IV	V
T_1	7	5	5	0	3
T_2	9	6	3	0	6
T_3	7	3	0	0	4
T_4	0	0	2	0	0
T_5 (Dummy)	0	0	0	0	0

Step III:

	I	II	III	IV	V
T_1	7	5	5	0	3
T_2	9	6	3	0	6
T_3	7	3	0	0	4
T_4	0	0	2	0	0
T_5 (Dummy)	0	0	0	0	0

(i)

Matrix after **Step II** -

	I	II	III	IV	V
T_1	7	5	5	0	3
T_2	9	6	3	0	6
T_3	7	3	0	0	4
T_4	0	0	2	0	0

(ii)

Based on the Matrix after Step II most difficult task for operator I, II and V are as follows-

Operator I	=	T_2 (9 hours)
Operator II	=	T_2 (6 hours)
Operator V	=	T_2 (6 hours)

(iii)

Based of the Matrix after Step II the most efficient operator is Operator IV.

(iv)

If the Manager's error is not known, then assignment would be-

	I	II	III	IV	V
T_1	4	2	5	0	$\boxed{0}$
T_2	6	3	3	$\boxed{0}$	3
T_3	4	0	$\boxed{0}$	0	1
T_4	0	0	5	3	0
T_5 (Dummy)	0	0	3	3	0

We continue the assignment; T_1 – V, T_2 – IV, T_3 – III are fixed. Between T_4 and T_5, I or II can be allotted. So, operator I or II can be denied the job.

Problem-18

Four operators O_1, O_2, O_3 and O_4 are available to a manager who has to get four jobs J_1, J_2, J_3 and J_4 done by assigning one job to each operator. Given the times needed by different operators for different jobs in the matrix below-

	J_1	J_2	J_3	J_4
O_1	12	10	10	8
O_2	14	12	15	11
O_3	6	10	16	4
O_4	8	10	9	7

Required

(i) How should the manager assign the jobs so that the total time needed for all four jobs is minimum?

(ii) *If job J2 is not to be assigned to operator O2 what should be the assignment and how much additional total time will be required?*

Solution

This is an assignment problem whose objective is to assign one job to one operator, so that total time needed for all four jobs is minimum. To determine appropriate assignment of jobs and operators, let us apply the assignment algorithm. Subtract the minimum element of each row from all elements of that row to get the following matrix-

	J_1	J_2	J_3	J_4
O_1	4	2	2	0
O_2	3	1	4	0
O_3	2	6	12	0
O_4	1	3	2	0

Now subtract the minimum element of each column from all elements of that column-

	J_1	J_2	J_3	J_4
O_1	3	1	$\boxed{0}$	0
O_2	2	$\boxed{0}$	2	0
O_3	2	5	10	$\boxed{0}$
O_4	$\boxed{0}$	2	0	0

The minimum number of lines drawn to cover all zeros is equal to 4. Since the number of lines drawn viz., 4 is equal to the number of jobs or the number of operators, so we proceed for making the optimal assignment.

Thus the optimal assignment in this part of the Problem is-

Operator	Job
O_1	J_3
O_2	J_2
O_3	J_4
O_4	J_1

The total time taken by four operators to perform the jobs is 34 (10+ 12 + 4 + 8).

If job J_2 is not to be assigned to operator O_2 then this objective can be achieved by replacing the time for cell (O_2, J_2) by a very large time estimate say M. Now apply the assignment algorithm to the following matrix so obtained-

	J_1	J_2	J_3	J_4
O_1	12	10	10	8
O_2	14	M	15	11
O_3	6	10	16	4
O_4	8	10	9	7

Perform row and column operations to the above matrix as mentioned in part (i) of the problem. We thus have the following matrix-

	J_1	J_2	J_3	J_4
O_1	4	2	2	0
O_2	3	M	4	0
O_3	2	6	12	0
O_4	1	3	2	0

	J_1	J_2	J_3	J_4
O_1	3	$\boxed{0}$	0	0
O_2	2	M	2	$\boxed{0}$
O_3	1	4	10	0
O_4	$\boxed{0}$	1	0	0

Since the minimum number of lines drawn in the above matrix to cover all the zeroes is 3 which is less than the number of operators or jobs, therefore the above table will not yield the optimal assignment. For obtaining the optimal assignment we increase the number of zeros by subtracting the minimum uncovered element from all uncovered elements and adding it to elements lying at the intersection of two lines, we get the following matrix-

	J_1	J_2	J_3	J_4
O_1	3	$\boxed{0}$	0	0
O_2	1	M	1	$\boxed{0}$
O_3	$\boxed{0}$	3	9	0
O_4	0	1	$\boxed{0}$	0

Since the minimum number of lines required to cover all zeros is four, so the above matrix will give the optimal solution. The required assignment is made as below-

Operator	Job
O_1	J_2
O_2	J_4
O_3	J_1
O_4	J_3

The minimum time required is 36 (10 + 11 + 6 + 9).

Additional total time required will be 2 (36 – 34) units of time.

Problem-19

Methods I, II, III and IV are available for one-to-one assignment to factories A, B and C. The time taken (in hours) for implementing these methods in the factories is tabulated below with the objective of minimization.

Factories→ *↓ Methods*	*(Time Taken – hours)*		
	A	*B*	*C*
I	*35*	*25*	*28*
II	*23*	*32*	*25*
III	*25*	*42*	*21*
IV	*35*	*35*	*28*

Required

(i) *Show the optimal assignment by circling the cells using the assignment algorithm (description of algorithm is not required). Which method will not be implemented?*

(ii) *What is the minimum savings (in hours) required) over the current given duration, for preferring the implementation of the method identified in (i) above? When it so justifies, which method will it replace? Why?*

Solution

(i) The order of the matrix shall be made balanced by introducing a Dummy Column-

Methods	Factory			
	A	B	C	Dummy
I	35	25	28	0

II	23	32	25	0
III	25	42	21	0
IV	35	35	28	0

Performing Column Operation by subtracting each cell value with lowest value in the respective column-

Methods	Factory			
	A	**B**	**C**	**Dummy**
I	~~12~~	~~$\boxed{0}$~~	~~7~~	~~0~~
II	~~$\boxed{0}$~~	~~7~~	~~4~~	~~0~~
III	~~2~~	~~17~~	~~$\boxed{0}$~~	~~0~~
IV	~~12~~	~~10~~	~~7~~	~~$\boxed{0}$~~

Assignment of Methods-

Method	Factory	Time Taken (hrs.)
I	B	25
II	A	23
III	C	21
	Total	69

Method IV has been assigned to Dummy factory. Hence, **Method IV** will not be implemented.

(ii) Minimum saving required (in hours) in current duration of Method IV in three Factories least of the following:

	A	B	C
Method Assigned	II	I	III
Minimum Time (assigned above)	23 hrs.	25 hrs	21 hrs.
Time Required (If implementing method IV)	35 hrs	35 hrs	28 hrs
Saving	12 hrs	10 hrs	7 hrs

The Minimum Savings required over the current given duration is **7 hours**.

Method IV will be preferred for implementation if the current duration in Factory C could be reduced by **more than 7 hours**.

If time duration taken by Method IV in Factory C will be reduced by **more than 7 hours**, it will be replacing **Method III**.

SECTION - C

Assignment Problem – Basic Concepts

Problem-1

Explain following statement

– Assignment problem is special case of transportation problem; it can also be solved by transportation methods.

Solution

The assignment problem is special case of transportation problem; it can also be solved by transportation method. But the solution obtained by applying this method would be severely degenerate.This is because the optimality test in the transportation method requires that there must be m+n-1 allocations/assignments. But due to the special structure of assignment problem of order n × n, any solution cannot have more than n assignments. Thus, the assignment problem is naturally degenerate. In order to remove degeneracy, n-1* number of dummy allocations will be required in order to proceed with the transportation method. Thus, the problem of degeneracy at each solution makes the transportation method computationally inefficient for solving an assignment problem.

$(*)\ \underline{m+n-1} - n \Rightarrow \underline{n+n-1} - n \Rightarrow \underline{2n-1} - n \Rightarrow \underline{n-1}$

Problem-2

In an assignment problem to assign jobs to men to minimize the time taken, suppose that one man does not know how to do a particular job, how will you eliminate this allocation from the solution?

Solution

In an assignment minimization problem, if one task cannot be assigned to one person, introduce a prohibitively large cost for that allocation, say M, where M has a high the value. Then, while doing the row minimum and column minimum operations, automatically this allocation will get eliminated.

Problem-3

Answer the following independent situations relating to an assignment problem with a minimization objective:

(i) Just after row and column minimum operations, we find that a particular row has 2 zeroes. Does this imply that the 2 corresponding numbers in the original matrix before any operation were equal? Why?

(ii) Under the usual notation, where a_{32} means the element at the intersection of the 3rd row and 2nd column, we have, in a 4 × 4 assignment. What can you conclude about the remaining assignments? Why?

Solution

(i) Under the Hungarian Assignment Method, the prerequisite to assign any job is that each row and column must have a zero value in its corresponding cells. If any row or column does not have any zero value then to obtain zero value, each cell values in the row or column is subtracted by the corresponding minimum cell value of respective rows or columns by performing row or column operation. This means *if any row or column have two or more cells having <u>same minimum value</u> then these row or column will have more than one zero.* However, having two zeros does not necessarily imply two equal values in the original assignment matrix just before row and column operations. *<u>Two zeroes in a same row can also be possible by two different operations</u> i.e. one zero from row operation and one zero from column operation*.

(ii) The order of matrix in the assignment problem is 4 × 4. The total assignment (allocations) will be four. In the assignment problem when any allocation is made in any cell then the corresponding row and column become unavailable for further allocation. Hence, these corresponding row and column are crossed mark to show unavailability. In the given assignment matrix two allocations have been made in a_{24} (2nd row and 4th column) and a_{32} (3rd row and 2nd column). This implies that 2nd and 3rd row and 4th and 2nd column are unavailable for further allocation.

Therefore, the other allocations are at **either at a_{11} and a_{43} or at a_{13} and a_{41}**.

Problem-4

R_3C_2 denotes the element at the intersection of the third row and 2nd column. Under this notation, R_1C_1, R_2C_1, R_3C_1, R_3C_2, R_3C_3, R_4C_3, R_4C_4, were the only zero elements in a 4x4 minimization assignment problem after the row minimum and column minimum operations.

(i) In the next step to draw lines to cover zeroes, a student drew 4 horizontal lines covering rows R_1, $R_{2,}$, R_3 R_4 . Will he arrive at the optimal assignment at the next step? Why? Explain the concept.

(ii) Independent of (i), if you are given the additional information that R_2C_2 element is lesser than the Row 1 and Row 2 non-zero values, how will you arrive at the optimal solution?

Solution

As per the problem the following cell has the Zero (0) element after the row minimum and column minimum operations:

	C_1	C_2	C_3	C_4
R_1	0			
R_2	0			
R_3	0	0	0	
R_4			0	0

(i) The step performed by the student is as follows:

	C_1	C_2	C_3	C_4
R_1	0			
R_2	0			
R_3	0	0	0	
R_4			0	0

Assignment is made in the cell which has zero (0) element and other zero elements in the corresponding row and column is crossed i.e. no further assignment is possible in that row and column in which first assignment has already been made.

Analysis of the operation performed by the student-

(1) The first (assuming) assignment has been made in cell R_1C_1, leaving no further scope for assignment in R_1 and C_1. However, in the above matrix a further assignment has also been made in **R_2C_1**, which could have not been done. It makes the above solution invalid and it will not arrive at the optimal assignment.

(2) However, assignment in R_3C_2 or R_3C_3 and R_4C_3 or R_4C_4 is possible provided no other assignment is made in the corresponding row and column.

(ii) Let us assume that the non-zero values in Row 1 and Row 2 except value at R_2C_2 is "x" and no assignments are possible in cells R_4C_1, R_4C_2 and R_3C_4. The following assignment matrix could be as below:

	C_1	C_2	C_3	C_4
R_1	$\boxed{0}$	x	x	x
R_2	0	x-1	x	x
R_3	0	$\boxed{0}$	0	-
R_4	-	-	$\boxed{0}$	0

Since, the numbers of assignment is not 4 as per the order of the matrix, hence, the lowest uncovered value i.e. x-1 has to be deducted from the all uncovered cells and also to be added to all the intersecting cells.

	C_1	C_2	C_3	C_4
R_1	$\boxed{0}$	1	1	1
R_2	0	$\boxed{0}$	1	1
R_3	x-1	0	$\boxed{0}$	-
R_4	-	-	0	$\boxed{0}$

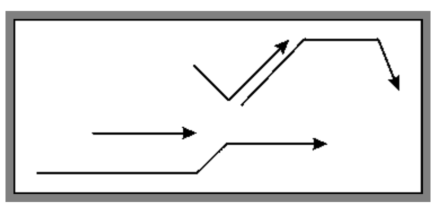
The optimal assignment will be at $\mathbf{R_1C_1}$, $\mathbf{R_2C_2}$, $\mathbf{R_3C_3}$ and $\mathbf{R_4C_4}$.

13 Critical Path Analysis

Basic Concepts

<table>
<tr><td>Activity</td><td>
An activity is any portion of a project which consumes time or resources and has a definable beginning and ending. For example, ‘laying of pipe’ is an activity requiring the use of resource mainly effort. Activity may involve labour, paper work, contractual negotiations, machinery operations, etc. Commonly used terms synonymous with ‘activity’ are ‘task’ and ‘job’.

Activities are graphically represented by arrows, usually with description and time estimates written along the arrows. The tail of the arrow portraying an activity represents the starting point of the activity and its head represents its completion. The arrow may be straight slanting, or bent but not broken (see following figure). The arrow is not a vector and need not be drawn to scale



Normally an activity can be categorized into four activities:
(i) Predecessor Activity: The activity or activities which immediately come before another activity without any intervening activities are called Predecessor activities.
(ii) Successor Activity: The activity or activities which follow another activity without any intervening activities are called successor activity.
(iii) Concurrent Activity: Activities or tasks that can be carried out concurrently with another activity is called concurrent activity. An activity may be concurrent with one or more than one activities.
</td></tr>
</table>

	(iv) **Dummy Activity:** It is a hypothetical activity and does not consumes any kind of resource. It is represented by dotted lines and is inserted in the network to clarify activity pattern under the situations – (a) to make activity/activities with common starting and finishing points distinguishable, (b) to identify and maintain the proper precedence relationship between activities that are not connected by events and (c) to bring all "loose ends" to a single initial and a single terminal event in each network using dummies, if necessary. When in a network diagram situation of duplicate activity arise, this situation is corrected by introducing a dummy activity.
Advantages of Critical Path Analysis	There are a number of advantages in using critical path analysis – (i) It allows for a comprehensive view of the entire project. Because of the sequential and concurrent relationships, time scheduling becomes very effective. Identifying the critical activities keeps the executive alert and in a state of preparedness, with alternative plans ready in case these are needed. Breaking down the project into smaller components permits better and closer control; (ii) Critical path analysis offers economical and effective system of control based on the principle of management by exception i.e. need for corrective action arises only in exceptional situations and in most of other cases, performance is in conformity with the plans; (iii) It is a dynamic tool of management which calls for constant review, a reformulation of the network, and finding the current path of relevance and optimum resources allocation.
Basic Steps Involved in Drawing a CPM/PERT Network	Network is defined as a diagram representing the activities and events of a project, their sequence and inter-relationships. The basic steps involved in drawing a network are – (i) Breaking up of the entire project into smaller systems known as tasks. (ii) For each task ascertain the activities and events to be performed. (iii) For each activity determine the preceding and succeeding activities.

	(iv) For each activity determine or estimate the time and other resources needed. (v) Draw a network depicting the assembly of tasks into a project.
Concurrent Activities	Activities may not always be discrete i.e. they may be done in part allowing the subsequent activities to commence before the preceding activity is fully completed. Activities of this kind are to be frequently encountered in batch production. If, for example, a batch of 50 spindles is to be processed on two machines obviously it is not necessary to process all the items of the batch on the first machine and then transfer these to the next machine. A few items processed on the first machine may be transferred to the second machine before completion of the entire batch on the first machine. Since this is a matter of great practical importance we shall dwell upon it at a greater length. Such simultaneous or concurrent activities are to be encountered in sewage work e.g., trenching, laying pipe, welding pipe and back filling, all going on simultaneously with suitable lags on construction work.
Conventions Adopted in Drawing Networks	There are two conventions normally adopted while drawing networks. In the early stages of network drawing, it is suggested that the conventions should be respected until sufficient experience has been gained to justify dropping them. These conventions are: (i) Time flows from left to right. (ii) Head events always have a number higher than that of the tail events. The above stated conventions allow activities to be referred uniquely by their tail and head event numbers, so that "activity 3-4" means only "the activity which starts from event 3 and proceeds to event 4"; it cannot mean "the activity which starts from event 4 and finishes at event 3".
Critical Path	A path in a project network is called critical if it is the longest path. The activities lying on the critical path are called the critical activities.
Dependency Relationships	Below figure shows three cases for the following set of dependency relationships: (i) Activity C is dependent upon both A and B. (ii) Activity D is dependent upon A alone.

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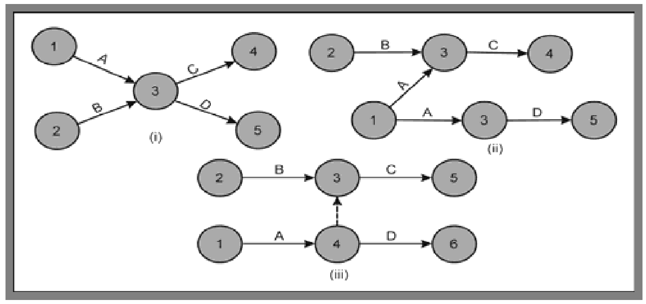
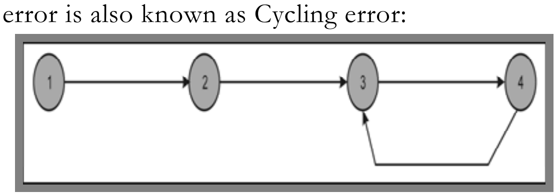
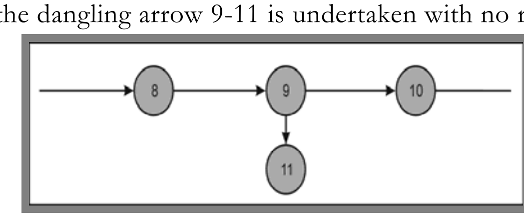


The first portrayal on (i) of above figure is clearly wrong since it shows D as dependent upon not only A but also B which is not desired. The other portrayal (ii) is also wrong since A is being shown twice and thus contravenes the fundamental axiom of network that there must be one arrow for each activity. The way out to this dilemma is the representation by means of the dummy activity. In the third portrayal of above figure, C is dependent upon both A and B (via dummy) whereas D is dependent upon just A.
</td>
</tr>
<tr>
<td>Errors in Logical Sequencing</td>
<td>
Generally three types of errors in logical sequencing may arise while drawing a network diagram, particularly when it is a complicated one. These are known as looping, dangling and redundancy.

(i) Looping: Normally in a network, the arrow points from left to right. This convention is to be strictly adhered, as this would avoid illogical looping. Looping error is also known as Cycling error:



(ii) Dangling: Activity which is not connected to any of the intermediate events or end event is called dangling activity. The situation represented by the following diagram is also at fault, since the activity represented by the dangling arrow 9-11 is undertaken with no result.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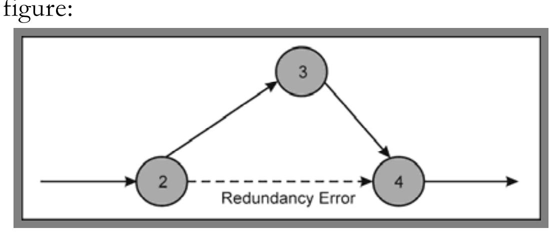
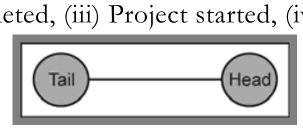
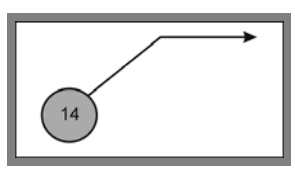
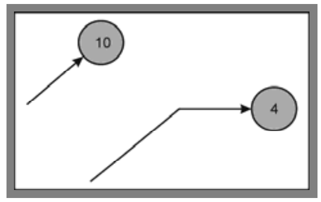
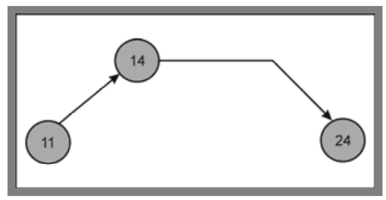
	To overcome the problem arising due to dangling arrows, following rules may be adopted. a) All events, except the first and the last, must have at least one activity entering and one activity leaving them, and b) All activities must start and finish with an event. (iii) **Redundancy:** When dummy activities are inserted in a network diagram unnecessarily, this type of error is called error of redundancy. It is shown in the following figure: 
Events	The beginning and ending points of an activity or a group of activities are called events. Synonyms of an event are "node" and "connectors" An event is often represented graphically by a numbered circle (see following figure), although any geometric figure such as square, oval, rectangle etc. will serve the purpose. We shall, however, stick to the most commonly used convention for representing an event viz, the circle. A few examples of events are as follows: (i) Material procured, (ii) Design completed, (iii) Project started, (iv) Bricks laid, etc.  All activities in a network must commence from some event. Such events are called the **Tail Events** because they are connected to the tail of an activity. These are shown in following figure.  Similarly, all activities in a network must have terminal points called the **Head Event**, because it is at the head of an activity. These are shown in following figure.



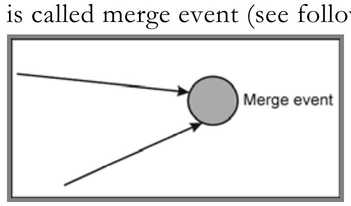
Following figure depicts the tail and head events connected by arrows representing activities i.e. it depicts the dual role of an event. Event 14 is the head event for one activity and tail event for another.



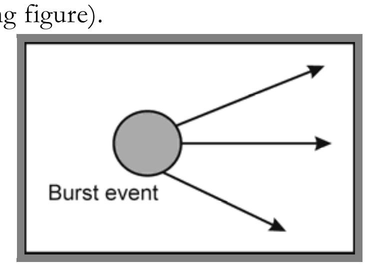
In a network, symbol "i" is used for the tail event (also called preceding event) and "j" for the head event (or succeeding event) of an activity. The activity, then being i-j.

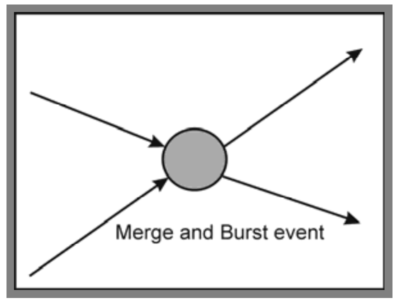
The events may be classified into three categories:

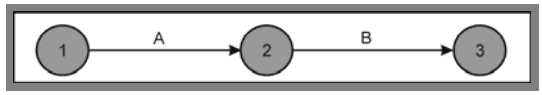
(i) **Merge Event:** If an event represents the joint completion of more than one activity i.e., a particular point (termed as event) where two or more activities complete is called merge event (see following figure).

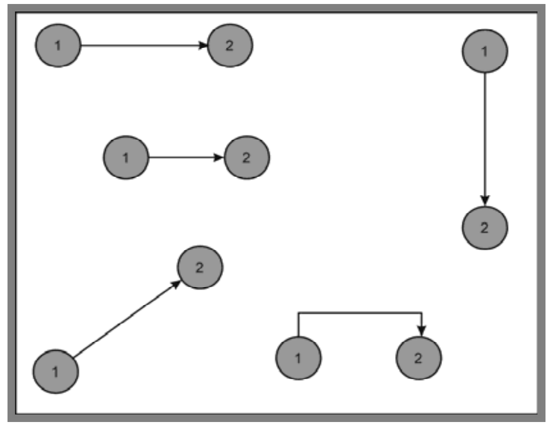


(ii) **Burst Event:** If an event represents joint initiation i.e., a particular point (termed as event) form where more than one activities starts, is called Burst event (see following figure).



	(iii) **Merge and Burst Event:** It is an event from where more than one activity starts and more than one activity complete as well. In general language it is a starting point for some activities and ending point for some activities (see following figure). 
Free Float	It is defined as that portion of the total float within which an activity can be manipulated without affecting the float of the succeeding activities. It can be determined by subtracting the head event slack from the total float of an activity. $FF_{ij} = TF_{ij}$ – (slack of event j) The free float indicates the value by which an activity in question can be delayed beyond the earliest starting point without affecting the earliest start, and therefore, the total float of the activities following it.
Float	It may be observed that for every critical activity in a network, the earliest start and latest start time are the same. This is so since the critical activities cannot be scheduled later than their earliest schedule time without delaying the total project duration, they do not have any flexibility in scheduling. However, non-critical activities do have some flexibility i.e. these activities can be delayed for some time without affecting the project duration. This flexibility is termed as slack in case of an event and as float in case of an activity.
Fundamental Properties Governing the Representation of Events and Activities	The representation of events and activities is governed by one simple dependency rule which requires that an activity which depends upon another activity is shown to emerge from the head event of the activity upon which it depends and that only dependent activities are drawn in this way. Thus, if activity B depends upon activity A, then the two activities are drawn in following figure.

	 The dependency rule gives rise to two fundamental properties of events and activities: (i) An event cannot occur until all activities leading to it are complete. (ii) No activity can start until its tail event is reached. The above two properties can be combined into a single one, namely that 'no activity may start until all previous activities in the same chain are completed'.
General Framework of PERT/CPM	A network is a graphical representation of a project, depicting the flow as well as the sequence of well-defined activities and events. CPM (Critical Path Method) and PERT (Programme Evaluation and Review Technique) are network techniques/ models. The network approach helps project managers in planning, scheduling and controlling. As a planning tool it helps the manager to estimate the requirements of resources viz., materials, equipment, manpower, cost and time for each activity or tasks of the project. This approach cannot make decisions by its own. It only provides additional information to executives to facilitate decision making process. Also it does not provide solution to every management problem. It certainly helps in identification of those activities, jobs or events which control the completion of the project.
Graphical Representation of Events and Activities	Events are represented by numbers within circles. Activities are represented by arrows, the arrow-heads represent the completion of the activities. The length and orientation of the arrow are of no significance whatsoever (chosen only for the convenience of drawing). The activity of leaving place A and walking to place B can equally well be represented by following figure.

	
Independent Float	It is defined as that portion of the total float within which an activity can be delayed for start without affecting float of the preceding activities. It is computed by subtracting the tail event slack from the free float of an activity. $IF_{ij} = FF_{ij} - \text{(slack of event i)}$ The independent float is always either equal to or less than the free float of an activity. If a negative value is obtained, the independent float is taken to be zero.
Interfering Float	Utilization of the float of an activity can affect the float of subsequent activities in the network. Thus, interfering float can be defined as that part of the total float which causes a reduction in the float of the successor activities. In other words, it can be defined as the difference between the latest finish time of the activity under consideration and the earliest start time of the following activity, or zero, whichever is larger. Thus, interfering float refers to that portion of the activity float which cannot be consumed without affecting adversely the float of the subsequent activity or activities.
Logical Sequencing and Connection of Activities	A project entails several activities. The arrows are arranged to show the plan of logical sequence in which the activities of the project are to be accomplished. The sequence is ascertained for each activity by answering the following three queries viz: (i) Which activity or activities must be completed before the start of a particular activity? (ii) Which activity or activities should follow this?

<table>
<tr>
<td></td>
<td>(iii) Which activities can be accomplished simultaneously?

Take an example of a pipe line project. Three activities have been identified for this project namely trenching, laying down of pipes and welding of pipes. To complete this project logical sequence is to be understood. Welding can’t be done until pipes are laid down and pipes can’t be laid down until the pipes are trenched. The logical sequence is like that first trenching second laying and lastly welding activity should be carried out.

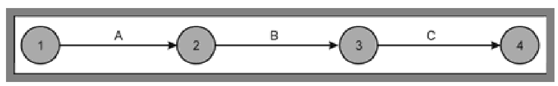
The activities will be as follows:

A → Trenching

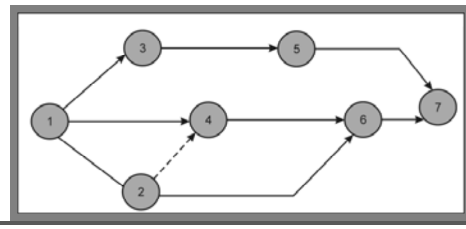
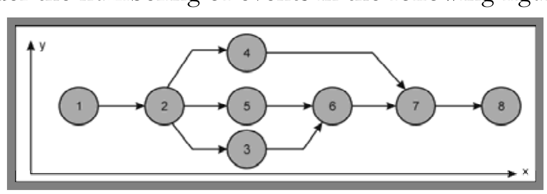
B → Laying

C → Welding

The Network for the same is as follows:


</td>
</tr>
<tr>
<td>Methodology of Critical Path Analysis</td>
<td>The working methodology of critical path analysis (CPA) which includes both CPM and PERT, consists of five steps –
(i) Analyse and break down the project in terms of specific activities and/ or events,
(ii) Determine the interdependence and sequence of specific activities and prepare a network,
(iii) Assign estimates of time, cost or both to all the activities of the network,
(iv) Identify the longest or critical path through the network,
(v) Monitor, evaluate and control the progress of the project by re-planning, re-scheduling and re-assignment of resources.

The central task in the control aspect of these models is to identify the longest path through the network. The longest path is the critical path because it equals the minimum time required to complete the project. All other paths other than the critical path (i.e. non-critical or slack paths) offer flexibility in scheduling and transferring resources, because they take less time to complete than the critical path.</td>
</tr>
<tr>
<td>Network</td>
<td>A network is, then, a graphical representation of a project plan, showing the inter-relationship of the various activities.</td>
</tr>
</table>

	Networks are also called arrow diagrams (see following figure). When the results of time estimates and computations have been added to a network, it may be used as a project schedule. 
Numbering the Events	The event numbers in a network should in some respect reflect their logical sequences. When a complicated network is drawn then the problem of assigning numbers to the events involved in the network arises. A rule devised by Delbert Ray Fulkerson, involving the following steps may be followed to resolve the problem of numbering the events. (i) An "initial" event is one which has arrow/arrows coming out of it and none of the arrow entering in it. In a network there will be only one such event. Call it "1". (ii) Delete all arrows coming out from the event 1. This will give us at least one more "initial event". (iii) Number these events as "2, 3...." (iv) Delete all emerging arrows from these numbered events which will create new initial events. Then follow step (iii). (v) Continue the above steps till last event is obtained which has no arrows coming out of it. Consider the numbering of events in the following figure.  Here we proceed from left to right. The event with least x-co-ordinate is assigned the smallest integer, say 1. Other events are assigned progressively higher integers with regard to x-co-ordinate. If two or more events (4 and 5 above) have the same x-co-ordinate, the one towards arrow should have higher number.

	Furthermore, it is not necessary, and in fact also not desirable to number the events consecutively. It would be a better scheme to number the events as 10, 20, 30, 40, 50, 60, 70, 80 in the above diagram instead of 1,2,3,4,5,6,7,8. This affords insertion of more activities and events omitted by oversight or having become necessary in view of certain logic revisions. It was mentioned earlier that it is desirable that all the activity arrows point from left to right. If the arrow is vertical it may point downwards or upwards. For the sake of presentability it is to be recommended that activities emanating from one event or converging to another may make as great angles between themselves as possible. A few more conventions are given below: (i) Keep the arrow to the extreme right. (ii) As far as possible avoid drawing arrows that cross each other. Usually by suitable 'stretching' the network diagram it is possible to avoid this. (iii) Where, however, crossing is unavoidable, bridging may be done. This applies to dummies as well. Draw boldly a big network. Smaller ones are confusing. Use of pencil and rubber is recommended.
Project	A project can be defined as a set of large number of activities or jobs that are performed in a certain sequence determined logically or technologically and it has to be completed within (i) a specified time, (ii) a specified cost and (iii) meeting the performance standards. Examples of a project from fairly diverse fields are – (i) Introducing a new product in the market, (ii) Construction of a new bridge over a river or construction of a 25 storied building (iii) Executing a large and complex order on jobbing production and (iv) Sending a spacecraft to the mars.
Slack Time for an Event	The slack time or slack of an event in a network is the difference between the latest event time and the earliest event time. Mathematically it may be calculated using the formula Li –Ei. where Li is the latest allowable occurrence time and Ei is the earliest allowable occurrence time of an event i.

Total Float of an Activity	The total activity float is equal to the difference between the earliest and latest allowable start or finish times for the activity in question. Thus, for an activity (i-j), the total float is given by $TF_{ij} = LST - EST$ or $TF_{ij} = LFT - EFT$ In other words, it is the difference between the maximum time available for the activity and the actual time it takes to complete. Thus, total float indicates the amount of time by which the actual completion of an activity can exceed its earliest expected completion time without causing any delay in the project duration.

SECTION - A

Methodology of Critical Path Analysis

Question-1

List the 5 steps involved in the methodology of Critical Path Analysis.

Answer

The working methodology of critical path analysis (CPA) which includes both CPM and PERT, consists of five steps –

(i) Analyse and break down the project in terms of specific activities and/ or events,

(ii) Determine the interdependence and sequence of specific activities and prepare a network,

(iii) Assign estimates of time, cost or both to all the activities of the network,

(iv) Identify the longest or critical path through the network,

(v) Monitor, evaluate and control the progress of the project by re-planning, re-scheduling and re-assignment of resources.

Question-2

Define a project and briefly explain the four common implications which characterize a project.

Answer

A project can be defined as a set of activities or jobs that are performed in a certain sequence determined logically or technologically and it has to be completed within (i) a specified time, (ii) a specified cost and (iii) meeting the performance standards. Examples of a project from fairly diverse fields could be cited. Some of them are given below:

(i) Introducing a new product in the market.

(ii) Construction of a new bridge over a river or construction of a 25 – storied building.

(iii) Executing a large and complex order on jobbing production.

(iv) Sending a spacecraft to the mars.

All these projects are characterized by the following set of common implications, although they pertain to widely different fields.

(i) *The Large-scale characteristic:* These projects are generally unusually large and complex. Thousands of suppliers, workers and other categories of persons are involved and their efforts have to be coordinated for completion of the project.

(ii) *The non-recurring characteristic:* These projects are generally of a one-time nature. Neither in the past, nor in the future they are likely to undertaken substantially in the same form.

(iii) *Uncertain and critical dates*: During of the various activities involved in such projects are usually uncertain. Further in such type of projects, many critical dates exits by which operations must be completed in order to complete the entire project on schedule.

(iv) *Completion dead line:* The fourth distinct feature of these projects is that there is dead line for the completion of the entire project. In case of any delay in the completion of the project, some penalty is levied for such delay beyond the dead line.

Question-3

State any 2 advantages of CPM.

Answer

There are a number of advantages in using critical path analysis –

(i) It allows for a comprehensive view of the entire project. Because of the sequential and concurrent relationships, time scheduling becomes very effective. Identifying the critical activities keeps the executive alert and in a state of preparedness, with alternative plans ready in case these are needed. Breaking down the project into smaller components permits better and closer control;

(ii) Critical path analysis offers economical and effective system of control based on the principle of management by exception i.e. need for corrective action arises only in exceptional situations and in most of other cases, performance is in conformity with the plans;

(iii) It is a dynamic tool of management which calls for constant review, a reformulation of the network, and finding the current path of relevance and optimum resources allocation.

Question-4

Explain the following in the context of a network:

(i) Critical path

(ii) Dummy activity.

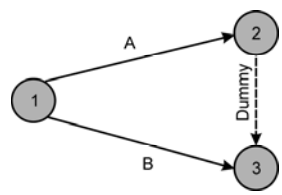
Answer

(i) Critical Path

Critical Path is a chain of activities that begin with the starting event and ends with ending event of a particular project. It is that path that runs through a network with the maximum length of time or it indicates the maximum possible time required for completion of a project. It is determined after identifying critical events. Critical path goes through critical events.

(ii) Dummy Activities

Dummy Activity is that activity which does not consume time or resources. It is used when two or more activities have same initial and terminal events. As a result of using dummy activities, other activities can be identified by unique end events. These are usually shown by arrows with dashed lines.



Question-5

Write short notes on:

(i) Merge Event

(ii) Burst Event

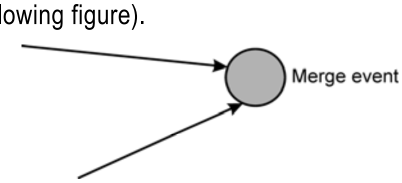
(iii) Interfering Float

(iv) Independent Float

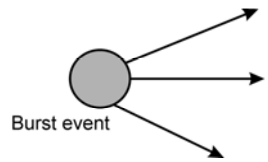
(v) Slack Time for an Event

Answer

(i) Merge Event: If an event represents the joint completion of more than one activity i.e., a particular point (termed as event) where two or more activities complete is called merge event (see following figure).



(ii) Burst Event: If an event represents joint initiation i.e., a particular point (termed as event) form where more than one activities starts, is called Burst event (see following figure).



(iii) Interfering Float: Utilization of the float of an activity can affect the float of subsequent activities in the network. Thus, interfering float can be defined as that part of the total float which causes a reduction in the float of the successor activities. In other words, it can be defined as the difference between the latest finish time of the activity under consideration and the earliest start time of the following activity, or zero, whichever is larger. Thus, interfering float refers to that portion of the activity float which cannot be consumed without affecting adversely the float of the subsequent activity or activities.

(iv) Independent Float: It is defined as that portion of the total float within which an activity can be delayed for start without affecting float of the preceding activities. It is computed by subtracting the tail event slack from the free float of an activity.

$$IF_{ij} = FF_{ij} - (\text{slack of event } i)$$

The independent float is always either equal to or less than the free float of an activity. If a negative value is obtained, the independent float is taken to be zero.

(v) Slack Time for an Event: The slack time or slack of an event in a network is the difference between the latest event time and the earliest event time. Mathematically it may be calculated using the formula $L_i - E_i$. where L_i is the latest allowable occurrence time and E_i is the earliest allowable occurrence time of an event i.

Question-6

Explain 'Numbering the Events' in the context of a network.

Answer

The event numbers in a network should in some respect reflect their logical sequences. When a complicated network is drawn then the problem of assigning numbers to the events involved in the network arises. A rule devised by Delbert Ray Fulkerson, involving the following steps may be followed to resolve the problem of numbering the events.

(i) An "initial" event is one which has arrow/arrows coming out of it and none of the arrow entering in it. In a network there will be only one such event. Call it "1".

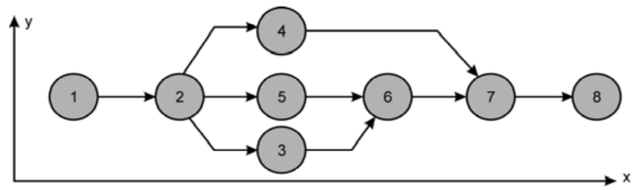
(ii) Delete all arrows coming out from the event 1. This will give us at least one more "initial event".

(iii) Number these events as “2, 3....”

(iv) Delete all emerging arrows from these numbered events which will create new initial events. Then follow step (iii).

(v) Continue the above steps till last event is obtained which has no arrows coming out of it.

Consider the numbering of events in the following figure.



Here we proceed from left to right. The event with least x-co-ordinate is assigned the smallest integer, say 1. Other events are assigned progressively higher integers with regard to x-co-ordinate. If two or more events (4 and 5 above) have the same x-co-ordinate, the one towards arrow should have higher number.

Furthermore, it is not necessary, and in fact also not desirable to number the events consecutively. It would be a better scheme to number the events as 10, 20, 30, 40, 50, 60, 70, 80 in the above diagram instead of 1,2,3,4,5,6,7,8. This affords insertion of more activities and events omitted by oversight or having become necessary in view of certain logic revisions.

It was mentioned earlier that it is desirable that all the activity arrows point from left to right. If the arrow is vertical it may point downwards or upwards.

For the sake of presentability it is to be recommended that activities emanating from one event or converging to another may make as great angles between themselves as possible.

A few more conventions are given below:

(i) Keep the arrow to the extreme right.

(ii) As far as possible avoid drawing arrows that cross each other. Usually by suitable 'stretching' the network diagram it is possible to avoid this.

(iii) Where, however, crossing is unavoidable, bridging may be done. This applies to dummies as well. Draw boldly a big network. Smaller ones are confusing. Use of pencil and rubber is recommended.

Question-7

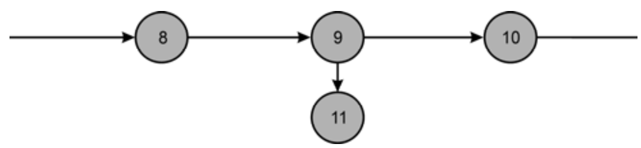
State the types of errors in logical sequencing may arise while drawing a network diagram?

Answer

Generally three types of errors in logical sequencing may arise while drawing a network diagram, particularly when it is a complicated one. These are known as *looping, dangling and redundancy.*

(i) **Looping:** Normally in a network, the arrow points are from left to right. This convention is to be strictly adhered, as this would avoid illogical looping. Looping error is also known as Cycling error.

(ii) **Dangling:** Activity which is not connected to any of the intermediate events or end event is called dangling activity. The situation represented by the following diagram is also at fault, since the activity represented by the dangling arrow 9-11 is undertaken with no result.

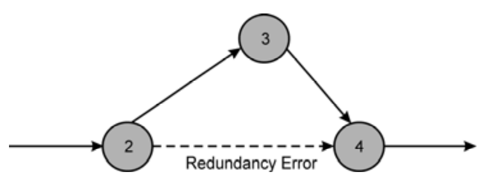


To overcome the problem arising due to dangling arrows, following rules may be adopted.

(a) All events, except the first and the last, must have at least one activity entering and one activity leaving them, and

(b) All activities must start and finish with an event.

(iii) **Redundancy**: When dummy activities are inserted in a network diagram unnecessarily, this type of error is called error of redundancy. It is shown in the following figure:

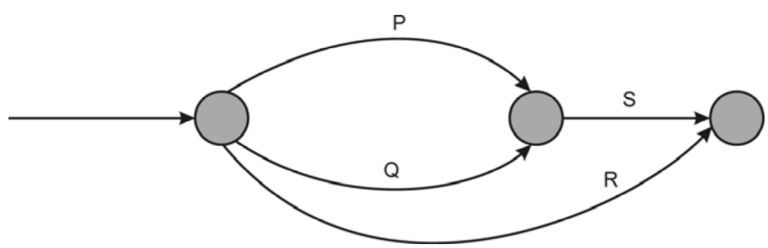


SECTION - B

Basic Concepts

Problem-1

The following is a part of a network.

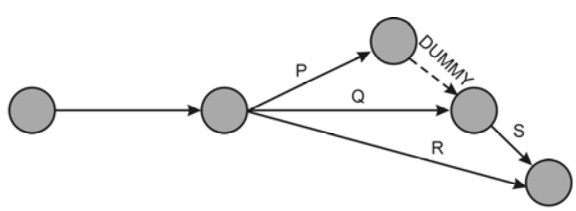


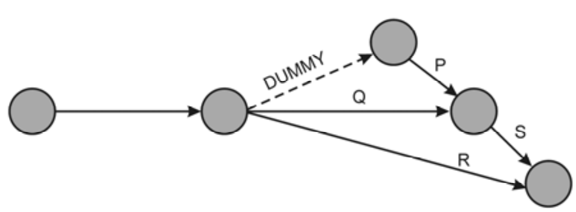
Required

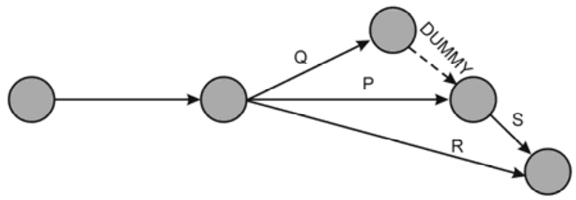
What are activities P and Q called? How would you rectify the situation?

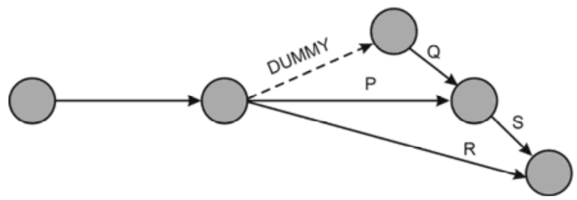
Solution

Activities P and Q are called duplicate activities (or parallel activities) since they have the same head and tail events. The situation may be rectified by introducing a dummy either between P and S or between Q and S or before P or before Q (i.e. introduce the dummy before the tail event and after the duplicate activity or Introduce the dummy activity between the head event and the duplicate activity). Possible situations are given below:



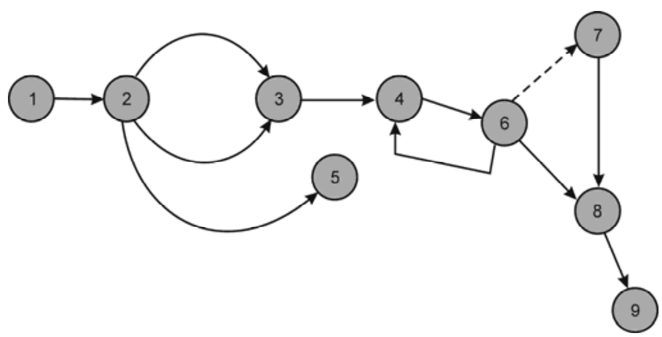






Problem-2

Point out the errors in the network given below, going by the usual conventions while drawing a network to use CPM.



Solution

Flows	Errors
2–3	There are 2 activities which are *duplicate or parallel*. In case they are two different activities, one may pass through a dummy.
2–5	This is a *dangling* activity; No complete path exists. Can be joined to (9) with a dummy.
4–6 & 6–4	*Looping* exists; This is not proper sequencing.

Network Diagram, Critical Path & Float

Problem-3

Given the following information:

Activity	***Duration (in Days)***
0–1	*2*
1–2	*8*
1–3	*10*
2–4	*6*
2–5	*3*
3–4	*3*
3–6	*7*
4–7	*5*
5–7	*2*
6–7	*8*

Required

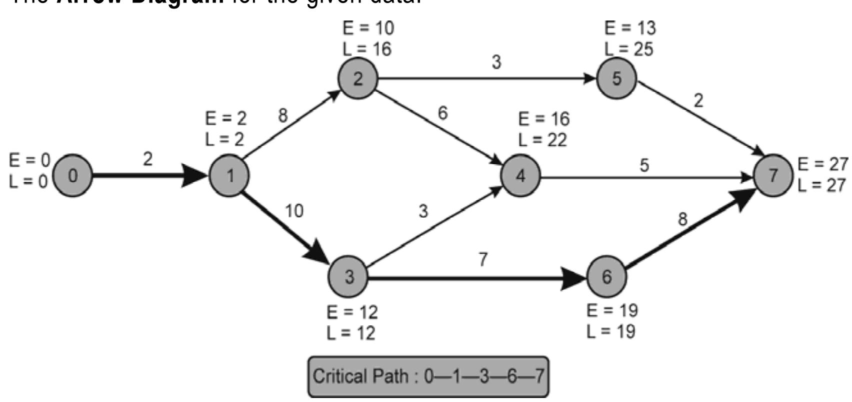
(i) *Draw the arrow diagram.*

(ii) *Identify critical path and find the total project duration.*

(iii) *Determine total, free and independent floats.*

Solution

(i) The **Arrow Diagram** for the given data:



(ii) The **Critical Path** is 0–1–3–6–7

Total Project Duration is 27 days.

(iii) The Total, Free and Independent Floats are computed in the following table:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
0–1	2	0	2	0	2	0	0	0	0	0
1–2	8	2	10	8	16	0	6	6	0	0
1–3	10	2	12	2	12	0	0	0	0	0
2–4	6	10	16	16	22	6	6	6	0	0*
2–5	3	10	13	22	25	6	12	12	0	0*
3–4	3	12	15	19	22	0	6	7	1	1
3–6	7	12	19	12	19	0	0	0	0	0
4–7	5	16	21	22	27	6	0	6	6	0
5–7	2	13	15	25	27	12	0	12	12	0
6–7	8	19	27	19	27	0	0	0	0	0

(*) Being negative, the independent float is taken to be equal to zero.

Problem-4

A project has the following time schedule:

Activity	***Duration (in Weeks)***
1–2	*2*
1–3	*2*
1–4	*1*

2–5	*4*
3–6	*8*
3–7	*5*
4–6	*3*
5–8	*1*
6–9	*5*
7–8	*4*
8–9	*3*

Required

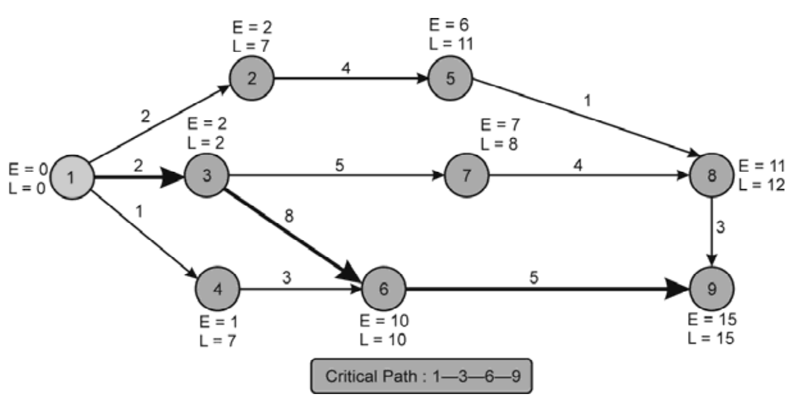
(i) *Draw the arrow diagram.*

(ii) *Identify critical path and find the total project duration.*

(iii) *Determine total, free and independent floats.*

Solution

(i) The **Arrow Diagram** for the given data is drawn below:



(ii) The **Critical Path** is 1–3–6–9.

Total Project Duration is 15 weeks.

(iii) The Total, Free and Independent Floats are computed in the following table:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
1–2	2	0	2	5	7	0	5	5	0	0
1–3	2	0	2	0	2	0	0	0	0	0
1–4	1	0	1	6	7	0	6	6	0	0
2–5	4	2	6	7	11	5	5	5	0	0*
3–6	8	2	10	2	10	0	0	0	0	0
3–7	5	2	7	3	8	0	1	1	0	0
4–6	3	1	4	7	10	6	0	6	6	0
5–8	1	6	7	11	12	5	1	5	4	0*
6–9	5	10	15	10	15	0	0	0	0	0
7–8	4	7	11	8	12	1	1	1	0	0*
8–9	3	11	14	12	15	1	0	1	1	0

(*) Being negative, the independent float is taken to be equal to zero.

Problem-5

A project has the following time schedule:

Activity	***Duration (in Weeks)***	***Activity***	***Duration (in Weeks)***
1–2	*4*	*5–7*	*8*
1–3	*1*	*6–8*	*1*
2–4	*1*	*7–8*	*2*
3–4	*1*	*8–9*	*1*
3–5	*6*	*8–10*	*8*
4–9	*5*	*9–10*	*7*
5–6	*4*		

Required

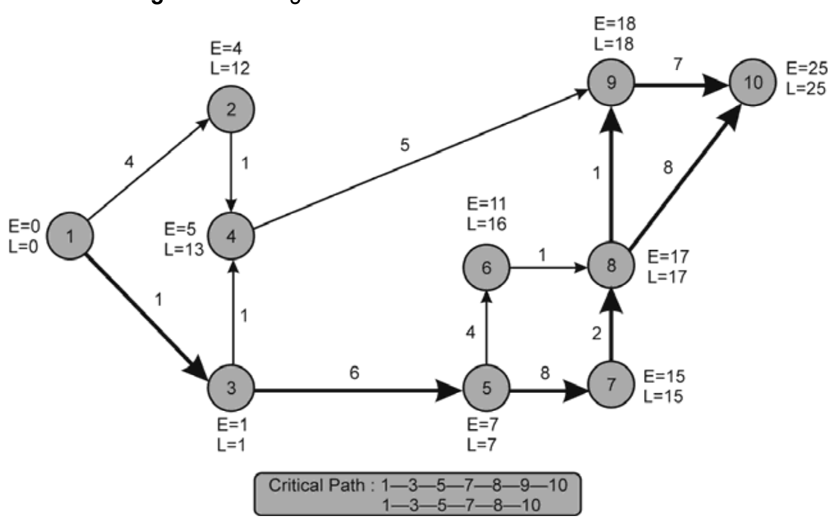
(i) *Draw the arrow diagram.*

(ii) *Identify critical path and find the total project duration.*

(iii) *Determine total, free and independent floats.*

Solution

(i) The **Arrow Diagram** for the given data:



(ii) The **Critical Paths** are 1–3–5–7–8–9–10 and 1–3–5–7–8–10.

Total Project Duration is 25 Weeks.

(iii) The Total, Free and Independent Floats are computed in the following table:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
1–2	4	0	4	8	12	0	8	8	0	0

1–3	1	0	1	0	1	0	0	0	0	0
2–4	1	4	5	12	13	8	8	8	0	0*
3–4	1	1	2	12	13	0	8	11	3	3
3–5	6	1	7	1	7	0	0	0	0	0
4–9	5	5	10	13	18	8	0	8	8	0
5–6	4	7	11	12	16	0	5	5	0	0
5–7	8	7	15	7	15	0	0	0	0	0
6–8	1	11	12	16	17	5	0	5	5	0
7–8	2	15	17	15	17	0	0	0	0	0
8–9	1	17	18	17	18	0	0	0	0	0
8–10	8	17	25	17	25	0	0	0	0	0
9–10	7	18	25	18	25	0	0	0	0	0

(*) Being negative, the independent float is taken to be equal to zero.

Problem-6

The time schedule for different activities of a project is given below:

Activity (i–j)	***Time (in Days)***
1–2	*8*
1–3	*10*
1–4	*8*
2–3	*10*
2–6	*16*
3–5	*17*
4–5	*18*
4–6	*14*
5–6	*9*

Required

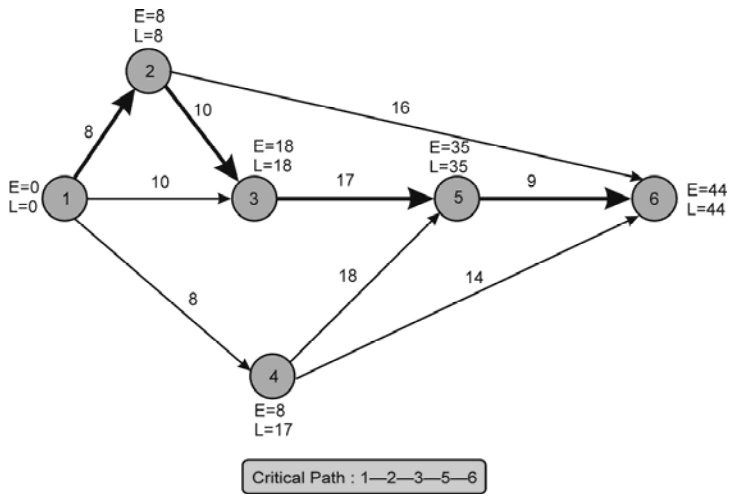
(i) *Draw the arrow diagram.*

(ii) *Identify critical path and find the total project duration.*

(iii) *Determine total, free and independent floats.*

Solution

(i) The **Arrow Diagram** for the given data:



(ii) The **Critical Path** is 1–2–3–5–6.

Total Project Duration is 44 Days.

(iii) The Total, Free and Independent Floats are computed in the following table:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
1–2	8	0	8	0	8	0	0	0	0	0
1–3	10	0	10	8	18	0	0	8	8	8
1–4	8	0	8	9	17	0	9	9	0	0
2–3	10	8	18	8	18	0	0	0	0	0
2–6	16	8	24	28	44	0	0	20	20	20
3–5	17	18	35	18	35	0	0	0	0	0

4–5	18	8	26	17	35	9	0	9	9	0
4–6	14	8	22	30	44	9	0	22	22	13
5–6	9	35	44	35	44	0	0	0	0	0

Problem-7

The following table gives the activities in a construction project and the time duration of each activity:

Activity	*Predecessors*	*Normal Time (Days)*
A	---	*16*
B	---	*20*
C	*A*	*8*
D	*A*	*10*
E	*B,C*	*6*
F	*D,E*	*12*

Required

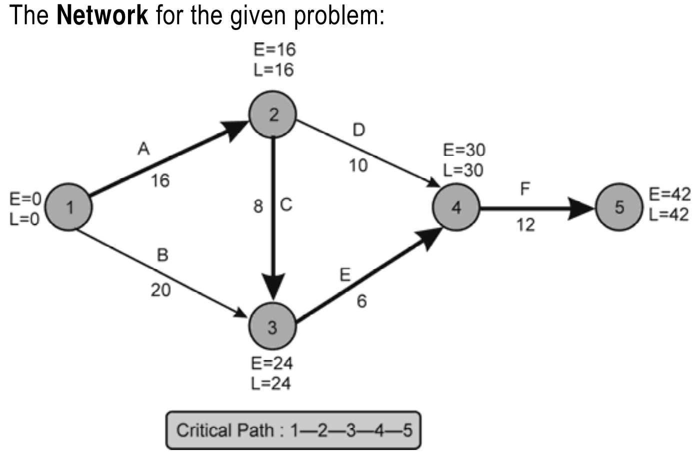
(i) *Draw the activity network of the project.*

(ii) *Find critical path.*

(iii) *Find the total float and free-float for each activity.*

Solution

(i) The **Network** for the given problem:



(ii) **Critical Path**: 1–2–3–4–5 (A–C–E–F).

(iii) Total Float and Free Float for each activity:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event
A (1–2)	16	0	16	0	16	0	0	0	0
B (1–3)	20	0	20	4	24	0	0	4	4
C (2–3)	8	16	24	16	24	0	0	0	0
D (2–4)	10	16	26	20	30	0	0	4	4
E (3–4)	6	24	30	24	30	0	0	0	0
F (4–5)	12	30	42	30	42	0	0	0	0

Problem-8

Given is the following information regarding a project:

Activity	*Required Preceding Activities*	*Duration (Days)*
A	*None*	*3*
B	*None*	*4*
C	*None*	*2*
D	*A, B*	*5*
E	*B*	*1*
F	*B*	*3*
G	*F, C*	*6*

H	*B*	*4*
I	*E, H*	*4*
J	*E, H*	*2*
K	*C,D,F,J*	*1*
L	*K*	*5*

Required

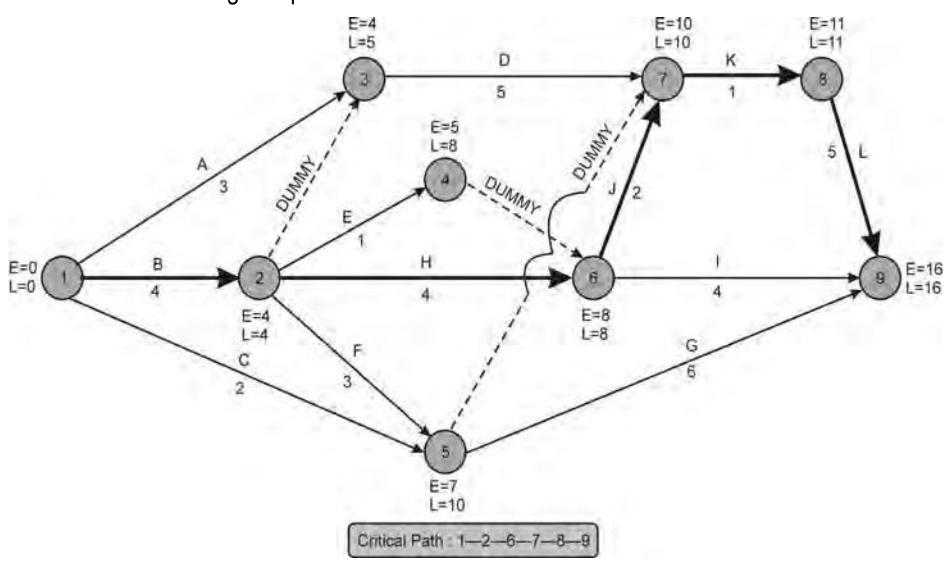
(i) *Draw the network for the above project.*

(ii) *Determine the critical path and the duration of the project.*

(iii) *Find the three types of floats (viz., total, free and independent) for each activity.*

Solution

(i) The **Network** for the given problem:



(ii) The **Critical Path** is 1–2–6–7–8–9 with Duration 16 Days.

(iii) Calculation of Total Float, Free Float and Independent Float:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
A (1–3)	3	0	3	2	5	0	1	2	1	1
B (1–2)	4	0	4	0	4	0	0	0	0	0
C (1–5)	2	0	2	8	10	0	3	8	5	5
Dum. (2–3)	0	4	4	5	5	0	1	1	0	0
D (3–7)	5	4	9	5	10	1	0	1	1	0
E (2–4)	1	4	5	7	8	0	3	3	0	0
F (2–5)	3	4	7	7	10	0	3	3	0	0
G (5–9)	6	7	13	10	16	3	0	3	3	0
H (2–6)	4	4	8	4	8	0	0	0	0	0
I (6–9)	4	8	12	12	16	0	0	4	4	4
Dum. (4–6)	0	5	5	8	8	3	0	3	3	0
Dum. (5–7)	0	7	7	10	10	3	0	3	3	0
J (6–7)	2	8	10	8	10	0	0	0	0	0
K (7–8)	1	10	11	10	11	0	0	0	0	0
L (8–9)	5	11	16	11	16	0	0	0	0	0

Problem-9

The following information is known for a project.

This must be completed	*Before this can start*
A (14)	*B, E, J*
B (28)	*C*
C (20)	*D*
D (14), E (42)	*F, G, K*
F (14), G (24)	*I (30)*
J (60)	*K (30)*

Note:

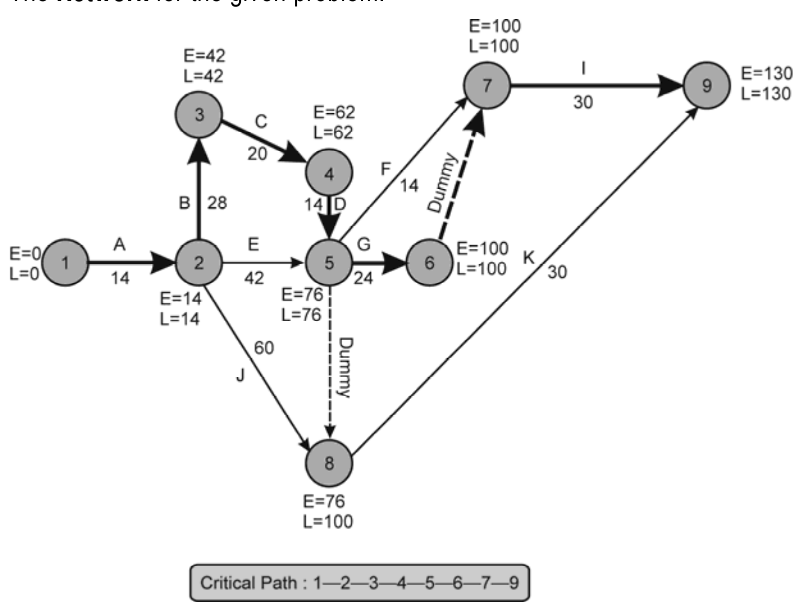
Capital letter denotes activities. Numbers in bracket denote activity times.

Required

Draw the network and find the critical path.

Solution

(i) The **Network** for the given problem:



(ii) **Critical Path** is 1–2–3–4–5–6–7–9.

Missing Figures & Network

Problem-10

The number of days of total float (TF), earliest start times (EST) and duration in days are given for some of the following activities.

Activity	*TF*	*EST*	*Duration*
1–2	*0*	*0*	*???*
1–3	*2*	*???*	*???*
1–4	*5*	*???*	*???*
2–4	*0*	*4*	*???*
2–5	*1*	*???*	*5*
3–6	*2*	*12*	*???*
4–6	*0*	*12*	*???*
5–7	*1*	*???*	*???*
6–7	*???*	*23*	*???*
6–8	*2*	*???*	*???*
7–8	*0*	*23*	*???*
8–9	*???*	*30*	*6*

Required

(i) Find the??? Figures.

(ii) Draw the network.

(iii) List the paths with their corresponding durations and state when the project can be completed.

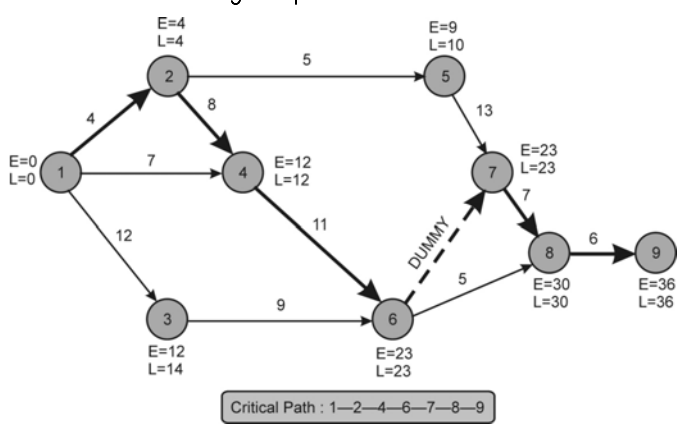
Solution

(i) Calculation of **Missing Figures**:

Activity	Duration	EST	EFT	LST	LFT	Total Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	LST− EST
1–2	4	0	4	0	4	0
1–3	12	0	12	2	14	2

1–4	7	0	7	5	12	5
2–4	8	4	12	4	12	0
2–5	5	4	9	5	10	1
3–6	9	12	21	14	23	2
4–6	11	12	23	12	23	0
5–7	13	9	22	10	23	1
6–7	0	23	23	23	23	0
6–8	5	23	28	25	30	2
7–8	7	23	30	23	30	0
8–9	6	30	36	30	36	0

(ii) The **Network** for the given problem:



(iii) The **Various Paths** in the Network are:

1–2–4–6–7–8–9 with Duration 36 Days
1–2–5–7–8–9 with Duration 35 Days
1–3–6–7–8–9 with Duration 34 Days
1–2–4–6–8–9 with Duration 34 Days
1–3–6–8–9 with Duration 32 Days
1–4–6–7–8–9 with Duration 31 Days
1–4–6–8–9 with Duration 29 Days

(iv) The **Critical Path** is 1–2–4–6–7–8–9 with Duration 36 Days.

SECTION - C

PERT/ CPM – Basic Concepts

Problem-1

State the validity of following statements along with the reasons:

(i) Two activities have common predecessor and successor activities. So, they can have common initial and final nodes.

(ii) In respect of any activity whether real or dummy, the terminal node should bear a number higher than the initial node number.

(iii) The difference between the latest event time and the earliest event time is termed as free float.

(iv) For every critical activity in a network, the earliest start and the earliest finish time as well as the latest finish time and the latest start time are the same.

(v) The optimal duration of a project is the minimum time in which it can be completed.

(vi) Resource leveling aims at smoothening of the resource usage rate without changing the project duration.

Solution

(i) Invalid

Reason: As per the rules of network construction, parallel activities between two events, without intervening events, are prohibited. Dummy activities are needed when two or more activities have same initial and terminal events. Dummy activities do not consume time or resources.

(ii) Valid

Reason: As per the conventions adopted in drawing networks, the head event or terminal node always has a number higher than that of initial node or tail event.

(iii) Invalid

Reason: The difference between the latest event time and the earliest event time is termed as slack of an event. Free float is determined by subtracting head event slack from the total float of an activity.

(iv) Invalid

Reason: For every critical activity in a network, the earliest start time and the latest start time is same and also the earliest finish time and the latest finish time is same.

(v) Invalid

Reason: The optimum duration is the time period in which the total cost of the project is minimum.

(vi) Valid

Reason: Resource leveling is a network technique used for reducing the requirement of a particular resource due to its paucity or insufficiency within a constraint on the project duration. The process of resource leveling utilize the large floats available on non-critical activities of the project and cuts down the demand of the resource.

14 Programme Evaluation and Review Technique

Basic Concepts

Estimate of Probability	Due to variability in the activity duration, the total project may not be completed exactly in time. Thus, it is necessary to calculate the probability of actual meeting the schedule time of the project as well as activities. Probability of completing the project by schedule time (T_s) is given by $$Z = \frac{T_s - T_e}{\sigma_e}$$ Te represents the duration on the critical path. T_e can be calculated by adding the expected time of each activity lying on the critical path. σ_e represents standard deviation of the critical path. Variance of the critical path can be get by adding variances of critical activities. σ_e is the square root of variance of the critical path.
Expected Time	The expected time (t_e) is the average time taken for the completion of the job. By using beta-distribution, the expected time can be obtained by following formula. $$t_e = \frac{t_o + 4t_m + t_p}{6}$$
Project Crashing	Project Crashing deal with those situations which will speak of the effect of increase or decrease in the total duration for the completion of a project and are closely associated with cost considerations. In such cases when the time duration is reduced, the project cost increases, but in some exceptional cases project cost is reduced as well. The reduction in cost occurs in the case of those projects which make use of a certain type of resources, for example, a machine and whose time is more valuable than the operator's time.

Activity Cost : It is defined as the cost of performing and completing a particular activity or task.

Crash Cost (C_c) : This is the direct cost that is anticipated in completing an activity within the crash time.

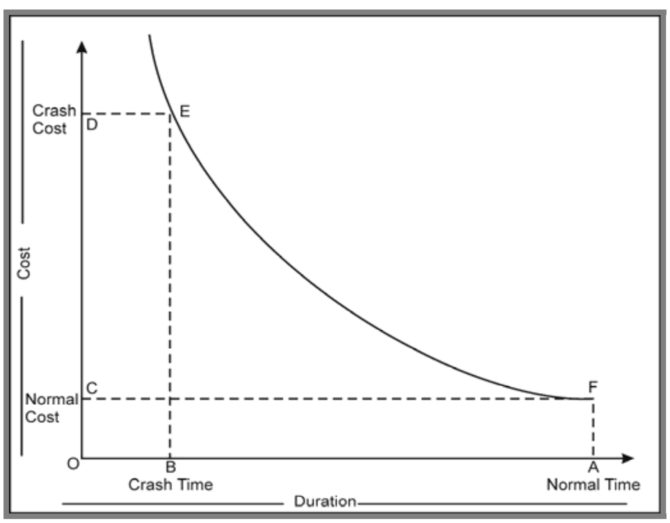
Crash Time (C_t) : This is the minimum time required to complete an activity.

Normal Cost (N_c) : This is the lowest possible direct cost required to complete an activity.

Normal Time (N_t) : This is the minimum time required to complete an activity at Cost normal cost.

Activity Cost Slope : The cost slope indicates the additional cost incurred per unit of time saved in reducing the duration of an activity. It can be understood more clearly by considering the below figure.

Let OA represent the normal time duration for completing a job and OC the normal cost involved to complete the job. Assume that the management wish to reduce the time of completing the job to OB from normal time OA. Therefore under such a situation the cost of the project increases and it goes up to say OD (Crash Cost). This only amounts to saving that by reducing the time period by BA the cost has increased by the amount CD. The rate of increase in the cost of activity per unit with a decrease in time is known as cost slope and is described as below.



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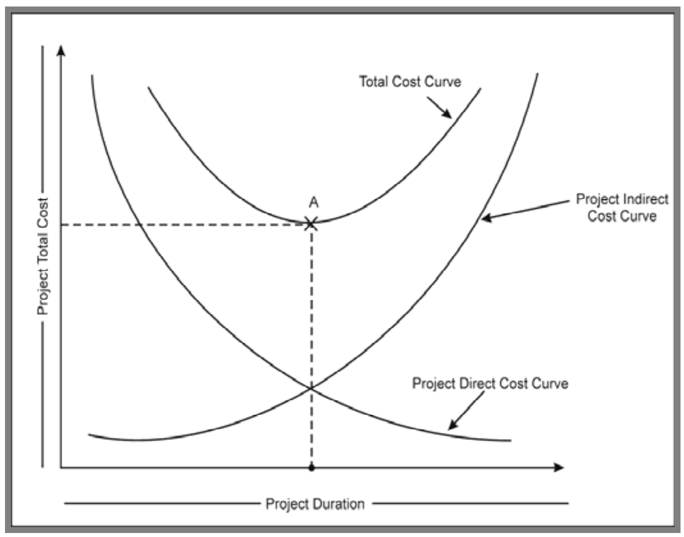
Activity Cost Slope $= \dfrac{CD}{AB} = \dfrac{OD - OC}{OA - OB}$

$= \dfrac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Time} - \text{Crash Time}}$

Optimum Duration: The total project cost is the sum of the direct and the indirect costs. In case the direct cost varies with the project duration time, the total project cost would have the shape indicated in the following figure:



At the point A, the cost will be minimum. The time corresponding, to point A is called the optimum duration and the cost as optimum cost for the project.

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Resource Smoothing

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It is a network technique used for smoothening peak resource requirement during different periods of the project network. Under this technique the total project duration is maintained at the minimum level. For example, if the duration of a project is 15 days, then the project duration is maintained, but the resources required for completing different activities of a project are smoothened by utilising floats available on non-critical activities. These non-critical activities having floats are rescheduled or shifted so that a uniform demand on resources is achieved. In other words, the constraint in the case of resource smoothing operation would be on the project duration time. Resource smoothing is a useful technique or business managers

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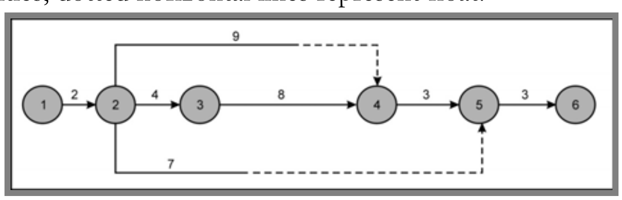
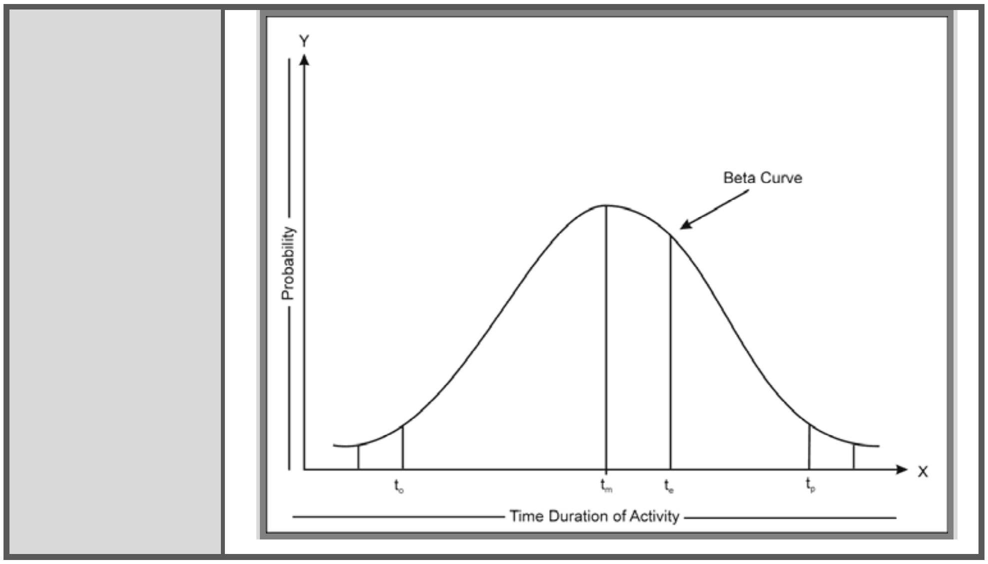
	to estimate the total resource requirements for various project activities. In resources smoothing, the time-scaled diagram of various activities and their floats (if any), along with resource requirements are used. The periods of maximum demand for resources are identified and non-critical activities during these periods are staggered by rescheduling them according to their floats for balancing the resource requirements.
Resource Leveling	It is also a network technique which is used for reducing the requirement of a particular resource due to its paucity. The process of resource levelling utilize the large floats available on non-critical activities of the project and thus cuts down the demand on the resource. In resource levelling, the maximum demand of a resource should not exceed the available limit at any point of time. In order to achieve this, non-critical activities are rescheduled by utilising their floats. Sometimes, the use of resource levelling may lead to enlonging the completion time of the project. In other words, in resource levelling, constraint is on the limit of the resource availability.
Time Scaled Diagrams	Below figure shows the network diagram drawn to a horizonal time scale. The critical path has been arranged as a straight line with non-critical events above or below it. Solid lines represent activities, dotted horizontal lines represent float. 
Updating the Network	The progress of various activities in a project network is measured periodically. Normally, either most of the activities are ahead or behind the schedule. It is therefore, necessary to update or redraw the network periodically to know the exact position of completion of each activity of the project. The task of updating the network may be carried out once in a month. Sometimes the updating of the network may provide useful information to such an extent that it may demand the revision of even those very activities which have not started. Even the logic may also change i.e. some of the existing activities may have to be dropped and new activities may be added up. In brief the network should be amended accordingly in the light of new developments. It is also not unlikely that the total physical quantum of work

	accomplished at a point of time may exceed what was planned but the progress against the critical path alone may be slower than the scheduled pace.
Variance	Beta distribution is assumed for these "guess estimates" and PERT analysts have found that beta-distribution curve happens to give fairly satisfactory results for most of the activities. For a distribution of this type, the standard deviation is approximately one sixth of the range, i.e. $$S_t = \frac{t_p - t_o}{6}$$ The variance, therefore; is $$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$$
Why PERT?	**PERT** (Program Evaluation and Review Technique) is more relevant for handing such projects which have a great deal of uncertainty associated with the activity durations. To take these uncertainty into account, three kinds of times estimates are generally obtained. These are: **(i) The Optimistic Times Estimate:** This is the estimate of the shortest possible time in which an activity can be completed under ideal conditions. For this estimate, no provision for delays or setbacks are made. We shall denote this estimate by to. **(ii) The Pessimistic Time Estimate:** This is the maximum possible time which an activity could take to accomplish the job. If everything went wrong and abnormal situations prevailed, this would be the time estimate. It is denoted by tp. **(iii) The Most Likely Time Estimate**: This is a time estimate of an activity which lies between the optimistic and the pessimistic time estimates. It assumes that things go in a normal way with few setbacks. It is represents by tm. Statistically, it is the model value if duration of the activity. These activity durations follow a probability distribution called Beta Distribution.


Y
Probability
Beta Curve
X
t_o
t_m
t_e
t_p
Time Duration of Activity

SECTION - A

Project Updating/ Crashing, Resource Levelling/ Smoothing

Question-1

Write a short note on 'Updating the Network'

Answer

The progress of various activities in a project network is measured periodically. Normally, either most of the activities are ahead or behind the schedule. It is therefore, necessary to update or redraw the network periodically to know the exact position of completion of each activity of the project. The task of updating the network may be carried out once in a month. Sometimes the updating of the network may provide useful information to such an extent that it may demand the revision of even those very activities which have not started. Even the logic may also change i.e. some of the existing activities may have to be dropped and new activities may be added up. In brief the network should be amended accordingly in the light of new developments.

It is also not unlikely that the total physical quantum of work accomplished at a point of time may exceed what was planned but the progress against the critical path alone may be slower than the scheduled pace.

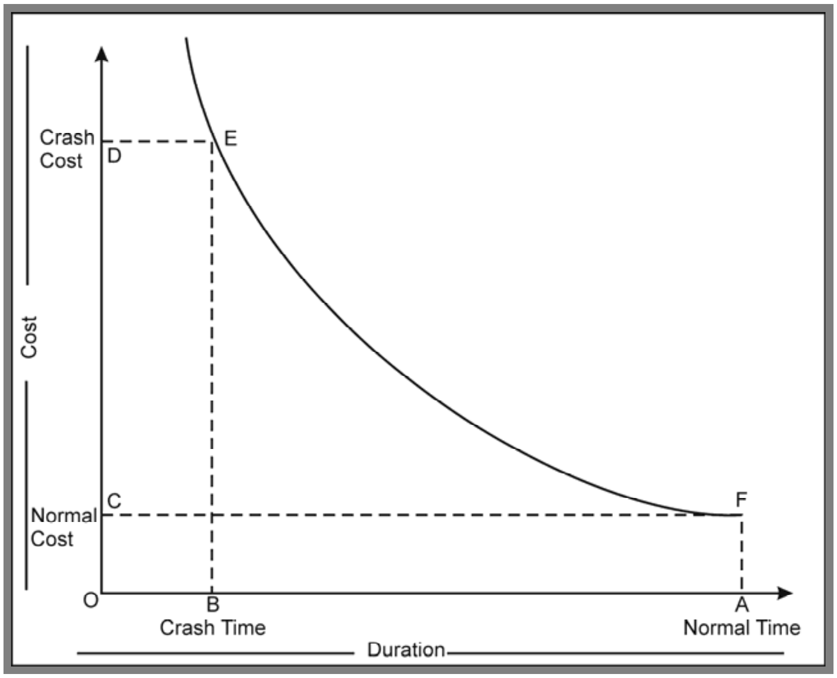
Question-2

Write a short note on 'Activity Cost Slope'

Answer

The cost slope indicates the additional cost incurred per unit of time saved in reducing the duration of an activity. It can be understood more clearly by considering the figure.

Let OA represent the normal time duration for completing a job and OC the normal cost involved to complete the job. Assume that the management wish to reduce the time of completing the job to OB from normal time OA. Therefore under such a situation the cost of the project increases and it goes up to say OD (Crash Cost). This only amounts to saving that by reducing the time period by BA the cost has increased by the amount CD. The rate of increase in the cost of activity per unit with a decrease in time is known as cost slope and is described as below.



$$\text{Activity Cost Slope} = \frac{CD}{AB} = \frac{OD - OC}{OA - OB}$$

$$= \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Time} - \text{Crash Time}}$$

Question-3

Explain the terms 'Resource Smoothing' and 'Resource Levelling'.

Answer

Resource Smoothing

It is a network technique used for smoothening peak resource requirement during different periods of the project network. Under this technique the total project duration is maintained at the minimum level. For example, if the duration of a project is 15 days, then the project duration is maintained, but the resources required for completing different activities of a project are smoothened by utilising floats available on non critical activities. These non critical activities having floats are rescheduled or shifted so that a uniform demand on resources is achieved. In other words, the constraint in the case of resource smoothing operation would be on the project duration time. Resource smoothing is a useful technique or business managers to estimate the total resource requirements for various project activities.

In resources smoothing, the time-scaled diagram of various activities and their floats (if any), along with resource requirements are used. The periods of maximum demand for resources are identified and non critical activities during these periods are staggered by rescheduling them according to their floats for balancing the resource requirements.

Resource Leveling

It is also a network technique which is used for reducing the requirement of a particular resource due to its paucity. The process of resource levelling utilize the large floats available on non-critical activities of the project and thus cuts down the demand on the resource. In resource levelling, the maximum demand of a resource should not exceed the available limit at any point of time. In order to achieve this, non critical activities are rescheduled by utilising their floats. Some times, the use of resource levelling may lead to enlonging the completion time of the project. In other words, in resource levelling, constraint is on the limit of the resource availability.

PERT/ CPM

Question-4

Under what circumstance PERT is more relevant? How?

Answer

PERT (Program Evaluation and Review Technique) is more relevant for handling such projects which have a great deal of uncertainty associated with the activity durations.

To take these uncertainty into account, three kinds of times estimates are generally obtained. These are:

- The Optimistic Times Estimate: This is the estimate of the shortest possible time in which an activity can be completed under ideal conditions. For this estimate, no provision for delays or setbacks are made. We shall denote this estimate by t_o.
- The Pessimistic Time Estimate: This is the maximum possible time which an activity could take to accomplish the job. If everything went wrong and abnormal situations prevailed, this would be the time estimate. It is denoted by t_p.
- The Most Likely Time Estimate: This is a time estimate of an activity which lies between the optimistic and the pessimistic time estimates. It assumes that things go in a normal way with few setbacks. It is represents by t_m.

Question-5

Write short notes on Distinction between PERT and CPM.

Answer

The PERT and CPM models are similar in terms of their basic structure, rationale and mode of analysis. However, there are certain distinctions between PERT and CPM networks which are enumerated below:

(i) CPM is activity oriented i.e. CPM network is built on the basis of activities. Also results of various calculations are considered in terms of activities of the project. On the other hand, PERT is event oriented.

(ii) CPM is a deterministic model i.e. it does not take into account the uncertainties involved in the estimation of time for execution of a job or an activity. It completely ignores the probabilistic element of the problem. PERT, however, is a probabilistic model. It uses three estimates of the activity time; optimistic, pessimistic and most likely, with a view to take into account time uncertainty. Thus, the expected duration for each activity is probabilistic and expected duration indicates that there is fifty per probability of getting the job done within that time.

(iii) CPM places dual emphasis on time and cost and evaluates the trade-off between project cost and project item. By deploying additional resources, it allows the critical path project manager to manipulate project duration within certain limits so that project duration can be shortened at an optimal cost. On the other hand, PERT is primarily concerned with time. It helps the manger to schedule and coordinate various activities so that the project can be completed on scheduled time.

(iv) CPM is commonly used for those projects which are repetitive in nature and where one has prior experience of handling similar projects. PERT is generally used for those projects where time required to complete various activities are not known as prior. Thus, PERT is widely used for planning and scheduling research and development project.

Question-6

State any 5 limitations of the assumptions of PERT and CPM.

Answer

(i) Beta distribution may not always be applicable

(ii) The formulae for expected duration and standard deviation are simplification. In certain cases, errors due to these have been found up to 33 %

(iii) The above errors may get compounded or may cancel each other

(iv) Activities are assumed to be independent. But the limitations on the resources may not justify the assumption.

(v) It may not always be possible to sort out completely_identifiable activities and to state where they begin and where they end

(vi) If there exist alternatives in outcome, they need to be incorporated by way of a decision tree analysis.

(vii) Time estimates have a subjective element and to this extent, techniques could be weak. Contractors can manipulate and underestimate time in cost plus contract bids. In incentive contracts, overestimation is likely.

(viii) Cost-time tradeoffs / cost curve slopes are subjective and even experts may be widely off the mark even after honest deliberations

SECTION - B

Estimate of Probability

Problem-1

The Chennai Construction Company is bidding on a contract to install a line of microwave towers. It has identified, the expected duration of the critical path is 18 weeks and the sum of the variances of the activities on the critical path is 9 weeks.

Required

Calculate the probability that the project may be completed not earlier than 15 weeks and not later than 21 weeks.

Solution

Probability of Completing the Project by Schedule Time T_s is given by

$$Z = \frac{T_s - T_e}{\sigma_e}$$

Probability if the Project is required to be completed in 15 weeks:

Probability if the Project is required to be completed in 15 weeks is given by

$$Z = \frac{15 - 18}{3}$$

$$Z = -1$$

Probability $(Z = -1) = 0.1587$

Probability if the Project is required to be completed in 21 weeks:

Probability if the Project is required to be completed in 21 weeks is given by

$$Z = \frac{21 - 18}{3}$$

$$Z = +1$$

Probability $(Z = +1) = 0.8413$

Probability that the Project may be completed not earlier than 15 weeks and not later than 21 weeks

$= 0.8413 – 0.1587$

$= 0.6826$

Or $= 68.26\%$

Problem-2

A small project is composed of seven activities, whose time estimates are listed below. Activities are identifies by their beginning (i) and ending (j) note numbers:

Activity	***Estimated Durations (in Days)***		
(i–j)	***Optimistic***	***Most Likely***	***Pessimistic***
1–2	*2*	*2*	*14*
1–3	*2*	*8*	*14*
1–4	*4*	*4*	*16*
2–5	*2*	*2*	*2*
3–5	*4*	*10*	*28*
4–6	*4*	*10*	*16*
5–6	*6*	*12*	*30*

Required

(a) Draw the project network.

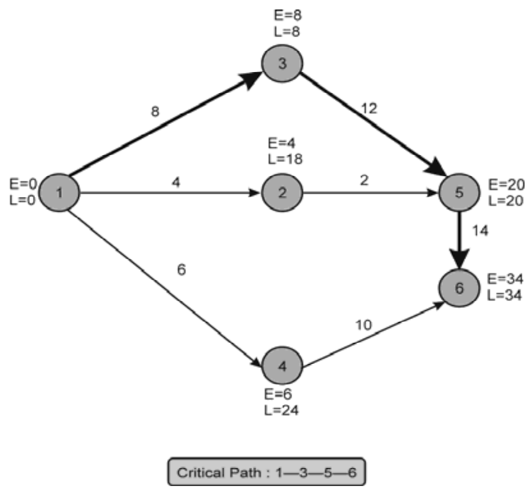
(b) Find the expected duration and variance for each activity. What is the expected project length?

Solution

(i) The **Expected Time** and **Variance** for each of the activities (in Days):

Activity	**Time Estimates (Days)**			**Expected Time**	**Variance**
	Optimistic (t_o)	**Most Likely (t_m)**	**Pessimistic (t_p)**	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1–2	2	2	14	4	4
1–3	2	8	14	8	4
1–4	4	4	16	6	4
2–5	2	2	2	2	0
3–5	4	10	28	12	16
4–6	4	10	16	10	4
5–6	6	12	30	14	16

(ii) The **network** for the given problem



(iii) **Expected Project Length** is 34 Days (8 Days + 12 Days + 14 Days).

Problem-3

Consider the schedule of activities and related information as given below, for the construction of a Plant:

Activity	*Expected Time (Months)*	*Variance*	*Expected Cost (Millions of ₹)*
1–2	*4*	*1*	*5*
2–3	*2*	*1*	*3*
3–6	*3*	*1*	*4*
2–4	*6*	*2*	*9*
1–5	*2*	*1*	*2*
5–6	*5*	*1*	*12*
4–6	*9*	*5*	*20*
5–7	*7*	*8*	*7*
7–8	*10*	*16*	*14*
6–8	*1*	*1*	*4*

Required

Assuming that the cost and time required for one activity is independent of the time and cost of any other activity and variations are expected to follow normal distribution, draw a network based on the above data and calculate:

(i) Critical path.

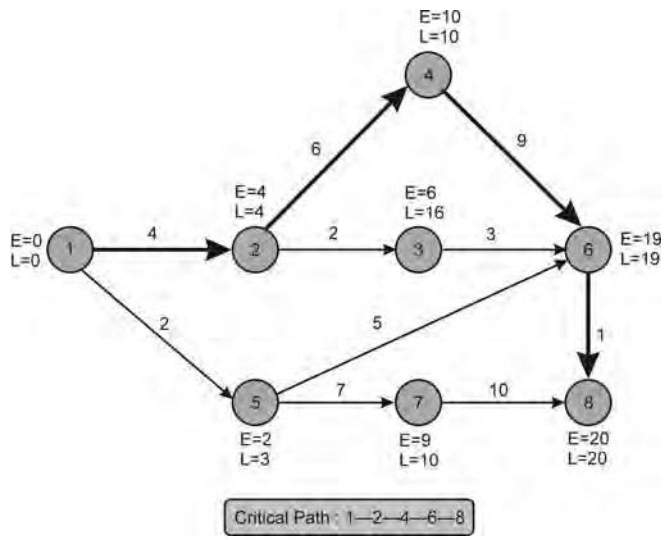
(ii) Expected cost of construction of the plant.

(iii) Expected time required to build the plant.

(iv) The standard deviation of the expected time.

Solution

(i) **Network** diagram for the given data:



(ii) **Expected Cost of Construction** of the plant is ₹80 millions (₹5 + ₹3 + ₹4 + ₹9 + ₹2 + ₹12 + ₹20 + ₹7 + ₹14 + ₹4, millions).

(iii) **Expected Time Required** to build the plant is 20 months (4 + 6 + 9 + 1, months)

(iv) The variance of the expected time is 9 months. Determined by summing the variance of critical activities (1 + 2 + 5 + 1, months). **Standard Deviation** of the expected time 3 months (root of variance).

Problem-4

A German Construction Company is preparing a network for laying the foundation of a new science museum. Given the following set of activities, their predecessor requirements and three time estimates of completion time:

Activity	*Predecessors*	*Time Estimates (Weeks)*		
		Optimistic	*Pessimistic*	*Most Likely*
A	*None*	*2*	*4*	*3*
B	*None*	*8*	*8*	*8*
C	*A*	*7*	*11*	*9*
D	*B*	*6*	*6*	*6*
E	*C*	*9*	*11*	*10*
F	*C*	*10*	*18*	*14*
G	*C,D*	*11*	*11*	*11*
H	*F,G*	*6*	*14*	*10*
I	*E*	*4*	*6*	*5*
J	*I*	*3*	*5*	*4*
K	*H*	*1*	*1*	*1*

Required

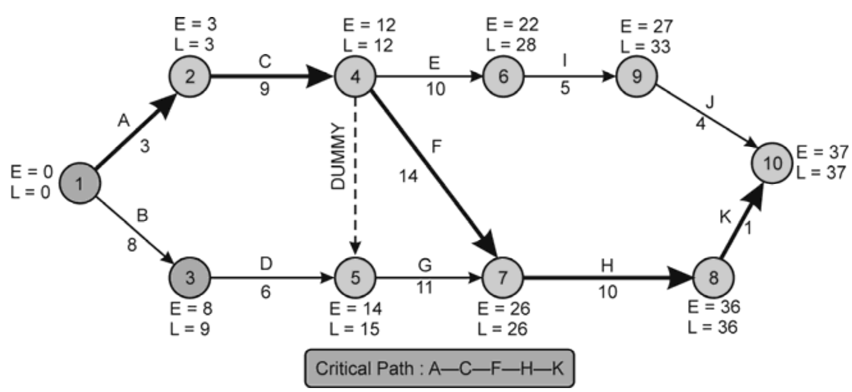
(i) *Draw the network and determine the critical path.*

(ii) *If the project due date is 41 weeks, what is the probability of not meeting the due date?*

(iii) *Compute the float for each activity.*

Solution

(i) The **network** for the given problem:



(ii) The **Expected Time** and **Variance** for each of the activities (in weeks):

Activity	Time Estimates (Weeks)			Expected Time	Variance
	Optimistic (t_o)	Pessimistic (t_p)	Most Likely (t_m)	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
A (1–2)	2	4	3	3	$\frac{1}{9}$
B (1–3)	8	8	8	8	0
C (2–4)	7	11	9	9	$\frac{4}{9}$
D (3–5)	6	6	6	6	0
Dummy (4–5)	0	0	0	0	0
E (4–6)	9	11	10	10	$\frac{1}{9}$
F (4–7)	10	18	14	14	$\frac{16}{9}$
G (5–7)	11	11	11	11	0
H (7–8)	6	14	10	10	$\frac{16}{9}$
I (6–9)	4	6	5	5	$\frac{1}{9}$
J (9–10)	3	5	4	4	$\frac{1}{9}$
K (8–10)	1	1	1	1	0

Expected Project Length (T_e) = 37 Weeks

Variance of the Critical Path A–C–F–H–K (σ_e^2) $= \frac{1}{9} + \frac{4}{9} + \frac{16}{9} + \frac{16}{9} + 0$

$= \frac{37}{9}$

Standard Deviation of the Critical Path (σ_e) $= \sqrt{\dfrac{37}{9}}$

$= 2.0276$

(iii) Probability of *not meeting* the due date of 41 weeks:

Probability of Completing the Project by Schedule Time T_s is given by $Z = \dfrac{T_s - T_e}{\sigma_e}$

Accordingly probability of meeting the due date of 41 weeks is given by $Z = \dfrac{41 - 37}{2.0276}$

$= 1.97$

Probability (Z = 1.97) $= 0.9756$

Probability of not meeting the due date of 41 weeks $= 1 - 0.9756$

$= 0.0244$

Or $= 2.44\%$

(iv) Calculation of **Total Float**, **Free Float** and **Independent Float**:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST – EST	Total Float – Slack of Head Event	Free Float – Slack of Tail Event
A (1–2)	3	0	3	0	3	0	0	0	0	0
B (1–3)	8	0	8	1	9	0	1	1	0	0
C (2–4)	9	3	12	3	12	0	0	0	0	0
D (3–5)	6	8	14	9	15	1	1	1	0	0*
Dum. (4–5)	0	12	12	15	15	0	1	3	2	2

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
E (4–6)	10	12	22	18	28	0	6	6	0	0
F (4–7)	14	12	26	12	26	0	0	0	0	0
G (5–7)	11	14	25	15	26	1	0	1	1	0
H (7–8)	10	26	36	26	36	0	0	0	0	0
I (6–9)	5	22	27	28	33	6	6	6	0	0*
J (9–10)	4	27	31	33	37	6	0	6	6	0
K (8–10)	1	36	37	36	37	0	0	0	0	0

(*) Being negative, the independent float is taken to be equal to zero.

Problem-5

The activities involved in a project are detailed below:

Job	***Duration (Weeks)***		
	Optimistic	***Most Likely***	***Pessimistic***
1–2	*3*	*6*	*15*
2–3	*6*	*12*	*30*
3–5	*5*	*11*	*17*
7–8	*4*	*19*	*28*

5–8	*1*	*4*	*7*
6–7	*3*	*9*	*27*
4–5	*3*	*6*	*15*
1–6	*2*	*5*	*14*
2–4	*2*	*5*	*8*

Required

(i) *Draw a network diagram.*

(ii) *Find the critical path after estimating the earliest and latest event times for all nodes.*

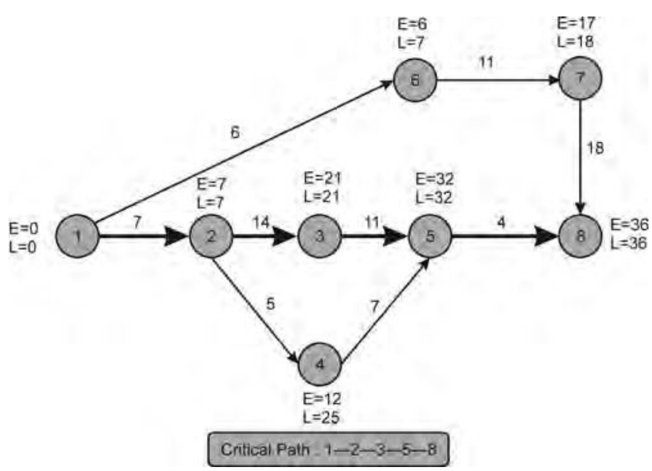
(iii) *Find the probability of completing the project before 31 weeks?*

(iv) *What is the chance of project duration exceeding 46 weeks?*

(v) *What will be the effect on the current critical path if the most likely time of activity 3–5 gets revised to 14 instead of 11 weeks given above?*

Solution

(i) The **network** for the given problem:



(ii) The **Expected Time** and **Variance** for each of the activities (in weeks):

Activity	Time Estimates (Weeks)			Expected Time	Variance
	Optimistic (t_o)	Most Likely (t_m)	Pessimistic (t_p)	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1–2	3	6	15	7	4
2–3	6	12	30	14	16
3–5	5	11	17	11	4
7–8	4	19	28	18	16
5–8	1	4	7	4	1
6–7	3	9	27	11	16
4–5	3	6	15	7	4
1–6	2	5	14	6	4
2–4	2	5	8	5	1

Expected Project Length (T_e) = 36 weeks

Variance of the Critical Path 1–2–3–5–8 (σ_e^2) = 4+16+4+1

= 25

Standard Deviation of the Critical Path (σ_e) = $\sqrt{25}$

= 5

(iii) Probability of completing the project *before* 31 weeks:

Probability of Completing the Project by Schedule Time T_s is given by Z $= \frac{T_s - T_e}{\sigma_e}$

Probability of completing the project before 31 weeks is given by Z $= \frac{31 - 36}{5}$

= −1

Probability (Z = -1) = 0.1587

Or = 15.87%

(iv) Chance of project duration *exceeding* 46 weeks:

Probability of Completing the Project by Schedule Time T_s is given by Z $= \frac{T_s - T_e}{\sigma_e}$

Chances that the project will be completed in a period 46 weeks is given by Z

$$= \frac{46 - 36}{5}$$

$= 2.00$

Probability (Z = 2.00) = 0.9772

Chances of the project duration exceeding 46 weeks = 1 – 0.9772

= 0.0228

Or = 2.28%

(v) Effect on the current critical path if the most likely time of activity 3–5 gets *revised to* 14:

If the most likely time of activity 3–5 gets revised to 14 instead of 11 weeks as given, the expected duration of the activity 3–5 will be

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

$$t_e = \frac{5 + 4x14 + 17}{6} = 13 \text{ Weeks}$$

Accordingly, expected duration of the activity 3–5 will be 13 weeks instead of 11 weeks calculated earlier. As activity 3–5 lie on the critical path, the project duration will increase by 2 weeks (13-11) and the total project duration will become 38 weeks (36+2).

Problem-6

Consider the following project:

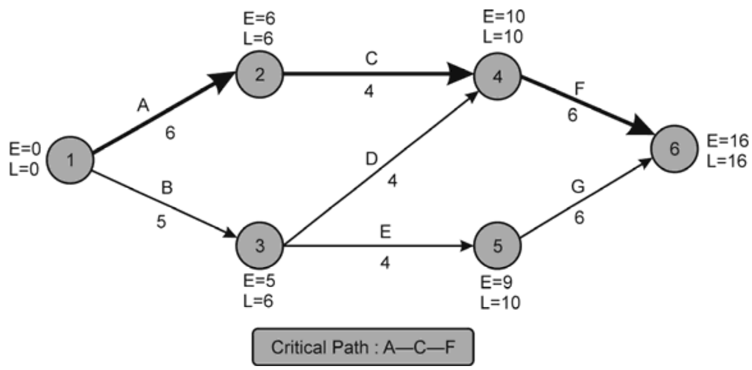
Activity	*Predecessors*	*Time Estimates (Weeks)*		
		Optimistic	*Most Likely*	*Pessimistic*
A	None	3	6	9
B	None	2	5	8
C	A	2	4	6
D	B	2	3	10
E	B	1	3	11
F	C,D	4	6	8
G	E	1	5	15

Required

Find the critical path and its standard deviation. What is the probability that the project will be completed by 18 weeks?

Solution

(i) The **network** for the given problem:



(ii) The **Expected Time** and **Variance** for each of the activities (in weeks):

Activity	Time Estimates (Weeks)			Expected Time	Variance
	Optimist. (t_o)	Most Likely (t_m)	Pessimistic (t_p)	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
A (1–2)	3	6	9	6	1
B (1–3)	2	5	8	5	1
C (2–4)	2	4	6	4	$\frac{4}{9}$
D (3–4)	2	3	10	4	$\frac{16}{9}$
E (3–5)	1	3	11	4	$\frac{25}{9}$
F (4–6)	4	6	8	6	$\frac{4}{9}$
G (5–6)	1	5	15	6	$\frac{49}{9}$

Expected Project Length (T_e) = 16 weeks

Variance of the Critical Path A–C–F (σ_e^2) = $1+\frac{4}{9}+\frac{4}{9}$

Or = $\frac{17}{9}$

Standard Deviation of the Critical Path (σ_e) = $\sqrt{\frac{17}{9}}$

Or = 1.3743

(iii) Probability of Completing of Project by 18 Weeks:

Probability of Completing the Project by Schedule Time T_s is given by Z = $\frac{T_s - T_e}{\sigma_e}$

Accordingly Probability of Completion of Project in 18 weeks is given by Z = $\frac{18-16}{1.3743}$

Or = 1.46

Probability (Z = 1.46) = 0.9279

Or = 92.79%

Problem-7

A project consisting of twelve distinct activities is to be analyzed by using PERT. The following information is given:

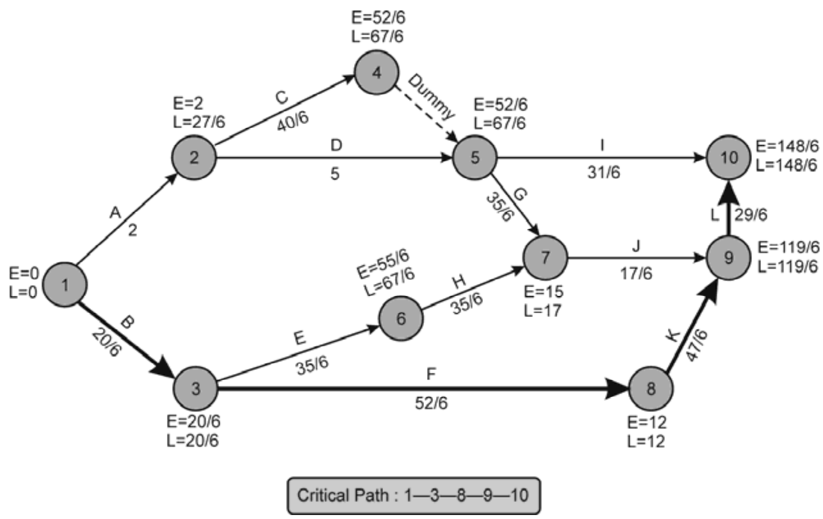
Activity	***Predecessors***	***Time Estimates***		
		Optimistic Time	***Most Likely Time***	***Pessimistic Time***
A	*None*	*2*	*2*	*2*
B	*None*	*1*	*3*	*7*
C	*A*	*4*	*7*	*8*
D	*A*	*3*	*5*	*7*
E	*B*	*2*	*6*	*9*
F	*B*	*5*	*9*	*11*
G	*C,D*	*3*	*6*	*8*
H	*E*	*2*	*6*	*9*
I	*C,D*	*3*	*5*	*8*
J	*G,H*	*1*	*3*	*4*
K	*F*	*4*	*8*	*11*
L	*J,K*	*2*	*5*	*7*

Required

Draw the PERT network. Indicate the expected total slack for each activity and hence indicate the average critical path. What time would you expect if the project to be completed with 99% chance?

Solution

(i) The **network** for the given problem:



(ii) The **Expected Time** and **Variance** for each of the activities:

Activity	Time Estimates			Expected Time	Variance
	Optimist. (t_o)	Most Likely (t_m)	Pessimistic (t_p)	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
A (1–2)	2	2	2	2	0
B (1–3)	1	3	7	$\frac{20}{6}$	1
C (2–4)	4	7	8	$\frac{40}{6}$	$\frac{16}{36}$
D (2–5)	3	5	7	5	$\frac{16}{36}$

Activity	Time Estimates			Expected Time	Variance
	Optimist. (t_o)	Most Likely (t_m)	Pessimistic (t_p)	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
E (3–6)	2	6	9	$\frac{35}{6}$	$\frac{49}{36}$
F (3–8)	5	9	11	$\frac{52}{6}$	1
G (5–7)	3	6	8	$\frac{35}{6}$	$\frac{25}{36}$
H (6–7)	2	6	9	$\frac{35}{6}$	$\frac{49}{36}$
I (5–10)	3	5	8	$\frac{31}{6}$	$\frac{25}{36}$
J (7–9)	1	3	4	$\frac{17}{6}$	$\frac{9}{36}$
K (8–9)	4	8	11	$\frac{47}{6}$	$\frac{49}{36}$
L (9–10)	2	5	7	$\frac{29}{6}$	$\frac{25}{36}$

Expected Project Length (T_e) = $\frac{148}{6}$

Or = 24.66…

Variance of the Critical Path B–F–K–L (σ_e^2) = $1 + 1 + \frac{49}{36} + \frac{25}{36}$

Or = $\frac{146}{36}$

Standard Deviation of the Critical Path (σ_e) = $\sqrt{\frac{146}{36}}$

Or = 2.014

(iii) Expected Time if the project to be completed with 99% chance:

Probability of Completing the Project by Schedule Time T_s is given by

$$Z = \frac{T_s - T_e}{\sigma_e}$$

Accordingly, $$Z = \frac{T_s - 24.66...}{2.014}$$

At 99% Chance Z equals to 2.326.

Accordingly, $$2.326 = \frac{T_s - 24.66...}{2.014}$$

Or $$T_s = 29.35$$

Hence, expected time of completing the project with 99% of chances is 29.35

(iv) **Total Slack** for activities of above network are given in the table below:

Activity	Duration	EST	EFT	LST	LFT	Total Slack
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	LST − EST
A (1–2)	2	0	2	$\frac{15}{6}$	$\frac{27}{6}$	$\frac{15}{6}$
B (1–3)	$\frac{20}{6}$	0	$\frac{20}{6}$	0	$\frac{20}{6}$	0
C (2–4)	$\frac{40}{6}$	2	$\frac{52}{6}$	$\frac{27}{6}$	$\frac{67}{6}$	$\frac{15}{6}$
D (2–5)	5	2	7	$\frac{37}{6}$	$\frac{67}{6}$	$\frac{25}{6}$
E (3–6)	$\frac{35}{6}$	$\frac{20}{6}$	$\frac{55}{6}$	$\frac{32}{6}$	$\frac{67}{6}$	2
F (3–8)	$\frac{52}{6}$	$\frac{20}{6}$	12	$\frac{20}{6}$	12	0
Dummy (4–5)	0	$\frac{52}{6}$	$\frac{52}{6}$	$\frac{67}{6}$	$\frac{67}{6}$	$\frac{15}{6}$
G (5–7)	$\frac{35}{6}$	$\frac{52}{6}$	$\frac{87}{6}$	$\frac{67}{6}$	17	$\frac{15}{6}$
H (6–7)	$\frac{35}{6}$	$\frac{55}{6}$	15	$\frac{67}{6}$	17	2
I (5–10)	$\frac{31}{6}$	$\frac{52}{6}$	$\frac{83}{6}$	$\frac{117}{6}$	$\frac{148}{6}$	$\frac{65}{6}$

Activity	Duration	EST	EFT	LST	LFT	Total Slack
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	LST − EST
J (7–9)	$\frac{17}{6}$	15	$\frac{107}{6}$	17	$\frac{119}{6}$	2
K (8–9)	$\frac{47}{6}$	12	$\frac{119}{6}$	12	$\frac{119}{6}$	0
L (9–10)	$\frac{29}{6}$	$\frac{119}{6}$	$\frac{148}{6}$	$\frac{119}{6}$	$\frac{148}{6}$	0

Problem-8

A project consists of seven activities and the time estimates of the activities are furnished as under:

Activity	*Optimistic Days*	*Most likely Days*	*Pessimistic Days*
1–2	*4*	*10*	*16*
1–3	*3*	*6*	*9*
1–4	*4*	*7*	*16*
2–5	*5*	*5*	*5*
3–5	*8*	*11*	*32*
4–6	*4*	*10*	*16*
5–6	*2*	*5*	*8*

Required

(i) *Draw the network diagram.*

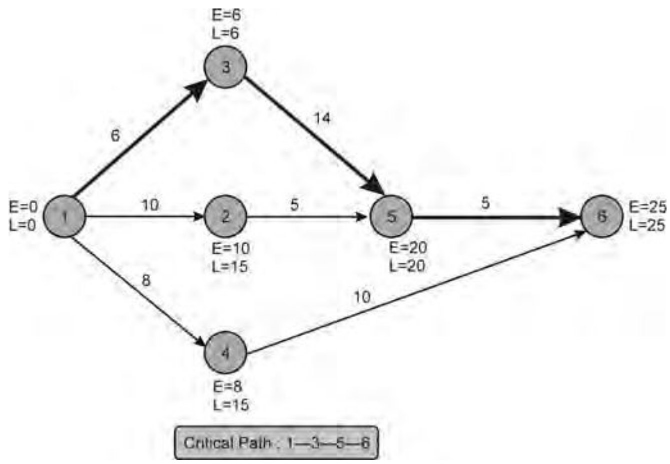
(ii) *Identify the critical path and its duration.*

(iii) *What is the probability that the project will be completed in 5 days earlier than the critical path duration?*

(iv) *What project duration will provide 95% confidence level of completion?*

Solution

(i) The **network** for the given problem:



(ii) The **Expected Time** and **Variance** for each of the activities (in days):

Activity	Time Estimates (Days)			Expected Time	Variance
	Optimistic (t_o)	**Pessimistic (t_p)**	**Most Likely (t_m)**	$t_e = \dfrac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\dfrac{t_p - t_o}{6}\right)^2$
1–2	4	16	10	10	4
1–3	3	9	6	6	1
1–4	4	16	7	8	4
2–5	5	5	5	5	0
3–5	8	32	11	14	16
4–6	4	16	10	10	4
5–6	2	8	5	5	1

Expected Project Length (T_e) = 25 Days

Variance of the Critical Path 1–3–5–6 (σ_e^2) = 1+16+1

= 18

Standard Deviation of the Critical Path (σ_e) = $\sqrt{18}$

= 4.24

(iii) Probability that the project will be completed in 5 days *earlier* than the critical path duration:

Probability of Completing the Project by Schedule Time T_s is given by Z = $\frac{T_s - T_e}{\sigma_e}$

Accordingly probability of meeting the due date of 20 days is given by Z = $\frac{20 - 25}{4.24}$

= –1.18

Probability (Z = –1.18) = 0.1190

Or = 11.90%

(iv) Project Duration for 95% confidence level of completion:

Probability of Completing the Project by Schedule Time Ts is given by

$$Z = \frac{T_s - T_e}{\sigma_e}$$

Accordingly, $Z = \frac{T_s - 25}{4.24}$

At 95% Chance Z equals to 1.645.

Accordingly, $1.645 = \frac{T_s - 25}{4.24}$

Or T_s = 31.97 Days

Hence, Project Duration for 95% confidence level of completion is 31.97 days.

Problem-9

A company is launching a new product and has made estimates of the time for the various activities associated with the launch as follows:

Activity	*Predecessor*	*Times (Days)*		
		Optimistic	*Most likely*	*Pessimistic*
A	None	1	3	5
B	None	3	4	5
C	A, B	1	3	11
D	B	3	3	9
E	A	1	2	3
F	C	2	5	14
G	E, F	2	3	4
H	D, F	2	2	2
I	G, H	10	10	10

Required

(i) Draw the network diagram.

(ii) Calculate the expected time and variance of each activity.

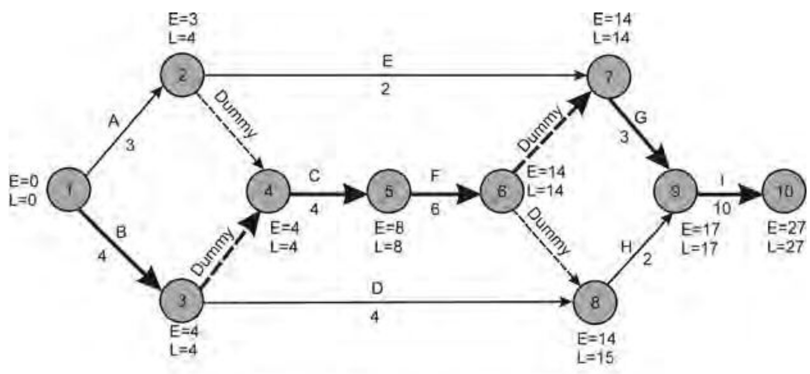
(iii) Find out the expected length of critical path and its standard deviation.

(iv) Find the probability that the launching will be completed in 27 days.

(v) Find the duration, which has 95% probability of completion.

Solution

(i) The **network** for the given problem:



(ii) The **Expected Time** and **Variance** for each of the activities (in days):

Act.	Time Estimates (Days)			Expected Time	Variance
	Optimist. (t_o)	**Most Likely (t_m)**	**Pessimistic (t_p)**	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
A (1–2)	1	3	5	3	4/9
B (1–3)	3	4	5	4	1/9
C (4–5)	1	3	11	4	25/9
D (3–8)	3	3	9	4	1

E (2–7)	1	2	3	2	1/9
F (5–6)	2	5	14	6	4
G (7–9)	2	3	4	3	1/9
H (8–9)	2	2	2	2	0
I (9–10)	10	10	10	10	0

Expected Project Length (T_e) = 27 Days

Variance of the Critical Path 1–3–4–5–6–7–9–10 (σ_e^2) $= \frac{1}{9} + \frac{25}{9} + 4 + \frac{1}{9}$

$= \frac{63}{9}$

Standard Deviation of the Critical Path (σ_e) $= \sqrt{\frac{63}{9}}$

$= 2.646$

(iii) Probability that the project will be completed in 27 days:

Probability of Completing the Project by Schedule Time T_s is given by $Z = \frac{T_s - T_e}{\sigma_e}$

Accordingly probability of meeting the due date of 20 days is given by $Z = \frac{27 - 27}{2.646}$

$= 0$

Probability (Z = 0) = 0.50

Or = 50.00%

(iv) Project Duration for 95% confidence level of completion:

Probability of Completing the Project by Schedule Time Ts is given by

$$Z = \frac{T_s - T_e}{\sigma_e}$$

Accordingly, $Z = \frac{T_s - 27}{2.646}$

At 95% Chance Z equals to 1.645

Accordingly, $1.645 = \frac{T_s - 27}{2.646}$

Or T_s = 31.35 Days

Hence, Project Duration for 95% confidence level of completion is 31.35 days.

Problem-10

A project consists of seven activities whose time estimates (optimistic - t_o, pessimistic - t_p and most likely - t_m) in days are given below:

Activity	t_o	t_p	t_m
1–2	1	5	3
1–3	1	7	4
1–4	2	10	6
2–5	2	8	2
3–5	3	15	6
4–6	2	8	5
5–6	2	14	5

Required

(i) Draw the network and find out the expected time and variance for each activity. What is the expected duration for completion of the project?

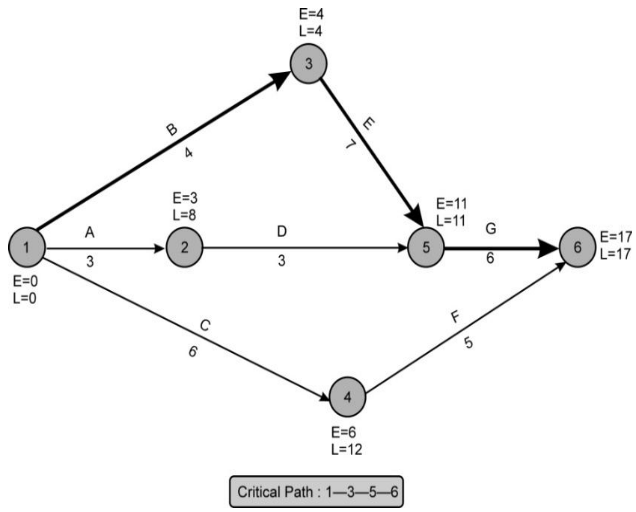
(ii) IT the target time is 22 days, what is the probability of not meeting the target?

(iii) Within how many days can the project be expected to be completed with 99 percent chance?

Given $Z_{2.33}$ = 0.9901 and $Z_{1.67}$ = 0.9525

Solution

(i) The **network** for the given problem



The **Expected Time** and **Variance** for each of the activities (in Days)

Activity	Time Estimates (Days)			Expected Time	Variance
	Optimistic (t_o)	Pessimistic (t_p)	Most Likely (t_m)	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$S_t^2 = \left(\frac{t_p - t_o}{6}\right)^2$
A (1–2)	1	5	3	3	$\frac{4}{9}$
B (1–3)	1	7	4	4	1
C (1–4)	2	10	6	6	$\frac{16}{9}$
D (2–5)	2	8	2	3	1
E (3–5)	3	15	6	7	4
F (4–6)	2	8	5	5	1
G (5–6)	2	14	5	6	4

Probability of Completing the Project by Schedule Time T_s is given by Z $= \dfrac{T_s - T_e}{\sigma_e}$

Expected Project Length (T_e) = 17 Days

Variance of the Critical Path 1–3–5–6 (σ_e^2) [1+4+4] = 9

Standard Deviation of the Critical Path (σ_e) $\left[\sqrt{9}\right]$ = 3

(ii) Probability of *not meeting* the target time of 22 days

Probability of Completing the Project by Schedule Time T_s is given by Z $= \dfrac{T_s - T_e}{\sigma_e}$

Accordingly probability of meeting the target time of 22 days is given by Z $= \dfrac{22 - 17}{3}$

= 1.67*

Probability (Z = 1.67) = 0.9525

Probability of not meeting the target time of 22 days [1– 0.9525] = 0.0475

Or = 4.75%

(iii) Expected Time if the project to be completed with 99% chance

Probability of Completing the Project by Schedule Time T_s is given by Z $= \dfrac{T_s - T_e}{\sigma_e}$

Accordingly,

$$Z = \frac{T_s - 17}{3}$$

At 99% Chance Z equals to 2.33

Accordingly,

$$2.33 = \frac{T_s - 17}{3}$$

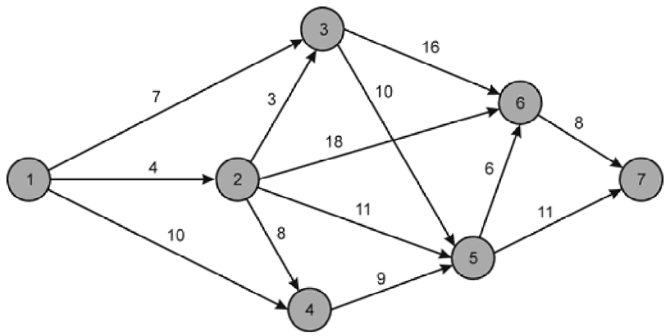
Or T_s = 23.99

Hence, expected time of completing the project with 99% of chances is 23.99 or 24 Days.

Project Updating

Problem-11

For the following project network:



Required

(i) *Calculate the each activity, its early start time, early finish time, late start time, late finish time, total float, free float and independent float.*

(ii) *Identify the critical path.*

(iii) *If the project manager finds that either of the activities 2–6 or 4–5 can each be speeded up by two days at the same cost, which of the two activities should be speeded up? Explain.*

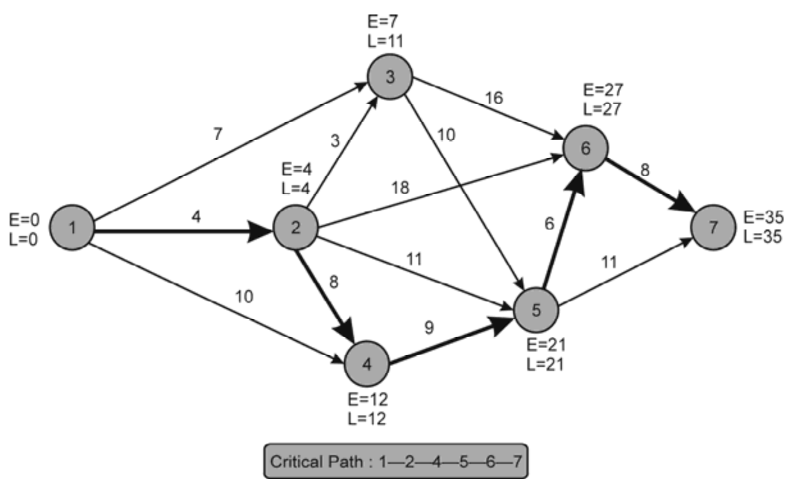
Solution

(i) The earliest start, earliest finish, latest start, latest finish, total float and free float for activities of above network are given in the table below:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST – EST	Total Float – Slack of Head Event	Free Float – Slack of Tail Event
1–2	4	0	4	0	4	0	0	0	0	0
1–3	7	0	7	4	11	0	4	4	0	0

1–4	10	0	10	2	12	0	0	2	2	2
2–3	3	4	7	8	11	0	4	4	0	0
2–4	8	4	12	4	12	0	0	0	0	0
2–5	11	4	15	10	21	0	0	6	6	6
2–6	18	4	22	9	27	0	0	5	5	5
3–5	10	7	17	11	21	4	0	4	4	0
3–6	16	7	23	11	27	4	0	4	4	0
4–5	9	12	21	12	21	0	0	0	0	0
5–6	6	21	27	21	27	0	0	0	0	0
5–7	11	21	32	24	35	0	0	3	3	3
6–7	8	27	35	27	35	0	0	0	0	0

(ii) The **Critical Path** is 1–2–4–5–6–7 with project duration of 35 days.



(iii) Activity 2–6 lies on the path 1–2–6–7 (having duration 30 days) which is not a critical path. If activity 2–6 is speeded up by 2 days, it will not reduce the total project duration.

Activity 4–5 lies on the critical path. If activity 4–5 is speeded up by 2 days, the project duration will come down to 33 days.

Hence activity 4–5 should be speeded up.

Problem-12

A company had planned its operations as follows:

Activity	*Duration (Days)*
1–2	*7*
2–4	*8*
1–3	*8*
3–4	*6*
1–4	*6*
2–5	*16*
4–7	*19*
3–6	*24*
5–7	*9*
6–8	*7*
7–8	*8*

Required

(i) Draw the network and find the critical paths.

(ii) After 15 days of working, the following progress is noted:

(a) Activities 1–2, 1–3 and 1–4 completed as per original schedule.

(b) Activity 2–4 is in progress and will be completed in 4 more days.

(c) Activity 3–6 is in progress and will need 17 more days to complete.

(d) The staff at activity 3–6 are specialised. They are directed to complete 3–6 and undertake an activity 6–7, which will require 7days. This rearrangement arose due to a modification in a specialisation.

(e) Activity 6–8 will be completed in 4 days instead of the originally planned 7 days.

(f) There is no change in the other activities.

Update the network diagram after 15 days of start of work based on the assumption given above. Indicate the revised critical paths along with their duration.

Solution

The **network** for the given problem:

Various Paths of the network are as follows:

Path	Duration (Days)
1–2–5–7–8	40 (7 + 16 + 9 + 8)
1–2–4–7–8	42 (7 + 8 + 19 + 8)
1–4–7–8	33 (6 + 19 + 8)
1–3–4–7–8	41 (8 + 6 + 19 + 8)
1–3–6–8	39 (8 + 24 + 7)

Critical Path is 1–2–4–7–8 with duration of 42 days.

The new formulation of the problem is as follows:

(i) Activities 1–2, 1–3 and 1–4 need 7 Days, 8 Days and 6 Days respectively as per Original Programme.

(ii) Activity 2–4 needs 12 Days (15 + 4 – 7) instead of Original Programme of 8 Days.

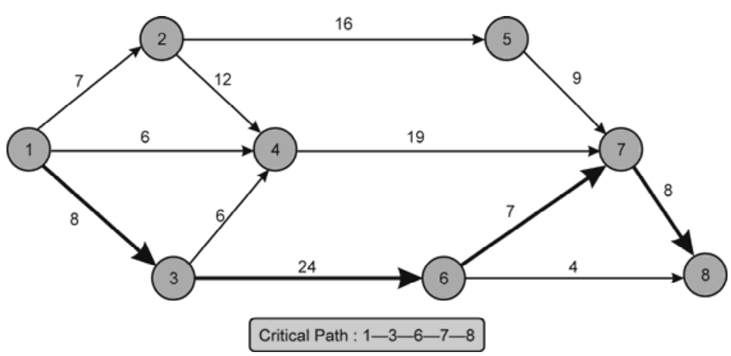
(iii) Activity 3–6 needs 24 Days (15 + 17 – 8) as per Original Schedule.

(iv) New Activity 6–7 needs 7 Days.

(v) Activity 6–8 needs lesser duration of 4 Days instead of Original Planned 7 Days.

(vi) Activities 2–5, 3–4, 4–7, 5–7, 7–8 need 16 Days, 6 Days, 19 Days, 9 Days, 8 Days respectively as per Original Schedule.

The **new network** based on the above listed activities will be as follows:



Various Paths of *revised network* are as follows:

Path	Duration (Days)
1–2–5–7–8	40 (7 + 16 + 9 + 8)
1–2–4–7–8	46 (7 + 12 + 19 + 8)
1–4–7–8	33 (6 + 19 + 8)
1–3–4–7–8	41 (8 + 6 + 19 + 8)
1–3–6–7–8	47 (8 + 24 + 7 + 8)
1–3–6–8	36 (8 + 24 + 4)

Critical Path is 1–3–6–7–8 with duration of 47 Days.

Project Crashing

Problem-13

A product comprised of 10 activities whose normal time and cost are given as follows:

Activity	*Normal Time (Days)*	*Normal Cost (₹)*
1–2	3	50
2–3	3	5
2–4	7	70
2–5	9	120
3–5	5	42
4–5	0	0
5–6	6	54
6–7	4	67
6–8	13	130
7–8	10	166

Indirect cost ₹ 9 per day.

Required

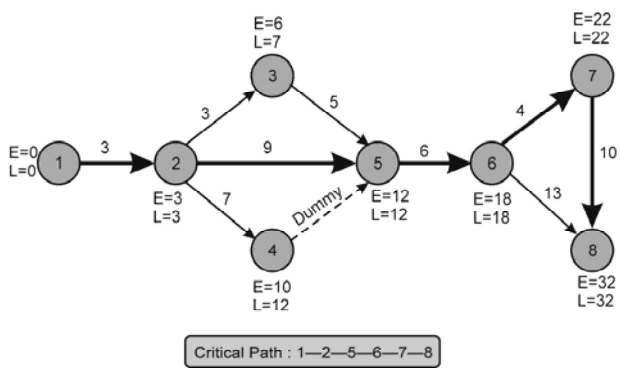
(i) *Draw the network and identify the critical path.*

(ii) *What are the project duration and associated cost?*

(iii) *Find out the total float associated with each activity.*

Solution

(i) The **network** for the given problem



(ii) **Critical Path** is 1–2–5–6–7–8 with normal duration of 32 days.

Normal duration cost of the project is ₹992.

	(₹)
Normal Cost [₹50 + ₹5 + ₹70 + ₹120 + ₹42 + ₹0 + ₹54 + ₹67 + ₹130 + ₹166]	704
Indirect Cost [32 Days × ₹9]	288
Total Cost	992

(iii) **Total Float** for each activity:

Activity	Duration	EST	EFT	LST	LFT	Total Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	LST – EST
1–2	3	0	3	0	3	0
2–3	3	3	6	4	7	1
2–4	7	3	10	5	12	2
2–5	9	3	12	3	12	0

3–5	5	6	11	7	12	1
4–5	0	10	10	12	12	2
5–6	6	12	18	12	18	0
6–7	4	18	22	18	22	0
6–8	13	18	31	19	32	1
7–8	10	22	32	22	32	0

Problem-14

As the Project Manager of KL Construction Company, you are involved in drawing a network for laying the foundation of a new art museum. The relevant information for all the activities of this project is given in the following table.

Activity	*Immediate Predecessors*	*Time Estimates (Weeks)*			*Normal Cost (₹)*	*Crash Cost (₹)*
		Optimistic	*Most Likely*	*Pessimistic*		
A	None	2	3	4	6,000	8,000
B	A	4	5	6	12,000	13,500
C	A	3	5	7	16,000	22,000
D	A	2	4	6	8,000	10,000
E	C, D	1	2	3	6,000	7,500
F	B, E	1	3	5	14,000	20,000

(i) *Construct the network for the project and determine the critical path and the expected duration of the project.*

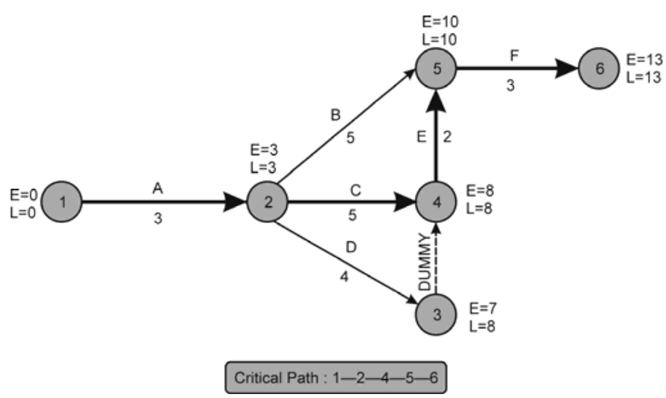
(ii) *The Director of your company is not impressed by your analysis. He draws your attention that the project must be completed by seven weeks and refers to the penalty clause in the agreement which provides for payment of penalty at the rate of ₹2,500 for every weeks or part thereof exceeding seven weeks. Your Director also strongly believes that the time duration of various activities of the project can be crashed to their optimistic time estimates with the crashing costs mentioned in the above table. Determine the optimal duration of the project if your objective is to minimise the sum of the project execution cost and the penalty cost.*

Solution

The **Expected Duration** of each activity:-

Activity	Time Estimates (Weeks)			Expected Time
	Optimistic (t_o)	Most Likely (t_m)	Pessimistic (t_p)	$t_e = \frac{t_o + 4t_m + t_p}{6}$
A	2	3	4	3
B	4	5	6	5
C	3	5	7	5
D	2	4	6	4
E	1	2	3	2
F	1	3	5	3

The **network** for the given problem:



The **Critical Path** is 1–2–4–5–6 or A–C–E–F with duration of 13 weeks.

The **Cost Slope** of each activity:-

Activity	Normal		Crash		Cost Slopes		
	Duration (Weeks)	Cost (₹)	Duration (Weeks)	Cost (₹)	ΔT (Weeks)	ΔC (₹)	ΔC/ΔT (₹)
A (1–2)	3	6,000	2	8,000	1	2,000	2,000
B (2–5)	5	12,000	4	13,500	1	1,500	1,500

C (2–4)	5	16,000	3	22,000	2	6,000	3,000
D (2–3)	4	8,000	2	10,000	2	2,000	1,000
E (4–5)	2	6,000	1	7,500	1	1,500	1,500
F (5–6)	3	14,000	1	20,000	2	6,000	3,000
Total		62,000					

Project has to be completed by seven weeks otherwise penalty has to be paid at the rate of ₹ 2,500 per week in respect of extra weeks.

Total Cost of the Project for the Expected Duration = Normal Cost + Penalty Cost

= ₹62,000 + ₹ 2,500 × 6 Weeks

= ₹62,000 + ₹15,000

= ₹77,000

Crashing First Step:

Let us now crash activities on the critical path.

Activity	ΔT	ΔC/ΔT	Remark
A (1–2)	1	2,000	
C (2–4)	2	3,000	
E (4–5)	1	1,500	Least Cost Slope
F (5–6)	2	3,000	

As activity E of critical path A–C–E–F has least cost slope, crash activity E by 1 week at a crash cost of ₹1,500

Revised Project Duration (Critical Path A–C–E–F)

= 12 Weeks

Total Cost of the Project for the 12 Weeks = Normal Cost + Penalty Cost + Crash Cost

= ₹62,000 + ₹2,500 × 5 Weeks + ₹1,500

= ₹76,000

Crashing Second Step:

Activity	ΔT	ΔC/ΔT	Remark
A (1–2)	1	2,000	Least Cost Slope
C (2–4)	2	3,000	
E (4–5)	1	1,500	Already Crashed
F (5–6)	2	3,000	

We shall now crash activity A by one week at a crash cost of ₹2,000

Revised Project Duration (Critical Path A–C–E–F) = 11 Weeks

Total Cost of the Project for the 11 Weeks = Normal Cost + Penalty Cost + Crash Cost

= ₹62,000 + ₹2,500 × 4 Weeks + ₹1,500 + ₹2,000

= ₹75,500

Crashing Final Step:

Activity	ΔT	ΔC/ΔT	Remark
A (1–2)	1	2,000	Already Crashed
C (2–4)	2	3,000	
E (4–5)	1	1,500	Already Crashed
F (5–6)	2	3,000	

Now remaining activities C and F (on the critical path A–C–E–F) have cost slope equal to ₹ 3,000. Crashing of any one of these shall increase the total cost of the project by ₹ 500 (₹ 3,000 − ₹ 2,500) per week.

As our objective is to minimize the sum of the project execution cost and the penalty cost, therefore the **Optimal Project Duration** is 11 weeks and the **Total Minimum Cost** is ₹ 75,500.

Problem-15

The table below provides cost and time estimates of seven activities of a project;

Activity (i–j)	*Time Estimates (Weeks)*		*Cost Estimates (₹'000)*	
	Normal	*Crash*	*Normal*	*Crash*
1–2	*2*	*1*	*10*	*15*
1–3	*8*	*5*	*15*	*21*
2–4	*4*	*3*	*20*	*24*
3–4	*1*	*1*	*7*	*7*
3–5	*2*	*1*	*8*	*15*
4–6	*5*	*3*	*10*	*16*
5–6	*6*	*2*	*12*	*36*

Required

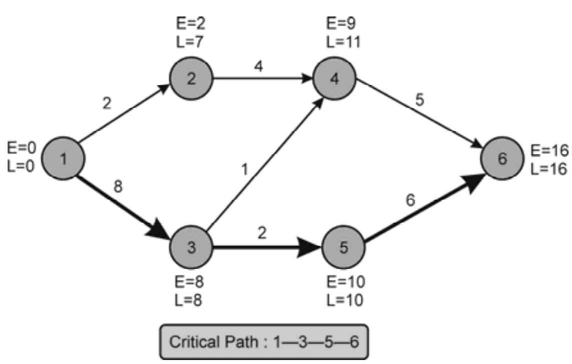
(i) Draw the project network corresponding to normal time.

(ii) Determine the critical path and the normal duration and normal costs of the project.

(iii) Crash the activities so that the project completion time reduces to 9 weeks, with minimum additional cost.

Solution

The **network** for the given problem:



The **Critical Path** is 1–3–5–6 with normal duration of 16 weeks. The normal cost of the project is ₹82,000.

The **Cost Slope** of each activity:-

Activity	Normal		Crash		Cost Slopes		
	Duration (Weeks)	Cost (₹'000)	Duration (Weeks)	Cost (₹'000)	∆T (Weeks)	∆C (₹'000)	∆C/∆T (₹'000)
1–2	2	10	1	15	1	5	5
1–3	8	15	5	21	3	6	2
2–4	4	20	3	24	1	4	4
3–4	1	7	1	7	0	0	---
3–5	2	8	1	15	1	7	7
4–6	5	10	3	16	2	6	3
5–6	6	12	2	36	4	24	6

The **Various Paths** in the network are:

1–3–5–6 with project duration = 16 Weeks
1–3–4–6 with project duration = 14 Weeks
1–2–4–6 with project duration = 11 Weeks

The critical path is 1–3–5–6. The normal length of the project is 16 days.

Crashing steps so that the project completion time reduces to 9 weeks with minimum additional cost:

Crashing Step 1:

We will first crash the *activities on the critical path*.

Activity 1–3 of critical path 1–3–5–6 has minimum costs slope. We can crash activity 1–3 by 3 weeks for additional cost of ₹6,000 (3Weeks × ₹2,000). Now the project duration is reduced to 13 weeks.

The various paths in the network with revised duration are:

1–3–5–6 with project duration = 13 Weeks
1–3–4–6 with project duration = 11 Weeks
1–2–4–6 with project duration = 11 Weeks

Crashing Step 2:

Crash activity 5–6 by 2 weeks for additional cost of ₹12,000 (2Weeks × ₹6,000). Now the project duration is reduced to 11 weeks.

The various paths in the network with revised duration are:

1–3–5–6 with project duration = 11 Weeks
1–3–4–6 with project duration = 11 Weeks
1–2–4–6 with project duration = 11 Weeks

Crashing Step 3:

Now there are three critical paths:

1–3–5–6 with project duration = 11 Weeks
1–3–4–6 with project duration = 11 Weeks
1–2–4–6 with project duration = 11 Weeks

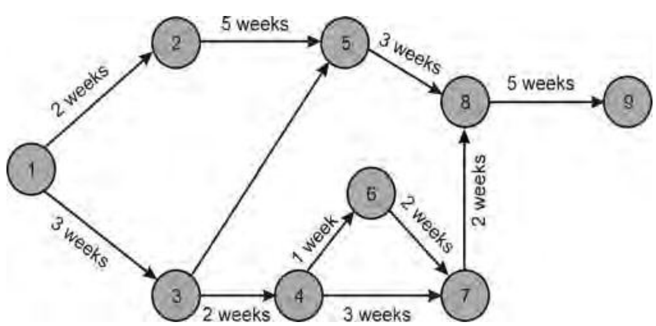
To reduce the project duration further, we crash activity 4–6 by 2 weeks at an additional costs of ₹ 6,000 (2Weeks × ₹3,000) and activity 5–6 by two weeks at an additional cost of ₹ 12,000 (2Weeks × ₹6,000).

Statement Showing "Additional Crashing Cost"

Normal Project Length (Weeks)	Job Crashed	Crashing Cost (₹)
16	---	---
13	1–3 by 3 Weeks	6,000
11	5–6 by 2 Weeks	12,000
9	4–6 by 2 Weeks & 5–6 by 2 Weeks	18,000
	Total Additional Cost	36,000

Problem-16

A network is given below:



Required

(i) *Name the paths and given their total duration.*

(ii) *Give three different ways of reducing the project above duration by four days.*

Solution

(i) Assuming that the duration of activity 3–5 is 4 weeks.

The various critical paths are:

1–2–5–8–9	15 Weeks
1–3–4–7–8–9	15 Weeks
1–3–4–6–7–8–9	15 Weeks
1–3–5–8–9	15 Weeks

(ii) As the duration for activity 3–5 is not specified it is open to assume the duration. Three possibilities emerge on the basis of the duration assumed.

a) If the duration assumed is **more than 4 weeks** then that path (1–3, 3–5, 5–8, 8–9) alone will be critical. In that case any of the activity in the critical path can be selected.

b) If the duration assumed is **exactly 4 weeks** then it will be one of the 4 critical paths. Since all the paths are critical, reduction is possible by combining activities. The activities can be *independent*, *common to few paths* and *common to all the paths*. The various categories are given below.

NO INDEPENDENT ACTIVITIES------

<Consider all Critical Paths {refer part (i)} simultaneously>

Activity **Common to all** the paths and no independent activity

Combination 1 **8–9**

Activities **common to two** of the paths and no independent activity

Combination 1 **5–8**, **3–4**

Combination 2 **5–8**, **7–8**

INDEPENDENT ACTIVITIES------

<Consider all Critical Paths {refer part (i)} simultaneously>

Activities **NOT common to any** of the path and **four** independent activities

Combination 1 1–2, 4–7, 4–6, and 3–5

Combination 2 1–2, 4–7, 6–7, and 3–5

Combination 3 2–5, 4–7, 4–6, and 3–5

Combination 4 2–5, 4–7, 6–7, and 3–5

Activities **common to two** of the paths and **two** independent activities

Combination 1 1–2, **3–4**, 3–5

Combination 2 2–5, **3–4**, 3–5

Combination 3 1–2, **7–8**, 3–5

Combination 4 2–5, **7–8**, 3–5

Combination 5 **5–8**, 4–7, 4–6

Combination 6 **5–8**, 4–7, 6–7

Activities **common to three** of the paths and **one** independent activity

Combination 1 1–2, **1–3**

Combination 2 2–5, **1–3**

c) If the duration assumed is **less than 4 weeks** then the solution should be based on 3 of the critical paths 1–2–5–8–9, 1–3–4–6–7–8–9 and 1–3–4–7–8–9.

Problem-17

A project is composed of seven activities as per details given below:

Activity	*Time Estimates (Days)*		*Cost Estimates (₹)*	
	Normal	*Crash*	*Normal*	*Crash*
1–2	*4*	*3*	*1,500*	*2,000*
1–3	*2*	*2*	*1,000*	*1,000*
1–4	*5*	*4*	*1,875*	*2,250*
2–3	*7*	*5*	*1,000*	*1,500*
2–5	*7*	*6*	*2,000*	*2,500*
3–5	*2*	*1*	*1,250*	*1,625*
4–5	*5*	*4*	*1,500*	*2,125*

Indirect cost per day of the project is ₹ 500

Required

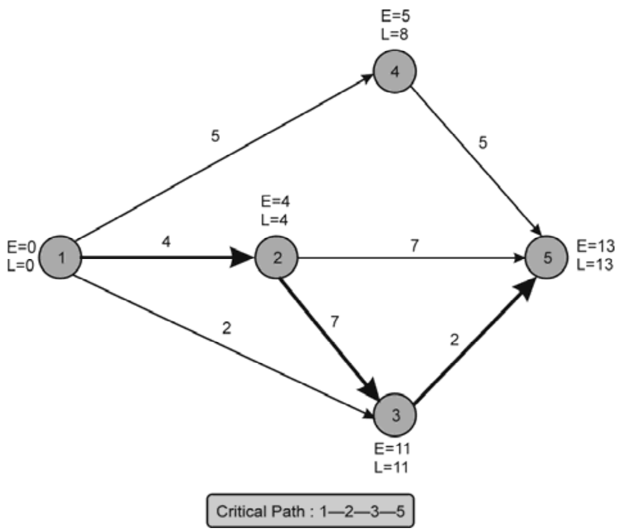
(i) Draw the project network.

(ii) Determine the critical path and its duration.

(iii) Find the optimum duration and the resultant cost of the project.

Solution

The **network** for the given problem:



The **Critical Path** is 1–2–3–5 with normal duration of 13 weeks. Normal duration cost of the project is ₹16,625.

	(₹)
Normal Cost	10,125
Indirect Cost[13 Days × ₹ 500]	6,500
Total Cost	16,625

The various paths in the network are:

1–2–3–5 with duration 13 days

1–2–5 with duration 11 days

1–4–5 with duration 10 days

1–3–5 with duration 4 days

The optimum duration of a project is that duration of the project for which the total cost will be least.

The **Cost Slope** of each activity:

Activity	Normal		Crash		Cost Slopes		
	Duration (Days)	Cost (₹)	Duration (Days)	Cost (₹)	∆T (Days)	∆C (₹)	∆C/∆T (₹)
1–2	4	1,500	3	2,000	1	500	500
1–3	2	1,000	2	1,000	0	0	---
1–4	5	1,875	4	2,250	1	375	375
2–3	7	1,000	5	1,500	2	500	250
2–5	7	2,000	6	2,500	1	500	500
3–5	2	1,250	1	1,625	1	375	375
4–5	5	1,500	4	2,125	1	625	625
	Total	10,125					

Crashing Step 1:

To determine the *optimum duration* and *resultant cost* we crash *activities on the critical path* by properly selecting them as under:

Activities	1–2	2–3	3–5
No. of Available Crash Days	1	2	1
Cost Slope per Day (₹)	500	250	375
Indirect Cost per day (₹)	500	500	500
Savings	--	250	125
Ranking	--	1	2

By crashing activity 2–3 for one day, we can save ₹ 250 per day.

Let us crash 2–3 by 2 days.

	(₹)
Normal Cost	10,125
Indirect Cost [11 Days × ₹500]	5,500
Crashing Cost [2 Days × ₹250]	500
Total Cost	16,125

After crashing the activity 2–3 by 2 day, revised position of various paths are as under:

1–2–3–5 with duration 11 days
1–2–5 with duration 11 days
1–4–5 with duration 10 days
1–3–5 with duration 4 days

Crashing Step 2:

1–2 is a common activity in the first two paths with cost slope of ₹ 500 per day. There is no profit or loss in crashing this activity. Hence we can crash it by one by one day.

	(₹)
Normal Cost	10,125
Indirect Cost [10 Days × ₹500]	5,000
Crashing Cost [2 Days × ₹250 + 1 Day × ₹500]	1,000
Total Cost	16,125

After crashing the activity 1–2 by one day, revised position of various paths are as under:

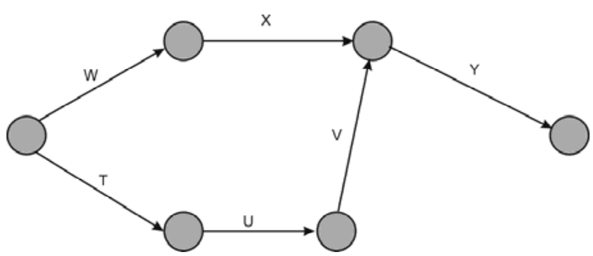
1–2–3–5 with duration 10 days
1–2–5 with duration 10 days
1–4–5 with duration 10 days
1–3–5 with duration 4 days

Crashing Step 3

To reduce the duration of project further, we are required to consider the activities on all the three paths. These activities may be 3–5, 2–5, and 1–4. If all of these activities are crash by even 1 day each, then the total increase in cost would be ₹1,250 (₹375 + ₹500 + ₹375) for saving ₹500. Accordingly further crashing is not possible. Hence **Optimal Project Duration** is 10 days with **Optimal Cost** of ₹16,125.

Problem-18

The following network and table are presented to you:



Activity	*Normal Duration (Days)*	*Normal Cost (₹)*	*Crash Duration (Days)*	*Crash Cost (₹)*
T	*8*	*2,250*	*6*	*2,750*
U	*16*	*1,875*	*11*	*2,750*
V	*14*	*2,250*	*9*	*3,000*
W	*12*	*3,000*	*9*	*3,750*

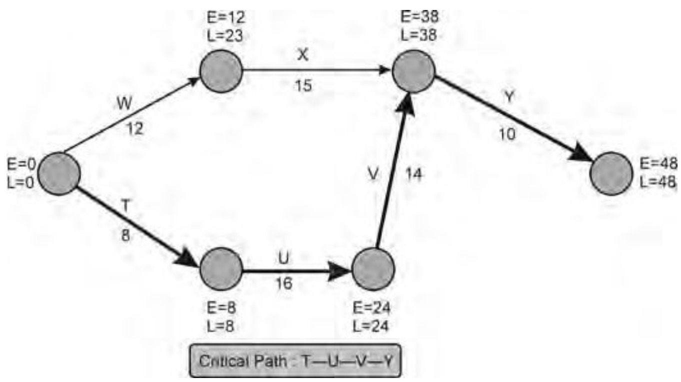
X	*15*	*1,000*	*14*	*2,500*
Y	*10*	*2,500*	*8*	*2,860*

Required

Perform step by step crashing and reduce the project duration by 11 days while minimizing the crashing cost. What would be the cost of the crashing exercise?

Solution

Network for the given problem:



The **Various Paths** in the network are:

T–U–V–Y with duration 48 days

W–X–Y with duration 37 days

The critical path is T–U–V–Y with normal duration of 48 weeks.

Particulars	**T**	**U**	**V**	**Y**
Crash Days Possible (ΔT)	2	5	5	2
Crash Cost *Less* Normal Cost (ΔC)	₹500	₹875	₹750	₹360
Crashing Cost per Day [(ΔC) / (ΔT)]	₹250	₹175	₹150	₹180
Step I Crash V *by* 5 Days	---	---	₹750	---
Step II Crash U *by* 5 Days	---	₹875	---	---
Step III Crash Y *by* 1 Day	---	---	---	₹180

Minimum Cost of Crashing Exercise is ₹1,805 (₹750 + ₹875 + ₹180) for **Project Duration** of 11 Days.

Problem-19

The Noida Nirman Authority intends to install a road traffic regulating signal in a heavy traffic prone area. The total installation work has been broken down into six activities. The normal duration, crash duration and crashing cost of the activities are expected as given in the following table:

Activity	***Normal Duration (Days)***	***Crash Duration (Days)***	***Crashing Cost per day (₹)***
1–2	*9*	*6*	*30,000*
1–3	*8*	*5*	*40,000*
1–4	*15*	*10*	*45,000*
2–4	*5*	*3*	*15,000*
3–4	*10*	*6*	*20,000*
4–5	*2*	*1*	*60,000*

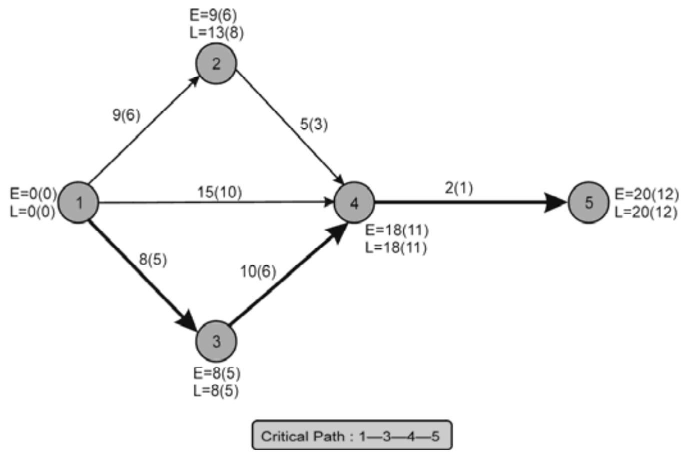
Required

(i) Draw the network and find the normal and minimum duration of the work.

(ii) Compute the additional cost involved if the authority wants to complete the work in the shortest duration.

Solution

The **Network** for the given problem:



The **Various Paths** in the network are:

1–3–4–5 with project duration	=	20 Days
1–4–5 with project duration	=	17 Days
1–2–4–5 with project duration	=	16 Days

The **Critical Path** is 1–3–4–5. The normal length of the project is 20 days and minimum project length is 12 days.

Crashing Step 1:

Crash Activity 3–4 by 3 Days

(As crashing cost of activity 3–4 is Minimum)

Crashing Cost	=	₹ 20,000 × 3 Days
	=	₹ 60,000

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	17 Days
1–4–5 with project duration	=	17 Days
1–2–4–5 with project duration	=	16 Days

Crashing Step 2:

Crash *Common* Activity 4–5 by One Day

Crashing Cost	=	₹ 60,000 × 1 Day
	=	₹ 60,000

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	16 Days
1–4–5 with project duration	=	16 Days
1–2–4–5 with project duration	=	15 Days

Crashing Step 3:

Crash Activity 3–4 by 1 Day & 1–4 by 1 Day

Crashing Cost	=	₹ (20,000 + 45,000) × 1 Day
	=	₹ 65,000

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	15 Days
1–4–5 with project duration	=	15 Days
1–2–4–5 with project duration	=	15 Days

Crashing Step 4:

Crash Activity 1–3 by 2 Days, 1– 4 by 2 Days and 2–4 by 2 Days

Crashing Cost	=	₹ (40,000 + 45,000 +15,000) × 2 Days
	=	₹ 2,00,000

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	13 Days
1–4–5 with project duration	=	13 Days
1–2–4–5 with project duration	=	13 Days

Crashing Step 5:

Crash Activity 1–3 by 1 Day, 1– 4 by 1 Day and 1–2 by 1 Day

Crashing Cost	=	₹ (40,000 + 45,000 + 30,000) × 1 Day
	=	₹ 1,15,000

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	12 Days
1–4–5 with project duration	=	12 Days
1–2–4–5 with project duration	=	12 Days

Further crushing is not possible.

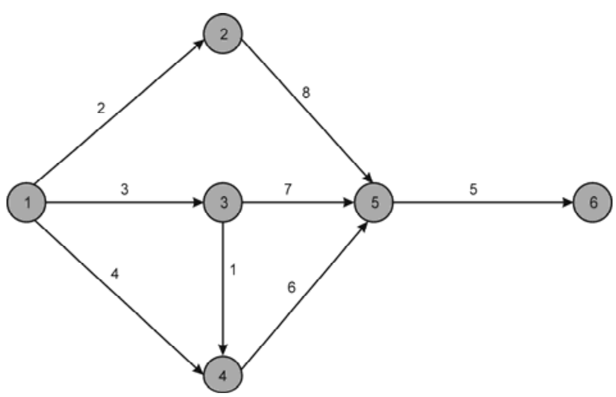
Statement Showing Crashing Cost

Normal Project Length Days	Job Crashed	Crashing Cost
20	-	-
19	3–4	₹ 20,000
18	3–4	₹40,000 (₹ 20,000 + ₹ 20,000)

17	3–4	₹60,000 (₹ 40,000 + ₹ 20,000)
16	4–5	₹1,20,000 (₹60,000 + ₹60,000)
15	3–4,1–4	₹1,85,000 (₹ 1,20,000 + ₹ 65,000)
14	1–3, 1–4, 2–4	₹ 2,85,000 (₹ 1,85,000 + ₹1,00,000)
13	1–3, 1–4, 2–4	₹3,85,000 (₹ 2,85,000 + ₹ 1,00,000)
12	1–3, 1–4, 1–2	₹ 5,00,000 (₹ 3,85,000 + ₹ 1,15,000)
Additional Cost *(For shortest duration)*		₹ 5,00,000/-

Problem-20

The following network gives the duration in days for each activity:



Required

(i) *List the critical paths.*

(ii) *Given that each activity can be crashed by a maximum of one day, choose to crash any four activities so that the project duration is reduced by 2 days.*

Solution

Critical Paths:

All are critical paths:

1–2–5–6	2 Days + 8 Days + 5 Days	15 Days
1–3–5–6	3 Days + 7 Days + 5 Days	15 Days
1–4–5–6	4 Days + 6 Days + 5 Days	15 Days
1–3–4–5–6	3 Days + 1 Days + 6 Days + 5 Days	15 Days

To reduce Project Duration by 2 Days:

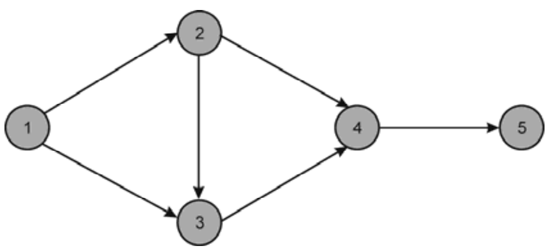
Crash Activity 5–6 by 1 Day

Crash Activities 1–2, 1–3, 1–4 by 1 Day

Note: Other Crashing Alternatives are also possible.

Problem-21

The normal time, crash time and crashing cost per day are given for the following network:



Activity	Normal Time (Days)	Crash Time (Days)	Crashing Cost (₹ / Day)
1–2	18	14	40
1–3	23	22	20
2–3	8	5	60
2–4	10	6	40
3–4	3	2	80
4–5	8	6	50

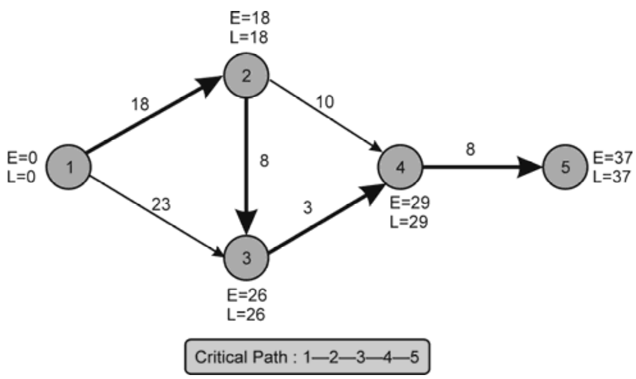
Required

(i) *Crash the project duration in steps and arrive at the minimum duration. What will be the critical path and the cost of crashing?*

(ii) *If there is an indirect cost of ₹ 70 per day, what will be the optimal project duration and the cost of crashing?*

Solution

The **Network** for the given problem:



The **Various Paths** in the network are:

1–2–3–4–5 with project duration	=	37 Days
1–2–4–5 with project duration	=	36 Days
1–3–4–5 with project duration	=	34 Days

The **Critical Path** is 1–2–3–4–5. The normal length of the project is 37 days.

Crashing Step 1:

Crash Activity 1–2 by 3 Days

Crashing Cost	=	₹ 40 × 3 Days
	=	₹120

Now the various paths in the network with revised duration are:

1–2–3–4–5 with project duration	=	34 Days
1–2–4–5 with project duration	=	33 Days
1–3–4–5 with project duration	=	34 Days

Crashing Step 2:

Crash Activity 1–2 by 1 Day & 1–3 by 1 Day

Crashing Cost	=	₹ (40 + 20) × 1 Day
	=	₹ 60

Now the various paths in the network with revised duration are:

1–2–3–4–5 with project duration	=	33 Days
1–2–4–5 with project duration	=	32 Days
1–3–4–5 with project duration	=	33 Days

Crashing Step 3:

Crash Common Activity 4–5 by Two Days

Crashing Cost	=	₹ 50 × 2 Days
	=	₹ 100

Now the various paths in the network with revised duration are:

1–2–3–4–5 with project duration	=	31 Days
1–2–4–5 with project duration	=	30 Days
1–3– 4–5 with project duration	=	31 Days

Crashing Step 4:

Crash Activity 3–4 by 1 Day

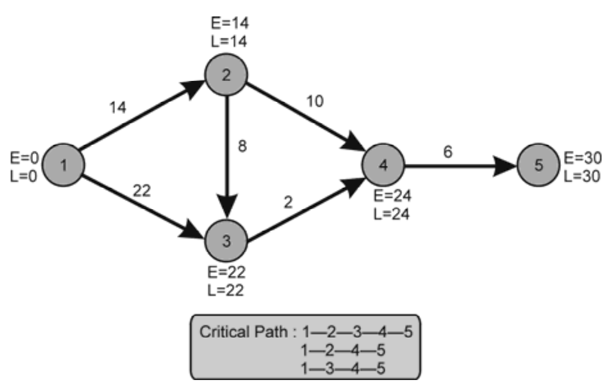
Crashing Cost	=	₹ 80 × 1 Day
	=	₹ 80

Now the various paths in the network with revised duration are:

1–2–3–4–5 with project duration	=	30 Days
1–2–4–5 with project duration	=	30 Days
1–3–4–5 with project duration	=	30 Days

Further crushing is not possible.

Revised Network for the given problem:



Statement Showing "Crashing Cost & Total Cost"

Normal Project Length Days	Job Crashed	Crashing Cost	Indirect Cost	Total Cost
37	–	–	₹2,590 (₹70 × 37 Days)	₹2,590
36	1–2	₹ 40	₹2,520 (₹70 × 36 Days)	₹2,560
35	1–2	₹80 (₹ 40 + ₹40)	₹2,450 (₹70 × 35 Days)	₹2,530
34	1–2	₹120 (₹ 80 + ₹40)	₹2,380 (₹70 × 34 Days)	₹2,500
33	1–2,1–3	₹180 (₹120 + ₹60)	₹2,310 (₹70 × 33 Days)	₹2,490
32	4–5	₹230 (₹ 180 + ₹ 50)	₹2,240 (₹70 × 32 Days)	₹2,470
31	**4–5**	**₹ 280 (₹ 230 + ₹50)**	**₹2,170 (₹70 × 31 Days)**	**₹2,450***
30	3–4	₹360 (₹ 280 + ₹80)	₹2,100 (₹70 × 30 Days)	₹2,460

Crash Cost at ***minimum duration*** of 30 Days is ₹ 360.

Since the total cost (crashing cost + indirect cost) starts increasing from 30 days, the **Optimum Project Duration** is 31 days with **Crashing Cost** of ₹ 280.

Problem-22

A project with normal duration and cost along with crash duration and cost for each activity is given below:

Activity	*Normal Time (Hrs.)*	*Normal Cost (₹)*	*Crash Time (Hrs.)*	*Crash Cost (₹)*
1–2	*5*	*200*	*4*	*300*
2–3	*5*	*30*	*5*	*30*
2–4	*9*	*320*	*7*	*480*
2–5	*12*	*620*	*10*	*710*
3–5	*6*	*150*	*5*	*200*
4–5	*0*	*0*	*0*	*0*
5–6	*8*	*220*	*6*	*310*
6–7	*6*	*300*	*5*	*370*

There is an Indirect Cost of ₹50 per Hour.

Required

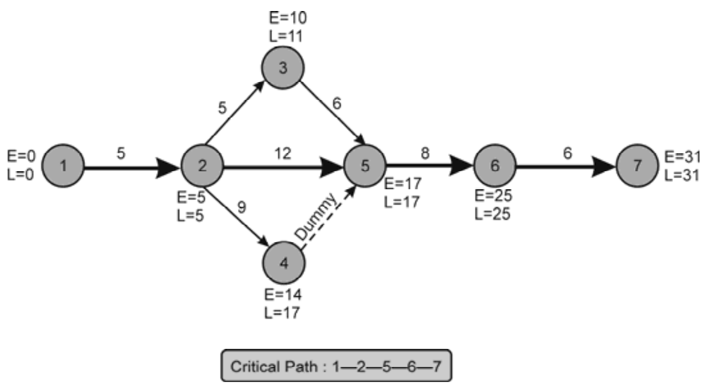
(i) Draw network diagram and identify the critical path.

(ii) Find out the total float associated with each activity.

(iii) Crash the relevant activities systematically and determine the optimum project completion time and corresponding cost.

Solution

The **network** for the given problem:



The **Various Paths** in the network are:

1–2–5–6–7 with project duration = 31 Hours

1–2–3–5–6–7 with project duration = 30 Hours

1–2–4–5–6–7 with project duration = 28 Hours

The **Critical Path** is 1–2–5–6–7. The normal length of the project is 31 Hours.

Activity	Normal		Crash		Cost Slopes		
	Time (Hrs.)	Cost (₹)	Time (Hrs.)	Cost (₹)	ΔT (Hrs.)	ΔC (₹)	ΔC/ΔT (₹)
1–2	5	200	4	300	1	100	100
2–3	5	30	5	30	0	0	---
2–4	9	320	7	480	2	160	80
2–5	12	620	10	710	2	90	45

3–5	6	150	5	200	1	50	50
4–5	0	0	0	0	0	0	---
5–6	8	220	6	310	2	90	45
6–7	6	300	5	370	1	70	70

Crashing Step 1:

Cost Slope of Critical Path Activities

Critical Path Activities	1–2	2–5	5–6	6–7
Cost Slopes (ΔC/ΔT)	₹100	₹45	₹45	₹70
Hours Available (ΔT)	1	2	2	1

Crash Activity 5–6 by 2 Hours

(As crashing cost of this activity is Minimum and this activity is *common* and *critical*)

Crashing Cost = ₹ 45 × 2 Hours
= ₹ 90

Now the various paths in the network with revised duration are:

1–2–5–6–7 with project duration = 29 Hours
1–2–3–5–6–7 with project duration = 28 Hours
1–2–4–5–6–7 with project duration = 26 Hours

Crashing Step 2:

Cost Slope of Critical Path Activities

Critical Path Activities	1–2	2–5	5–6	6–7
Cost Slopes (ΔC/ΔT)	₹100	₹45	₹45	₹70
Hours Available (ΔT)	1	2	0	1

Crash Activity 2–5 by 1 Hour

(As Crashing Cost of this Activity is Minimum and this activity is *critical*)

Crashing Cost = ₹ 45 × 1 Hours
= ₹ 45

Now the various paths in the network with revised duration are:

1–2–5–6–7 with project duration = 28 Hours
1–2–3–5–6–7 with project duration = 28 Hours
1–2–4–5–6–7 with project duration = 26 Hours

Crashing Step 3:

Now there are two critical paths

1–2–5–6–7 with project duration = 28 Hours
1–2–3–5–6–7 with project duration = 28 Hours

Cost Slope of Critical Path Activities

Critical Path Activities	1–2	2–3	2–5	3–5	5–6	6–7
Cost Slopes (∆C/∆T)	₹100	---	₹45	50	₹45	₹70
Hours Available (∆T)	1	0	1	1	0	1

Possible Crashing Alternatives are

Critical Path Activities	1–2	2–5 & 3–5	6–7
Cost Slopes (∆C/∆T)	₹100	₹45 + ₹50	₹70
Remark	Common Activity	Independent Activities	Common Activity

As cost per hour for every alternative is greater than ₹50 i.e. indirect cost per hour. Therefore, any reduction in the duration of project will increase the cost of project completion. Hence, optimum project completion time is 28 hours with cost of ₹3,375.

Statement Showing "Crashing Cost & Total Cost"

Normal Project Length Hours	Job Crashed	Crashing Cost	Normal Cost	Indirect Cost	Total Cost
31	–	–	₹1,840	₹1,550 (₹50 × 31 Hrs.)	₹3,390
30	5–6	₹ 45	₹1,840	₹1,500 (₹50 × 30 Hrs.)	₹3,385
29	5–6	₹90 (₹ 45 + ₹45)	₹1,840	₹1,450 (₹50 × 29 Hrs.)	₹3,380
28	**2–5**	**₹135 (₹ 90 + ₹45)**	**₹1,840**	**₹1,400 (₹50 × 28 Hrs.)**	**₹3,375**

Working for Total Float

Activity	Duration	EST	EFT	LST	LFT	Total Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	LST − EST
1–2	5	0	5	0	5	0
2–3	5	5	10	6	11	1

2–4	9	5	14	8	17	3
2–5	12	5	17	5	17	0
3–5	6	10	16	11	17	1
4–5	0	14	14	17	17	3
5–6	8	17	25	17	25	0
6–7	6	25	31	25	31	0

Problem-23

A project comprised of 10 activities whose normal time and cost are given as follows:

Activity	*Normal Time (Days)*	*Normal Cost (₹)*
1–2	*3*	*800*
2–3	*3*	*100*
2–4	*7*	*900*
2–5	*9*	*1,400*
3–5	*5*	*600*
4–5	*0*	*0*
5–6	*6*	*590*
6–7	*4*	*720*
6–8	*13*	*1,490*
7–8	*10*	*1,780*

Indirect cost ₹ 115 per day.

Required

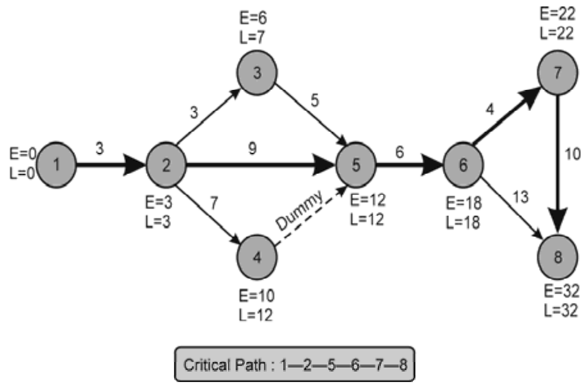
(i) *Draw the network.*

(ii) *List all the paths along with their corresponding durations and find the critical path.*

(iii) *When and at what cost will the project be completed?*

Solution

(i) The **Network** for the given problem



(ii) The **Various Paths** in the **Network** are:

1–2–3–5–6–7–8 with Project Duration = 31 Days (3+3+5+6+4+10)

1–2–3–5–6–8 with Project Duration = 30 Days (3+3+5+6+13)

1–2–5–6–7–8 with Project Duration = 32 Days (3+9+6+4+10)

1–2–5–6–8 with Project Duration = 31 Days (3+9+6+13)

1–2–4–5–6–7–8 with Project Duration = 30 Days (3+7+0+6+4+10)

1–2–4–5–6–8 with Project Duration = 29 Days (3+7+0+6+13)

Critical Path is **1–2–5–6–7–8** with Duration of **32** Days.

(iii) Project will be completed in **32 Days** with Cost of **₹12,060**

	₹
Normal Cost*	8,380
Indirect Cost (32 Days × ₹115)	3,680
Total Cost	12,060

(*)

[₹800 + ₹100 + ₹900 + ₹1,400 + ₹600 + ₹0 + ₹590 + ₹720 + ₹1,490+ ₹1,780]

Problem-24

The following table relates to a network:

Activity	*Normal Time (Days)*	*Crash Time (Days)*	*Normal Cost (₹)*	*Crash Cost (₹)*
1–2	*5*	*4*	*30,000*	*40,000*
2–3	*6*	*4*	*48,000*	*70,000*
2–4	*8*	*7*	*1,25,000*	*1,50,000*
2–5	*9*	*6*	*75,000*	*1,20,000*

3–4	*5*	*4*	*82,000*	*1,00,000*
4–5	*7*	*5*	*50,000*	*84,000*

The overhead cost per day is ₹ 5,000 and the contract includes a penalty clause of ₹ 15,000 per day if the project is not completed in 20 days.

Required

(i) *Draw the network and calculate the normal duration and its cost.*

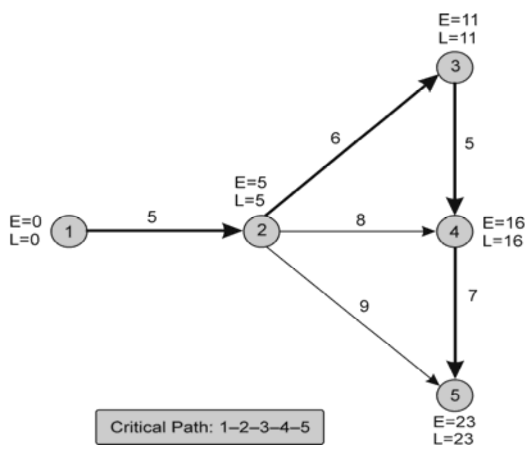
(ii) *Find out:*

(1) *the lowest cost and the associated time.*

(2) *the lowest time and the associated cost.*

Solution

(i) The **network** for the given problem



Normal Duration = 23 Days

Associated Cost = ₹5,70,000

(Refer Statement Showing Project Cost & Duration)

(ii) Lowest Cost = ₹ 5,42,000

Associated Time = 20 Days

(Refer Statement Showing Project Cost & Duration)

Lowest Time = 17 Days

Associated Cost = ₹ 5,79,000

(Refer Statement Showing Project Cost & Duration)

Workings

Statement Showing "Project Cost & Duration"

Project Length Days	Job Crashed	Crashing Cost	Normal Cost	Indirect Cost	Penalty	Total Cost
23	–	–	₹4,10,000	₹1,15,000 (₹5,000 × 23 Days)	₹45,000 (₹15,000 × 3 Days)	**₹5,70,000**
22	1–2	₹10,000 (₹10,000 × 1 Day)	₹4,10,000	₹1,10,000 (₹5,000 × 22 Days)	₹30,000 (₹15,000 × 2 Days)	₹5,60,000
20	2–3	₹32,000 (₹10,000 + ₹11,000 × 2 Days)	₹4,10,000	₹1,00,000 (₹5,000 × 20 Days)	₹0 (₹15,000 × 0 Days)	**₹5,42,000**
18	4–5	₹66,000 (₹32,000 + ₹17,000 × 2 Days)	₹4,10,000	₹90,000 (₹5,000 × 18 Days)	₹0 (₹15,000 × 0 Days)	₹5,66,000
17	3–4	₹84,000 (₹66,000 + ₹18,000 × 1 Day)	₹4,10,000	₹85,000 (₹5,000 × 17 Days)	₹0 (₹15,000 × 0 Days)	**₹5,79,000**

Statement Showing "Cost Slope of *each activity*"

Activity	Normal		Crash		Cost Slopes		
	Duration (Days)	Cost (₹)	Duration (Days)	Cost (₹)	ΔT (Days)	ΔC (₹)	ΔC/ΔT (₹)
1–2	5	30,000	4	40,000	1	10,000	10,000
2–3	6	48,000	4	70,000	2	22,000	11,000
2–4	8	1,25,000	7	1,50,000	1	25,000	25,000
2–5	9	75,000	6	1,20,000	3	45,000	15,000
3–4	5	82,000	4	1,00,000	1	18,000	18,000
4-5	7	50,000	5	84,000	2	34,000	17,000
Total		4,10,000					

Resource Levelling/Smoothing

Problem-25

The following information is available:

Activity	***No. of Days***	***No. of Men Required per Day***
A (1–2)	*4*	*2*
B (1–3)	*2*	*3*
C (1–4)	*8*	*5*
D (2–6)	*6*	*3*
E (3–5)	*4*	*2*
F (5–6)	*1*	*3*
G (4–6)	*1*	*7*

Required

(i) *Draw the network and find the critical path.*

(ii) *Find out the different type of float associated with each activity.*

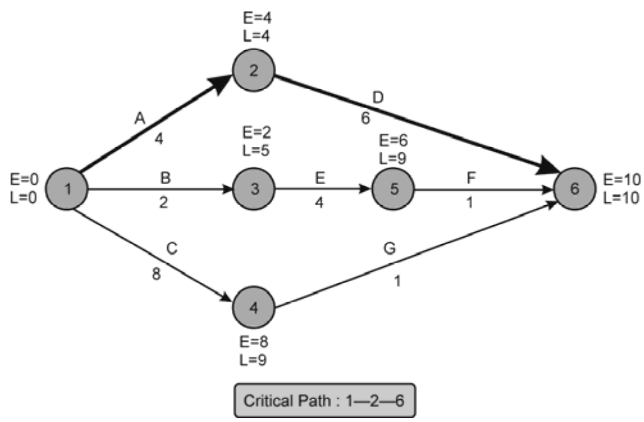
(iii) *Prepare time scale diagram.*

(iv) *What is peak requirement of Manpower? On which day(s) will this occur?*

(v) *If the maximum labour available on any day is only 10, when can the project be completed?*

Solution

The **network** for the given problem:

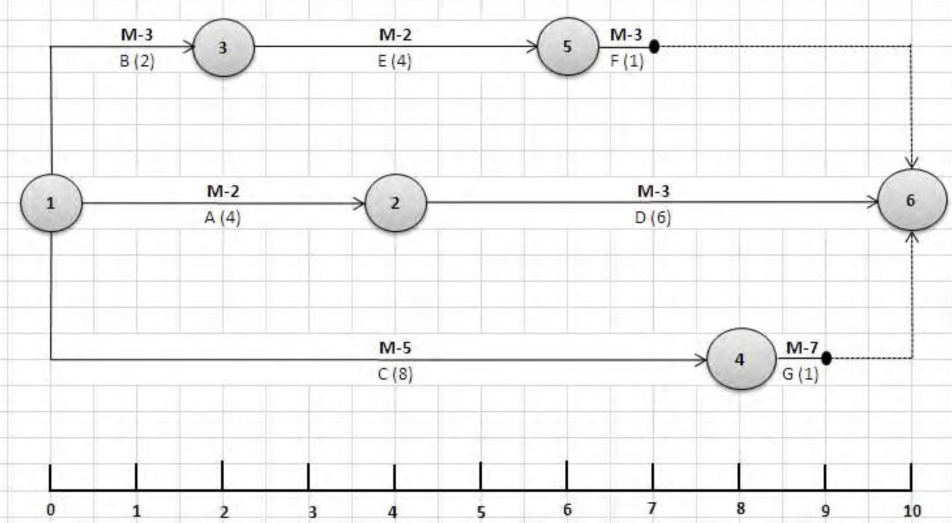


Critical Path is 1–2–6 with Duration of 10 Days.

Working for **Total Float**, **Free Float** & **Independent Float**:

Activity	Duration	EST	EFT	LST	LFT	Slack of Tail Event	Slack of Head Event	Total Float	Free Float	Ind. Float
	D_{ij}	E_i	$E_i + D_{ij}$	$L_j - D_{ij}$	L_j	$L_i - E_i$	$L_j - E_j$	LST − EST	Total Float − Slack of Head Event	Free Float − Slack of Tail Event
A (1–2)	4	0	4	0	4	0	0	0	0	0
B (1–3)	2	0	2	3	5	0	3	3	0	0
C (1–4)	8	0	8	1	9	0	1	1	0	0
D (2–6)	6	4	10	4	10	0	0	0	0	0
E (3–5)	4	2	6	5	9	3	3	3	0	0*
F (5–6)	1	6	7	9	10	3	0	3	3	0
G (4–6)	1	8	9	9	10	1	0	1	1	0

(*) Being negative, the independent float is taken to be equal to zero.

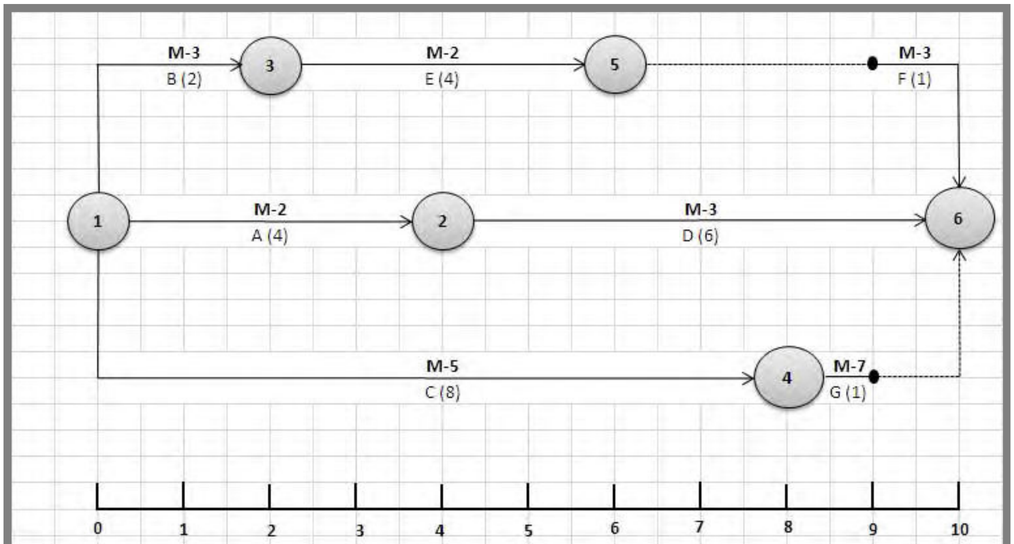


D	10	10	9	9	10	10	11	8	10	3
S	10	10	10	10	10	10	10	10	10	10
SH	0	0	1	1	0	0	-1	2	0	7

Note: D refers to Men Required; S refers to Men Available; SH refers to (Shortage)/Excess; M refers to No. of Man

Peak requirement is 11 men and same is required on 7th Day (Refer above Time Scale Diagram).

As only 10 men are available on any day, we have to shift Activity F to 10th Day. Now the project can be completed in 10 days (Refer below Time Scale Diagram).



D	10	10	9	9	10	10	8	8	10	6
S	10	10	10	10	10	10	10	10	10	10
SH	0	0	1	1	0	0	2	2	0	4

Note: D refers to Men Required; S refers to Men Available; SH refers to (Shortage)/Excess; M refers to No. of Man

Problem-26

The global construction company is bidding on a contract to install a line of microwave towers. It has identified the following activities, along with their expected times, predecessor restriction and worker requirements:

Activity	Duration (weeks)	Predecessors	Crew Size, Workers
A	8	—	8
B	14	—	4
C	6	A	4
D	6	A	8
E	4	B	12
F	4	B	6
G	4	D, E	6
H	6	F, G	8

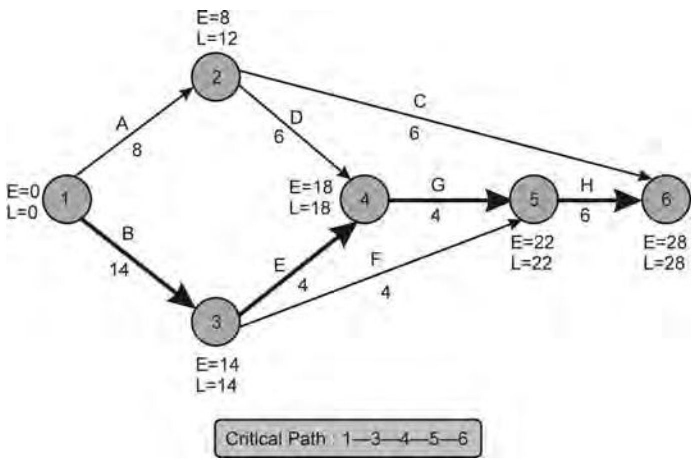
The contract specifies that the project must be completed in 28 weeks. This company will assign a fixed number of workers to the project for its entire duration, and so it would like to ensure that the minimum number of workers is assigned and that the project will be completed in the 28 weeks.

Required

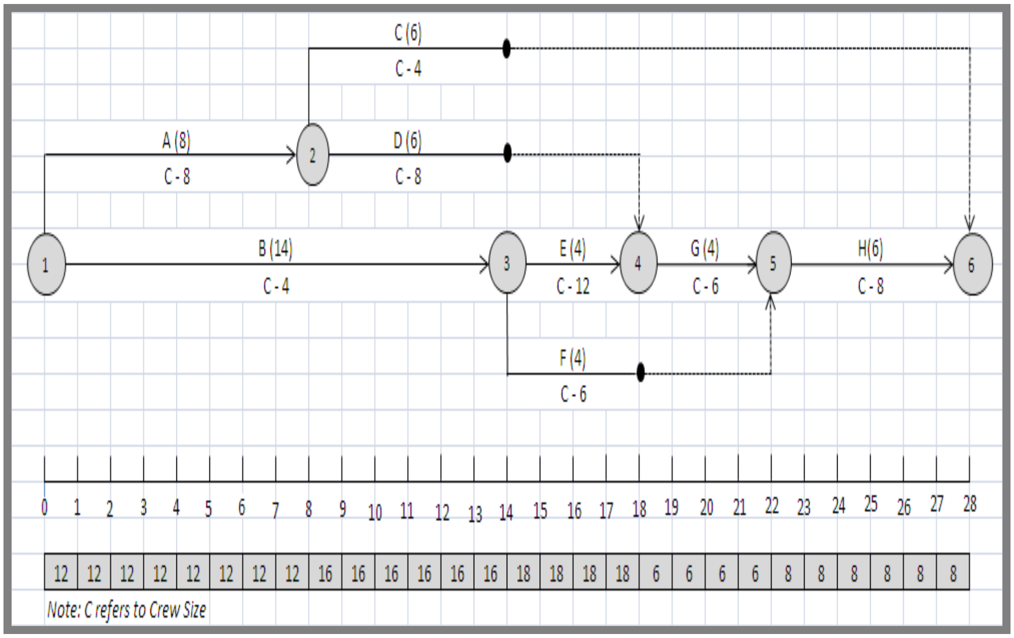
Find a schedule which will do this.

Solution

Critical Path of the network is 1–3–4–5–6 (i.e., B–E–G–H). The duration of the project is 28 weeks.



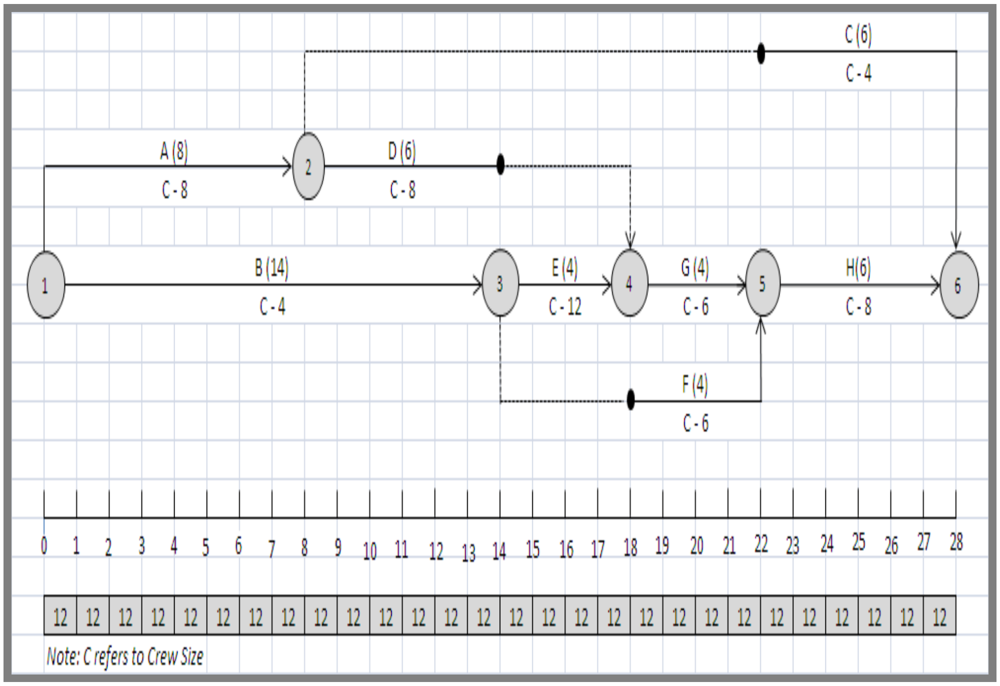
It can be seen from below given resource accumulation table and the time-scaled version of the project that demand on the resources is not even on the 15th, 16th, 17th and 18th week the demand of workers is as high as 18 on the 19th, 20th, 21st and 22nd week, it is only 6. If workers are to be hired for the entire project duration for 28 weeks, then during most of the days, they will be idle.



Re-Scheduling of Activities

As mentioned above the maximum demand of the resources occurs during 9th weeks to 14 weeks (i.e., 16 workers) and during 15th week to 18th weeks (i.e.18 workers). The activities on these days will have to be shifted depending upon their floats such that the demand comes down. As can be seen from the above time –scaled version, activity C has a float of 14 weeks and activity F has a float of 4 weeks. We will try to shift activity C by Fourteen weeks so that it starts on 23rd week instead of 9th week. This reduces demand of workers from 16 to 12 workers during 9th to 14th week.

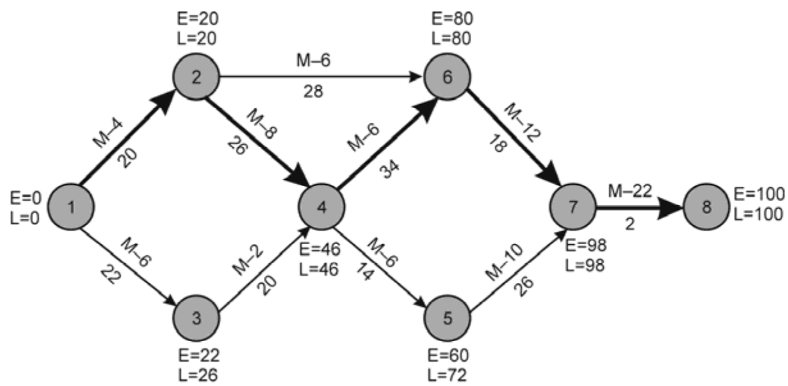
Similarly, we will try to shift activity F by four weeks so that it starts on 19th week instead of 15th week. The requirement during 15th to 18th week now reduces to 12 workers instead of 18 workers required earlier.



The modified resource accumulation table and the time-scaled version of the project are given above. As can be seen from the above figure the requirement for workers reduces to 12 as against 18 workers originally estimated. Hence, by judiciously utilizing the float, we can smooth the demand on the resources.

Problem-27

Rearrange the activities suitably for leveling the audit executives with the help of time scale diagram if during first 52 days only 8 to 10 audit executives and during remaining days 16 to 22 audit executives can be made available.



* M indicates requirement of audit executives.

Solution

Refer Time Scale Diagram-1:

This is a problem of duration constraint of 100 days as also resource constraint (audit executives).

We have to re-arrange the activities so that they can be performed with the given resource availabilities in the stipulated time of 100 days.

Refer Time Scale Diagram-2:

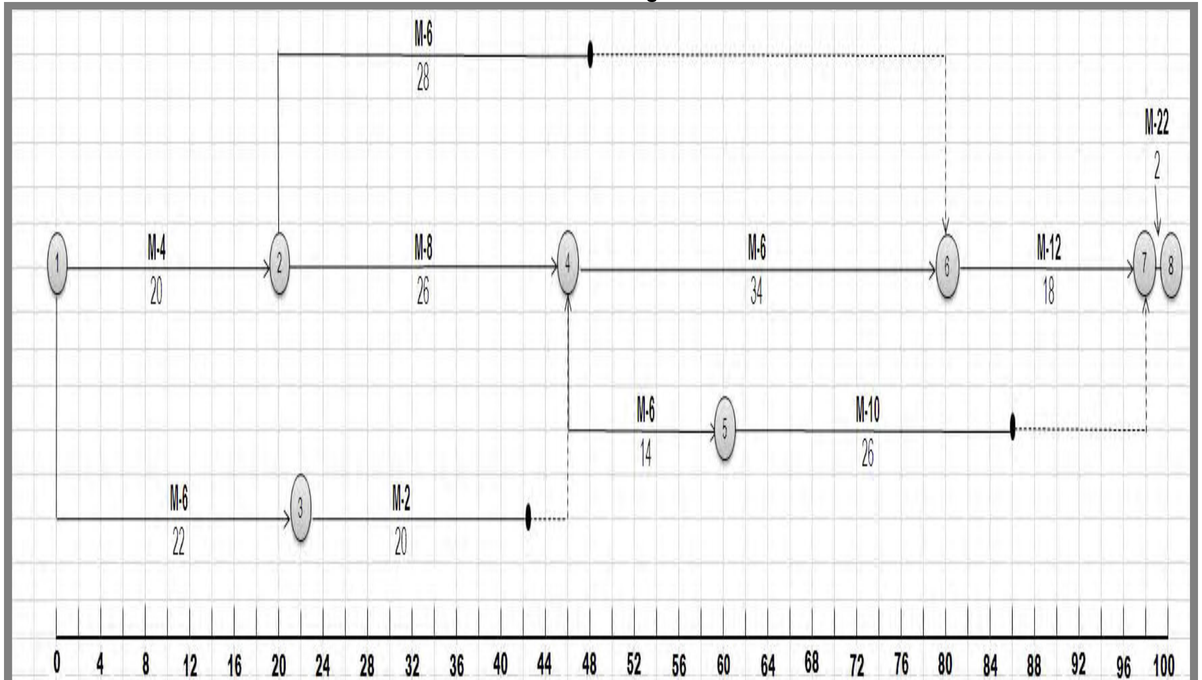
The critical activities 1–2, 2–4, 4–6, 6–7, and 7–8 would be scheduled first. Activity 1–3 is not critical. However scheduling 1–3 even at the scheduled time zero would involve increase of audit executives to 14 on days 21 & 22, which is in excess of availability. We therefore have to resort to do this by doing overtime.

Now activities 2–6 can be delayed by 32 days i.e. instead of starting it on 21st day we can delay it to start on 53rd day.

Similarly we delay activities 4–5 and 5–7 by twelve days each to start on 59th day and 73rd day.

This would ensure that the resources are demanded as per availability and project completion too take place at 100 days.

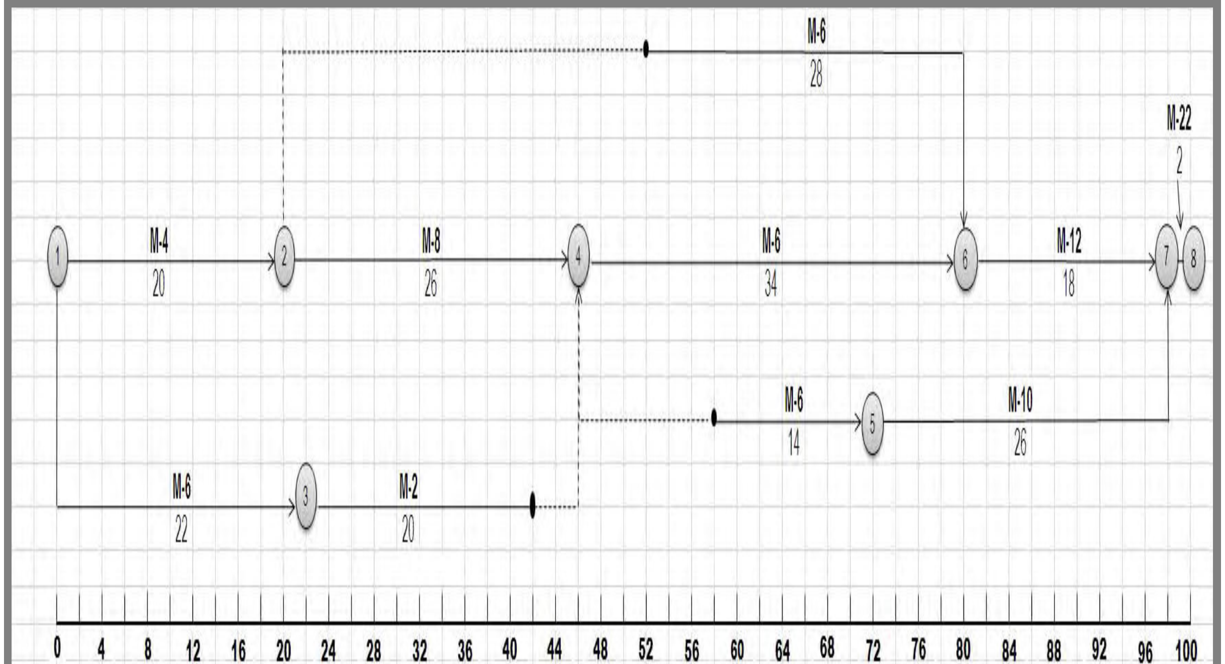
Time Scale Diagram-1



Demand	10	10	10	10	10	10	10	10	10	10	20	16	16	16	16	16	16	16	16	16	16	14	14	18	12
Supply	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Shortage	0	0	0	0	0	0	0	0	0	0	-10	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-4	-4	-8	-2

Demand	12	12	12	12	12	12	16	16	16	16	16	16	16	16	16	16	22	22	22	12	12	12	12	12	12	22
Supply	10	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Shortage	-2	10	10	10	10	6	6	6	6	6	6	6	6	6	6	0	0	0	10	10	10	10	10	10	0

Time Scale Diagram-2



Demand	10	10	10	10	10	10	10	10	10	10	14	10	10	10	10	10	10	10	10	10	10	8	8	6	6
Supply	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Shortage	0	0	0	0	0	0	0	0	0	0	-4	0	0	0	0	0	0	0	0	0	0	2	2	4	4

Demand	6	12	12	12	18	18	18	18	18	18	18	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Supply	10	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Shortage	4	10	10	10	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Problem-28

The following information is given for a certain project:

Activity	Normal Duration (Days)	Crash Duration (Days)	Difference (Days)	Normal Cost (₹)	Crash Cost (₹)	Difference (₹)	Activity slope (₹/day)
	I	II	III = I - II	IV	V	VI = V - IV	VII = VI/ III
1–2	9	6	3	640	700	60	20
1–3	8	5	3	500	575	75	25
1–4	15	10	5	400	550	150	30
2–4	5	3	2	100	120	20	10
3–4	10	6	4	200	260	60	15
4–5	2	1	1	100	140	40	40

Required

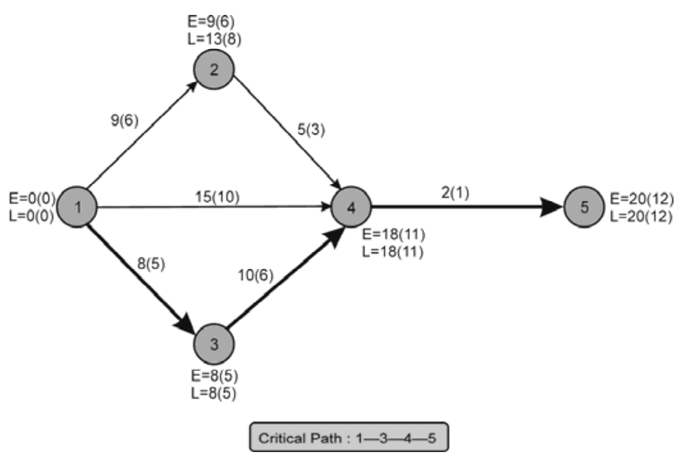
(i) What is the normal project duration?

(ii) Perform step-by step crashing to reduce the project duration by 5 days. What is the cost incurred for the optional crashing exercised?

(iii) Independent of (ii) above, if the Project Manager is able to save as per rates in Column VII of the above table for every day relaxed for the activities, compute the number of days and associated savings for 5 days of relaxation, in the order of optimality, without extending the project duration as per (i). The Project Manager is interested in this exercise to schedule resources.

Solution

(i) The **Network** for the given problem



The **Various Paths** in the network are:

1–3–4–5 with project duration	=	20 Days
1–4–5 with project duration	=	17 Days
1–2–4–5 with project duration	=	16 Days

The critical path is 1–3–4–5. The **normal length of the project is 20 days**.

(ii) Step-by Step Crashing

Crashing Step 1:

Crash Activity 3–4 by 3 Days

Crashing Cost	=	₹15 × 3 Days
	=	₹45

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	17 Days
1–4–5 with project duration	=	17 Days
1–2–4–5 with project duration	=	16 Days

Crashing Step 2:

Crash *Common* Activity 4–5 by One Day

Crashing Cost	=	₹40

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	16 Days
1–4–5 with project duration	=	16 Days
1–2–4–5 with project duration	=	15 Days

Crashing Step 3:

Crash Activity 3–4 by 1 Day & 1–4 by 1 Day

Crashing Cost	=	₹ (15 + 30) × 1 Day
	=	₹ 45

Now the various paths in the network with revised duration are:

1–3–4–5 with project duration	=	15 Days
1–4–5 with project duration	=	15 Days
1–2–4–5 with project duration	=	15 Days
Total Crashing Cost	=	Rs 45 + ₹ 40 + ₹ 45
	=	₹ 130

Statement Showing "Crashing Cost (5 Days)"

Normal Project Length (Days)	Job Crashed	Crashing Cost (₹)
20	-	-
19	3–4	₹ 15
18	3–4	₹ 30 (₹ 15 + ₹ 15)
17	3–4	₹ 45 (₹ 30 + ₹ 15)
16	4–5	₹ 85 (₹ 45 + ₹ 40)
15	3–4,1–4	**₹ 130** (₹ 85 + ₹ 15+ ₹ 30)

(iii) The Project Manager can save some costs by relaxing non-critical activities. Activity 4–5 is a common as well as last activity of the critical path. This particular activity starts on 18th Day of the Project, hence the non-critical activities can be relaxed up to this day i.e. 18th Day.

Among various non-critical activities 1–2, 2–4 and 1–4, activities 1–2 and 2–4 are laying on same path.

It is clear from the table that activity **1–4** has the *highest saving* per day which is ₹ 30 and it can be relaxed up to **3 Days** {i.e. 4–5 Start Day (18) *less* 1–4 Duration (15)}.

Between activity 1–2 and 2–4, activity **1–2** has *higher saving* i.e. ₹ 20 per day and it can be relaxed up to 4 days {i.e. 4–5 Start Day (18) *less* 1–2 Duration (9) *less* 2–4 Duration (5)}. Since there is a specific requirement of 'maximum 5 Days of Relaxation', it can be relaxed by **2 Days** only.

Statement Showing "Saving Due to Relaxation"

Activity	Savings *per day* (₹)	No. of Days	Total (₹)
1–4	30	3	90
1–2	20	2	40
		Total	130

15 Simulation

Basic Concepts

Monte Carlo Simulation	The Monte Carlo method employs random numbers and is used to solve problems that depend upon probability, where physical experimentation is impracticable and the creation of a mathematical formula impossible. In other words, it is method of Simulation by the sampling technique. First of all, the probability distribution of the variable under consideration is determined; then a set of random numbers is used to generate a set of values that have the same distributional characteristics as the actual experience it is devised to simulate.
Simulation	Simulation is a quantitative procedure which describes a process by developing a model of that process and then conducting a series of organised trial and error experiments to predict the behaviour of the process over time.
Steps in the Simulation Process	Steps in Simulation Process- (i) Define the problem or system you intend to simulate. (ii) Formulate the model you intend to use. (iii) Test the model; compare its behaviour with the behaviour of the actual problem environment. (iv) Identify and collect the data needed to test the model. (v) Run the simulation. (vi) Analyze the results of the simulation and, if desired, change the solution you are evaluating. (vii) Rerun the simulation to test the new solution. (viii) Validate the simulation, that is, increase the chances that any inferences you draw about the real situation from running the simulation will be valid.
Steps in Monte Carlo Simulation	The steps involved in carrying out Monte Carlo Simulation are:

	(i) Select the measure of effectiveness of the problem. (ii) Identify the variables which influence the measure of effectiveness significantly. (iii) Determine the proper cumulative probability distribution of each variable selected under step (ii). Plot these, with the probability on the vertical axis and the values of variables on horizontal axis. (iv) Get a set of random numbers. (v) Consider each random number as a decimal value of the cumulative probability distribution. With the decimal, enter the cumulative distribution plot from the vertical axis. Project this point horizontally, until it intersects cumulative probability distribution curve. Then project the point of intersection down into the vertical axis. (vi) Record the value (or values if several variables are being simulated) generated in step (v) into the formula derived from the chosen measure of effectiveness. Solve and record the value. This value is the measure of effectiveness for that simulated value. (vii) Repeat steps (v) and (vi) until sample is large enough for the satisfaction of the decision maker.

SECTION - A

Simulation Technique

Question-1

(i) What is simulation?

(ii) What are the steps in simulation?

Answer

(i) Simulation is a quantitative procedure which describes a process by developing a model of that process and then conducting a series of organized trial and error experiments to product the behaviour of the process over time.

(ii) Steps in the simulation process:

- Define the problem and system you intend to simulate.
- Formulate the model you intend to use.
- Test the model, compare with behaviour of the actual problem environment.
- Identify and collect data to test the model.
- Run the simulation.
- Analyse the results of the simulation and, if desired, change the solution you are evaluating.
- Rerun the simulation to tests the new solution.
- Validate the simulation i.e., increase the chances of valid inferences.

Question-2

How would you use the Monte Carlo Simulation method in inventory control?

Answer

Steps involved in carrying out Monte Carlo simulation are:

(i) Define the problem and select the measure of effectiveness of the problem that might be inventory shortages per period.

(ii) Identify the variables which influence the measure of effectiveness significantly for example, number of units in inventory.

(iii) Determine the proper cumulative probability distribution of each variable selected with the probability on vertical axis and the values of variables on horizontal axis.

(iv) Get a set of random numbers.

(v) Consider each random number as a decimal value of the cumulative probability distribution with the decimal enter the cumulative distribution plot from the vertical axis. Project this point horizontally, until it intersects cumulative probability distribution curve. Then project the point of intersection down into the vertical axis.

(vi) Then record the value generated into the formula derived from the chosen measure of effectiveness. Solve and record the value. This value is the measure of effectiveness for that simulated value. Repeat above steps until sample is large enough for the satisfaction of the decision maker.

Question-3

State major reasons for using simulation technique to solve a problem and also describe basic steps in a general simulation process.

Answer

Reasons

(i) It is not possible to develop a mathematical model and solutions with out some basic assumptions.

(ii) It may be too costly to actually observe a system.

(iii) Sufficient time may not be available to allow the system to operate for a very long time.

(iv) Actual operation and observation of a real system may be too disruptive.

Steps

(i) Define the problem or system which we want to simulate.

(ii) Formulate an appropriate model of the given problem.

(iii) Ensure that model represents the real situation/ test the model, compare its behaviour with the behaviour of actual problem environment.

(iv) Identify and collect the data needed to list the model.

(v) Run the simulation

(vi) Analysis the results of the simulation and if desired, change the solution.

(vii) Return and validate the simulation.

Question-4

Write a short note on the advantages of simulation.

Answer

Advantages of simulation are enumerated below:

(i) Simulation techniques allow experimentation with a model of the system rather than the actual operating system. Sometimes experimenting with the actual system itself could prove to be too costly and, in many cases too disruptive. For example, if you are comparing two ways of providing food service in a hospital, the confusion that would result from operating two different systems long enough to get valid observations might be too great. Similarly, the operation of a large computer centre under a number of different operating alternatives might be too expensive to be feasible.

(ii) The non-technical manager can comprehend simulation more easily than a complex mathematical model. Simulation does not require simplifications and assumptions to the extent required in analytical solutions. A simulation model is easier to explain to management personnel since it is a description of the behaviour of some system or process.

(iii) Sometimes there is not sufficient time to allow the actual system to operate extensively. For example, if we were studying long-term trends in world population, we simply could not wait the required number of years to see results. Simulation allows the manager to incorporate time into an analysis. In a computer simulation of business operation the manager can compress the result of several years or periods into a few minutes of running time.

(iv) Simulation allows a user to analyze these large complex problems for which analytical results are not available. For example, in an inventory problem if the distribution for demand and lead time for an item follow a standard distribution, such as the poison distribution, then a mathematical or analytical solution can be found. However, when mathematically convenient distributions are not applicable to the problem, an analytical analysis of the problem may be impossible. A simulation model is a useful solution procedure for such problems.

SECTION - B

Car Manufacturer's Problem

Problem-1

A Car Manufacturing Company manufactures 40 cars per day. The sale of cars depends upon demand which has the following distribution:

Sales of Cars	***Probability***
37	*0.10*
38	*0.15*
39	*0.20*
40	*0.35*
41	*0.15*
42	*0.05*

The production cost and sale price of each car are ₹ 4 lakh and ₹ 5 lakh respectively. Any unsold car is to be disposed off at a loss of ₹ 2 lakh per car. There is a penalty of ₹ 1 lakh per car, if the demand is not met.

Required

(i) Using the following random numbers, estimate total profit/ loss for the company for the next ten days:

9, 98, 64, 98, 94, 01, 78, 10, 15, 19

(ii) If the company decides to produce 39 cars per day, what will be its impact on profitability?

Solution

First of all random numbers 00-99 are allocated in proportion to the probabilities associated with the sales of cars as given below:

Sales of Car	**Probability**	**Cumulative Probability**	**Range for Random Numbers**
37	0.10	0.10	00 – 09
38	0.15	0.25	10 – 24

39	0.20	0.45	25 − 44
40	0.35	0.80	45 − 79
41	0.15	0.95	80 − 94
42	0.05	1.00	95 − 99

Based on the given random numbers, we simulate the estimated sales and calculate the profit / loss on the basis of specified units of production.

Day	Random Numbers	Estimated Sale	Profit (Production 40 Cars / Day) (₹Lakh)	Profit (Production 39 Cars / Day) (₹Lakhs)
1	9	37	₹31 (37Cars × ₹1 − 3Cars × ₹2)	₹33 (37Cars × ₹1 − 2Cars × ₹2)
2	98	42	₹38 (40Cars × ₹1 − 2Cars × ₹1)	₹36 (39Cars × ₹1 − 3Cars × ₹1)
3	64	40	₹40 (40Cars × ₹1)	₹38 (39Cars × ₹1 − 1Car × ₹1)
4	98	42	₹38 (40Cars × ₹1 − 2Cars × ₹1)	₹36 (39Cars × ₹1 − 3Car × ₹1)
5	94	41	₹39 (40Cars × ₹1 − 1Car × ₹1)	₹37 (39Cars × ₹1 − 2Car × ₹1)
6	01	37	₹31 (37Cars × ₹1 − 3Cars × ₹2)	₹33 (37Cars × ₹1 − 2Car × ₹2)
7	78	40	₹40 (40Cars × ₹1)	₹38 (39Cars × ₹1 − 1Car × ₹1)
8	10	38	₹34 (38Cars × ₹1 − 2Cars × ₹2)	₹36 (38Cars × ₹1 − 1Car × ₹2)
9	15	38	₹34 (38Cars × ₹1 − 2Cars × ₹2)	₹36 (38Cars × ₹1 − 1Car × ₹2)
10	19	38	₹34 (38Cars × ₹1 − 2Cars × ₹2)	₹36 (36Cars × ₹1 − 1Car × ₹2)
		Total	₹359	₹359

There is no additional profit or loss if the company decides to reduce production to 39 cars per day.

Publisher's Problem

Problem-2

A Publishing house has bought out a new monthly magazine, which sells at ₹ 37.5 per copy. The cost of producing it is ₹ 30 per copy. A Newsstand estimates the sales pattern of the magazine as follows:

Demand Copies			*Probability*
0	*<*	*300*	*0.18*
300	*<*	*600*	*0.32*
600	*<*	*900*	*0.25*
900	*<*	*1,200*	*0.15*
1,200	*<*	*1,500*	*0.06*
1,500	*<*	*1,800*	*0.04*

The newsstand has contracted for 750 copies of the magazine per month from the publisher.

The unsold copies are returnable to the publisher who will take them back at cost less ₹ 4 per copy for handling charges.

The newsstand manager wants to simulate of the demand and profitability. The following random number may be used for simulation:

27, 15, 56, 17, 98, 71, 51, 32, 62, 83, 96, 69.

Required

(i) *Allocate random numbers to the demand pattern forecast by the newsstand.*

(ii) *Simulate twelve months sales and calculate the monthly and annual profit/loss.*

(iii) *Calculate the loss on lost sales.*

Solution

(i) Allocation of Random Numbers

Demand			Probability	Cumulative Probability	Allocated RN
0	<	300	0.18	0.18	00 – 17
300	<	600	0.32	0.50	18 – 49
600	<	900	0.25	0.75	50 – 74
900	<	1,200	0.15	0.90	75 – 89
1,200	<	1,500	0.06	0.96	90 – 95
1,500	<	1,800	0.04	1.00	96 – 99

(ii) Simulation: Twelve Month's Sales, Monthly and Annual Profit / Loss

Month	RN	Demand	Sold	Return	Profit on Sales (₹)	Loss on Return (₹)	Net Profit (₹)	Lost Units
1	27	450	450	300	3,375 (450Copies×₹7.5)	1,200 (300Copies×₹4)	2,175	---
2	15	150	150	600	1,125 (150Copies×₹7.5)	2,400 (600Copies×₹4)	(1,275)	---
3	56	750	750	---	5,625 (750Copies×₹7.5)	---	5,625	---
4	17	150	150	600	1,125 (150Copies×₹7.5)	2,400 (600Copies×₹4)	(1,275)	---
5	98	1,650	750	---	5,625 (750Copies×₹7.5)	---	5,625	900
6	71	750	750	---	5,625 (750Copies×₹7.5)	---	5,625	---
7	51	750	750	---	5,625 (750Copies×₹7.5)	---	5,625	---
8	32	450	450	300	3,375 (450Copies×₹7.5)	1,200 (300Copies×₹4)	2,175	---
9	62	750	750	---	5,625 (750Copies×₹7.5)	---	5,625	---
10	83	1,050	750	---	5,625 (750Copies×₹7.5)	---	5,625	300
11	96	1,650	750	---	5,625 (750Copies×₹7.5)	---	5,625	900
12	69	750	750	---	5,625 (750Copies×₹7.5)	---	5,625	---
				Total	54,000	7,200	46,800	2,100

(iii) Loss on Lost Sale ₹15,750 (2,100 units × ₹ 7.5).

Travelling Agency/ Reservation Centre's Problem

Problem-3

A car rental agency has collected the following data on the demand for five-seater vehicles over the past 50 days.

Daily Demand	*4*	*5*	*6*	*7*	*8*
No. of Days	*4*	*10*	*16*	*14*	*6*

The agency has only 6 cars at present.

Use the following 5 random numbers to generate 5 days of demand for the rental agency

Random Nos: 15, 48, 71, 56, 90

Required

(i) What is the average number of cars rented per day for the 5 days?

(ii) How many rentals will be lost over the 5 days?

Solution

Daily Demand	Days	Probability	Cumulative Probability	Random No. Assigned
4	4	0.08	0.08	00 – 07
5	10	0.20	0.28	08 – 27
6	16	0.32	0.60	28 – 59
7	14	0.28	0.88	60 – 87
8	6	0.12	1.00	88 – 99

Day	Random No.	Demand	No. of Cars on Rent	Rent Lost
1	15	5	5	---
2	48	6	6	---
3	71	7	6	1
4	56	6	6	---
5	90	8	6	2
		Total	29	3

Average no. of Cars Rented are 5.8 $\left(\frac{29\text{Cars}}{5}\right)$

Rental Lost equals to 3 Cars

Problem-4

A refreshment centre in a railway station has two counters - (i) self-service (opted by 60 % of the customers) and (ii) attended service (opted by 40 % of the customers). Both counters can serve one person at a time. The arrival rate of customers is given by the following probability distribution:

No. of Arrivals	*1*	*3*	*4*	*0*	*2*
Probability	*0.10*	*0.30*	*0.05*	*0.20*	*0.35*

Required

Formulate the associated interval of 2 digit random numbers for generating

(i) the type of service and

(ii) the arrival rate

Solution

Type of Service	**Probability**	**Cumulative Probability**	**Random No. Interval**
Self- Service	0.60	0.60	00 – 59
Attended Service	0.40	1.00	60 – 99

Arrival Rate

No. of Arrivals	**Probability**	**Cumulative Probability**	**Random Number Interval**
0	0.20	0.20	00 – 19
1	0.10	0.30	20 – 29
2	0.35	0.65	30 – 64
3	0.30	0.95	65 – 94
4	0.05	1.00	95 – 99

Problem-5

A single counter ticket booking centre employs one booking clerk. A passenger on arrival immediately goes to the booking counter for being served if the counter is free. If, on the other hand, the counter is engaged, the passenger will have to wait. The passengers are served on first come first served basis. The time of arrival and the time of service varies from one minute to six minutes. The distribution of arrival and service time is as under:

Arrival / Service Time (Minutes)	***Arrival (Probability)***	***Service (Probability)***
1	*0.05*	*0.10*
2	*0.20*	*0.20*
3	*0.35*	*0.40*
4	*0.25*	*0.20*
5	*0.10*	*0.10*
6	*0.05*	*---*

Required

(i) *Simulate the arrival and service of 10 passengers starting from 9 A.M. by using the following random numbers in pairs respectively for arrival and service.*

Random numbers-

(60, 09); (16, 12); (08, 18); (36, 65); (38, 25); (07, 11); (08, 79); (59, 61); (53, 77); (03, 10).

(ii) *Determine the total duration of*

(1) *Idle time of booking clerk and*

(2) *Waiting time of passengers.*

Solution

Random Allocation Table

Time *	Arrival (Probability)	Arrivals Cumulative Probability	Random No. Allocated	Time *	Service (Probability)	Service Cumulative (Probability)	Random No. Allocated
1	0.05	0.05	00 – 04	1	0.10	0.10	00 – 09
2	0.20	0.25	05 – 24	2	0.20	0.30	10 – 29
3	0.35	0.60	25 – 59	3	0.40	0.70	30 – 69
4	0.25	0.85	60 – 84	4	0.20	0.90	70 – 89
5	0.10	0.95	85 – 94	5	0.10	1.00	90 – 99
6	0.05	1.00	95 – 99				

(*) in minutes

Simulation of Trails

R. No.	Arrival*	Time	Start	R. No.	Time*	Finish Time	Waiting Time	
							Clerk	Passenger
60	4	9.04	9.04	09	1	9.05	4	---
16	2	9.06	9.06	12	2	9.08	1	---
08	2	9.08	9.08	18	2	9.10	---	---
36	3	9.11	9.11	65	3	9.14	1	---
38	3	9.14	9.14	25	2	9.16	---	---
07	2	9.16	9.16	11	2	9.18	---	---
08	2	9.18	9.18	79	4	9.22	---	---
59	3	9.21	9.22	61	3	9.25	---	1
53	3	9.24	9.25	77	4	9.29	---	1
03	1	9.25	9.29	10	2	9.31	---	4
						Total	6	6

(*) in minutes

In the above ten trial, the clerk was idle for 6 minutes and the passengers had to wait for 6 minutes.

Problem-6

An international tourist company deals with numerous personal callers each day and prides itself on its level of service. The time to deal with each caller depends on the client's requirements which range from, say, a request for a brochure to booking a round-the-world cruise. If a client has to wait for more than 10 minutes for attention, it is company's policy for the manager to see him personally and to give him a holiday voucher worth ₹ 15.

The company's observations have shown that the time taken to deal with clients and the arrival pattern of their calls follow the following distribution pattern:

Time to deal with clients	***Minutes***	*2*	*4*	*6*	*10*	*14*	*20*	*30*
	Probability	*0.05*	*0.10*	*0.15*	*0.30*	*0.25*	*0.10*	*0.05*

Time between call arrivals	***Minutes***	*1*	*8*	*15*	*25*
	Probability	*0.2*	*0.4*	*0.3*	*0.1*

Required

(i) Describe how you would simulate the operation of the travel agency based on the use of random number tables;

(ii) Simulate the arrival and serving of 12 clients and show the number of clients who receive a voucher (use line 1 of the random numbers below to derive the arrival pattern and line 2 for serving times); and

(iii) Calculate the weekly cost of vouchers; assuming the proportion of clients receiving vouchers derived from (ii) applies throughout a week of 75 operating hours.

Random Numbers

Line 1	*03*	*47*	*43*	*73*	*86*	*36*	*96*	*47*	*36*	*61*	*46*	*98*
Line 2	*63*	*71*	*62*	*33*	*26*	*16*	*80*	*45*	*60*	*11*	*14*	*10*

Solution

Time to Deal with Clients

Time (Minutes)	Probability	Cumulative Probability	Assigned Numbers
2	0.05	0.05	00 – 04
4	0.10	0.15	05 – 14
6	0.15	0.30	15 – 29
10	0.30	0.60	30 – 59
14	0.25	0.85	60 – 84
20	0.10	0.95	85 – 94
30	0.05	1.00	95 – 99

Time between Arrivals

Time (Minutes)	Probability	Cumulative Probability	Assigned Numbers
1	0.20	0.20	00 – 19
8	0.40	0.60	20 – 59
15	0.30	0.90	60 – 89
25	0.10	1.00	90 – 99

Simulation Table for Time between Arrivals and Service Time

Client	Time Between Arrivals	Arrival Time	Time In	Serving Time	Time Out	Waiting Time	Voucher
1	1	1	1	14	15	---	---
2	8	9	15	14	29	6	---
3	8	17	29	14	43	12	Yes
4	15	32	43	10	53	11	Yes
5	15	47	53	6	59	6	---
6	8	55	59	6	65	4	---
7	25	80	80	14	94	---	---
8	8	88	94	10	104	6	---
9	8	96	104	14	118	8	---
10	15	111	118	4	122	7	---
11	8	119	122	4	126	3	---
12	25	144	144	4	148	---	---

Total Clients in a Week of 75Hours = 433 (75 hours × 60 minutes /10.4[#] minutes)

[#]Average Time between Arrivals = 10.4 minutes (0.2 × 1 + 0.4 × 8 + 0.3 × 15 + 0.1 × 25)

2 out of the 12 clients receive ₹15 voucher. So the Cost will be ₹1,082.50 or ₹1,083 [(2/12 × 433) × ₹15].

☞

Taking Cycle Time as 148 minutes, Voucher Cost can be computed as follows:

₹15 per Client × [(75 hours × 60 minutes /148 minutes) No. of Cycles × 2 Clients per Cycle Time]

So, Voucher Cost will be ₹912.16

Bank's Problem

Problem-7

With a view to improving the quality of customer services, a Bank is interested in making an assessment of the waiting time of its customers coming to one of its branches located in a *residential area. This branch has only one teller's counter. The arrival rate of the customers and the service rate of the teller are given below:*

Time between two consecutive arrivals of customers (in minutes)	*Probability*
3	*0.17*
4	*0.25*
5	*0.25*
6	*0.20*
7	*0.13*

Service time by the teller (in minutes)	*Probability*
3	*0.10*
4	*0.30*
5	*0.40*
6	*0.15*
7	*0.05*

Required

Simulate 10 arrivals of customers in the system starting 11 AM and show the waiting time of the customers and idle time of the teller.

Use the following random numbers taking the first two random numbers digits each for trial and so on:

11, 56, 23, 72, 94, 83, 83, 02, 97, 99, 83, 10, 93, 34, 33, 53, 49, 94, 37 and 97.

Solution

Random Numbers Allocation

Arrivals

Time Between Two Consecutive Arrivals of Customers *in minutes*	Probability	Cumulative Probability	Random Nos. Allocated
3	0.17	0.17	00 – 16
4	0.25	0.42	17 – 41

5	0.25	0.67	42 – 66
6	0.20	0.87	67 – 86
7	0.13	1.00	87 – 99

Service Time

Arrivals Time by the Teller *in minutes*	Probability	Cumulative Probability	Random Nos. Allocated
3	0.10	0.10	00 – 09
4	0.30	0.40	10 – 39
5	0.40	0.80	40 – 79
6	0.15	0.95	80 – 94
7	0.05	1.00	95 – 99

Simulation Table

S. No	R. No	Arrival Time *in minutes*	Arrival Time A.M.	Service Begins A.M.	R. No	Service Time *in minutes*	Service Ends A.M.	Waiting Time for Customer Time *in minutes*	Idle Time *In mints*
1	11	3	11.03	11.03	56	5	11.08	---	3
2	23	4	11.07	11.08	72	5	11.13	1	---
3	94	7	11.14	11.14	83	6	11.20	---	1
4	83	6	11.20	11.20	02	3	11.23	---	---
5	97	7	11.27	11.27	99	7	11.34	---	4
6	83	6	11.33	11.34	10	4	11.38	1	---
7	93	7	11.40	11.40	34	4	11.44	---	2
8	33	4	11.44	11.44	53	5	11.49	---	---
9	49	5	11.49	11.49	94	6	11.55	---	---
10	37	4	11.53	11.55	97	7	12.02	2	---
							Total	4	10

Total Waiting Time of Customers: 4 minutes

Total Idle Time of Teller: 10 minutes

Service Centre's Problem

Problem-8

A computer service centre services laptops. It is proposed to study the arrival and servicing pattern of the service centre. The following in information was collected, over a period of 100 days.

No. of computers	*Frequency of arrival*	*Frequency of service*
8	10	15
9	25	20
10	20	25
11	15	16
12	18	14
13	12	10

Required

Simulate the arrival and servicing pattern for 10 days and find out the average number of laptops held for more than one day for service.

Assume FIFO method is followed for service/repair and there is one laptop held from previous day for repair at the beginning of the first day.

Use the following series of random numbers:

Arrivals	69	45	46	10	82	16	35	70	57	92
Service	52	36	62	49	68	77	55	66	51	88

Solution

The arrival patterns yield the following probability distribution. The numbers 00–99 are allocated in proportion to the probabilities associated with each event.

Random No. Coding for Arrival

No. of Laptops	Probability	Cumulative Probability	Random Numbers
8	0.10	0.10	00 – 09
9	0.25	0.35	10 – 34

10	0.20	0.55	35 – 54
11	0.15	0.70	55 – 69
12	0.18	0.88	70 – 87
13	0.12	1.00	88 – 99

The service patterns yield the following probability distribution. The numbers 00–99 are allocated in proportion to the probabilities associated with each event.

Random No. Coding for Service

No. of Laptops	Probability	Cumulative Probability	Random Numbers
8	0.15	0.15	00 – 14
9	0.20	0.35	15 – 34
10	0.25	0.60	35 – 59
11	0.16	0.76	60 – 75
12	0.14	0.90	76 – 89
13	0.10	1.00	90 – 99

Let us simulate the arrival and service of laptops for the next ten days using the given random numbers / information.

Simulation Sheet

Day	R. No. of Arrival	No. of Laptops Arrived	Opening Job	R. No. of Service	No. of Laptops Serviced*	Closing Job
1	69	11	1	52	10	2
2	45	10	2	36	10	2
3	46	10	2	62	11	1
4	10	9	1	49	10	0
5	82	12	0	68	11	1
6	16	9	1	77	12	0
7	35	10	0	55	10	0
8	70	12	0	66	11	1
9	57	11	1	51	10	2
10	92	13	2	88	12	3
					Total	12

** This represents the service capacity of service centre.*

Average No. of Laptops held for more than one day $= \dfrac{\text{Total of Closing Jobs}}{\text{No. of Days}}$

$= \dfrac{12\,\text{Laptops}}{10\,\text{Days}}$

$=$ 1.2 Laptops *per day*

Bakery/ Retailer's Problem – Perishable Commodity

Problem-9

A retailer deals in a perishable commodity. The daily demand and Supply are variables. The data for the past 500 days show the following demand and supply:

Supply		***Demand***	
Availability (Kg.)	***No. of Days***	***Demand (Kg.)***	***No. of Days***
10	*40*	*10*	*50*
20	*50*	*20*	*110*
30	*190*	*30*	*200*
40	*150*	*40*	*100*
50	*70*	*50*	*40*

The retailer buys the commodity at ₹ 20 per kg. and sell it at ₹ 30 per kg. Any commodity remains at the end of the day, has no saleable value. Moreover, the loss (unearned profit) on any unsatisfied demand is ₹ 8 per kg.

Required

Given the following pair of random numbers, simulate 6 days sales, demand and profit.

(31 ,18); (63 , 84); (15 , 79); (07 , 32); (43, 75); (81, 27)

The first random number in the pair is for supply and the second random number is for demand viz. in the first pair (31, 18), use 31 to simulate supply and 18 to simulate demand.

Solution

The demand and supply patterns yield the following probability distribution. The numbers 00-99 are allocated in proportion to the probabilities associated with each event.

Availability (kg)	Prob.	Cum Prob.	Random Number Allocated	Demand (Kg)	Prob.	Cum Prob.	Random Numbers Allocated
10	0.08	0.08	00 – 07	10	0.10	0.10	00 – 09
20	0.10	0.18	08 – 17	20	0.22	0.32	10 – 31
30	0.38	0.56	18 – 55	30	0.40	0.72	32 – 71
40	0.30	0.86	56 – 85	40	0.20	0.92	71 – 91
50	0.14	1.00	86 – 99	50	0.08	1.00	92 – 99

Let us simulate the supply and demand for the next six days using the given random numbers in order to find the profit if the cost of the commodity is ₹20 per kg, the selling price is ₹30 per kg, loss on any unsatisfied demand is ₹8 per kg and unsold commodities at the end of the have no saleable value.

Day	R No	Avail (i)	R No	Demand (ii)	Buying Cost (i) × ₹20	Sales Revenue Min. [(i) or (ii)] × ₹30	Profit (₹) (iii) = (ii) – (i)	Loss * (iv)	Net Profit (iii) – (iv)
1	31	30	18	20	600	600	---	---	---
2	63	40	84	40	800	1,200	400	---	400
3	15	20	79	40	400	600	200	160	40
4	07	10	32	30	200	300	100	160	(60)
5	43	30	75	40	600	900	300	80	220
6	81	40	27	20	800	600	(200)	---	(200)
						Total	800	400	400

(*) Due to unsatisfied Demand

During the simulated period of six days, the net profit of the retailer is ₹400.

Problem-10

A bakery sells a popular brand of bread. Cost price per bread is ₹ 16 and selling price per bread is ₹ 20. Shelf life of the bread is 2 days and if it is not sold within two days, then it has no sale value at the end of second day. Daily demand based on past experience is as under:

Daily Demand	*0*	*20*	*25*	*35*	*40*	*45*
Probability	*.01*	*.15*	*.30*	*.40*	*.10*	*.04*

Consider the following sequence of random numbers:

58, 80, 51, 09, 47, 26, 64, 43, 86, 35

Required

Using the sequence, simulate the demand for the next 10 days and find out the total profit or loss for 10 days assuming 35 breads are purchased every day in the morning and there is an opening stock of 5 breads (purchased the previous day) on the 1st day morning. Assume LIFO basis (Last In First Out basis - where the fresh bread is sold first).

Solution

The demand patterns yield the following probability distribution. The numbers 00–99 are allocated in proportion to the probabilities associated with each event.

Random No. Coding for Demand

Demand	Prob.	Cum Prob.	Random Numbers
0	0.01	0.01	00 – 00
20	0.15	0.16	01 – 15
25	0.30	0.46	16 – 45
35	0.40	0.86	46 – 85
40	0.10	0.96	86 – 95
45	0.04	1.00	96 – 99

Let us simulate the supply and demand for the next ten days using the given random numbers / information in order to find the profit if

– the cost of the bread is ₹16,

– the selling price is ₹20 and

– unsold bread after the end of the 2nd Day have no saleable value.

Simulation Sheet for Finding Profit

Day	Random No	Op. Stock (In No.)	Demand (In No.)	Supply (In No.)	Waste (In No.)	Cl. Stock (In No.)	Loss on Waste (In ₹)	Profit on Sale (In ₹)	Net Profit (In ₹)
1	58	5	35	35	5	0	80 (5b×₹16)	140 (35b×₹4)	60
2	80	0	35	35	0	0	0	140 (35b×₹4)	140
3	51	0	35	35	0	0	0	140 (35b×₹4)	140

4	09	0	20	35	0	15	0	80 (20b×₹4)	80
5	47	15	35	35	15	0	240 (15b×₹16)	140 (35b×₹4)	–100
6	26	0	25	35	0	10	0	100 (25b×₹4)	100
7	64	10	35	35	10	0	160 (10b×₹16)	140 (35b×₹4)	–20
8	43	0	25	35	0	10	0	100 (25b×₹4)	100
9	86	10	40	35	5	0	80 (5b×₹16)	160 (40b×₹4)	80
10	35	0	25	35	0	10	0	100 (25b×₹4)	100

**b refers to no. of breads*

Profit on Sale of one Bread ₹4 (₹20 – ₹16).

Total Profit for 10 Days is ₹680.

(₹60 + ₹140 + ₹140 + ₹80 – ₹100 + ₹100 – ₹20 + ₹100 + ₹80 + ₹100)

Cost of Bread in Stock at the end of the 10th Day is ₹160 (10 Breads × ₹16).

Problem-11

A bakery bakes 100 cakes per day. The sale of cakes depends upon demand which has the following distribution:

Sale of Cakes (Nos.)	*Probability*
97	*0.10*
98	*0.15*
99	*0.20*
100	*0.35*
102	*0.15*
103	*0.05*

There is no carryover of inventory.

The following details are given:

	₹
Variable Production cost per cake	*14*
Selling price per cake	*18*
Penalty attracted per unsold cake	*3*
Penalty attracted per unit of demand not met	*1*

Random Numbers to be used:

9, 98, 64, 98, 94, 01, 78, 10, 15, 19

Required

(i) Estimate the profit/loss for the next ten days using the above random numbers and assuming 100 cakes are produced per day.

(ii) If the bakery decides to produce 97 cakes per day, will the profits as per (i) above increase or decrease? Why?

Solution

(i) According to the given distribution of demand, the random number coding for various demand levels is shown in Table below:

Random Number Coding

Demand	Probability	Cumulative Probability	Random Nos. Fitted
97	0.10	0.10	00 – 09
98	0.15	0.25	10 – 24
99	0.20	0.45	25 – 44
100	0.35	0.80	45 – 79
102	0.15	0.95	80 – 94
103	0.05	1.00	95 – 99

The simulated demand for the cakes for the next 10 days is given in the Table below in order to find the estimated profit/loss if the variable cost of production is ₹14 per cake, the selling price is ₹18 per cake, penalty on any unsatisfied demand is Re.1 per cake and penalty on any unsold cake at the end of the day is ₹3 per cake.

Simulation Sheet

Day	Random No.	Demand of Cakes	Prod. of Cakes	Cakes Sold	Unsatisfied Demand	Unsold Cake
1	9	97	100	97	-	3
2	98	103	100	100	3	-
3	64	100	100	100	-	-
4	98	103	100	100	3	-
5	94	102	100	100	2	-
6	01	97	100	97	-	3
7	78	100	100	100	-	-
8	10	98	100	98	-	2
9	15	98	100	98	-	2
10	19	98	100	98	-	2
Total		996	1,000	988	8	12

Calculation of "Bakery's Profit/ Loss"

	Amount (₹)
Sales of Cakes (988 Cakes × ₹18)	17,784.00
Less: Variable Production Cost [(988 Cakes + 12 Cakes) × ₹14]	14,000.00
Less: Penalty on Unsatisfied Demand (8 Cakes × Re. 1)	8.00
Less: Penalty on Unsold Cakes (12 Cakes × ₹3)	36.00
Profit / (Loss)	3,740.00

(ii) If the bakery decided to produce 97 Cakes per day which is equal to minimum demand level.

– Cakes Produced and Sold will be reduced to 970 i.e. 97 per day.

– Unsatisfied Demand will be increase to 26 Cakes (996 Cakes – 970 Cakes).

– There will be no unsold Cake at the end of the day as production is equal to minimum demand level.

Calculation of "Bakery's Profit/ Loss"

	Amount (₹)
Sales of Cakes (970 Cakes × ₹18)	17,460.00
Less: Variable Production Cost (970 Cakes × ₹14)	13,580.00
Less: Penalty on Unsatisfied Demand [26 Cakes × Re. 1]	26.00
Less: Penalty on Unsold Cake [0 Cakes × ₹3]	0.00
Profit / (Loss)	3,854.00

In this situation, the estimated profit of the bakery will be increased by ₹114 (₹3,854 – ₹3,740).

The estimated profit is increased due to avoiding unnecessary variable production cost as well as penalty on unsold stock. Further, Production of 97 cakes match with minimum demand on a day.

Problem-12

A cake vendor buys pieces of cake every morning at ₹4.50 each by placing his order one day in advance and sale them at ₹7.00each. Unsold cake can be sold next day at ₹ 2.00 per piece and there after it should be treated as no value. The pattern for demand of cake is given below:

Fresh Cake:

Daily Sale	*100*	*101*	*102*	*103*	*104*	*105*	*106*	*107*	*108*	*109*	*110*
Probability	*.01*	*.03*	*.04*	*.07*	*.09*	*.11*	*.15*	*.21*	*.18*	*.09*	*.02*

One day old cake:

Daily Sale	*0*	*1*	*2*	*3*
Probability	*.70*	*.20*	*.08*	*.02*

Use the following set of random numbers:

Fresh Cake	*37*	*73*	*14*	*17*	*24*	*35*	*29*	*37*	*33*	*68*
One day old cake	*17*	*28*	*69*	*38*	*50*	*57*	*82*	*44*	*89*	*60*

The vendor adopts the following rule.

If there is no stock of cake with him at the end of previous day, he orders for 110pieces otherwise he orders 100 or 105 pieces whichever is nearest actual fresh cake sale on the previous day.

Required

Starting with zero stock and a pending order of 105 pieces, simulate for 10 days and calculate vendor's profit.

Solution

Random No. Coding for Fresh Cake

No. of Cakes	Probability	Cumulative Probability	Random Numbers
100	0.01	0.01	00 – 00
101	0.03	0.04	01 – 03
102	0.04	0.08	04 – 07
103	0.07	0.15	08 – 14
104	0.09	0.24	15 – 23
105	0.11	0.35	24 – 34
106	0.15	0.50	35 – 49
107	0.21	0.71	50 – 70
108	0.18	0.89	71 - 88
109	0.09	0.98	89 - 97
110	0.02	1.00	98 - 99

Random No. Coding for One Day Old Cake

No. of Cakes	Probability	Cumulative Probability	Random Numbers
0	0.70	0.70	00 – 69
1	0.20	0.90	70 – 89
2	0.08	0.98	90 – 97
3	0.02	1.00	98 – 99

Let us simulate the sale of fresh and one day old cakes for the next ten days using the given random numbers / information.

Simulation Sheet

Day	R. No. of Fresh Cake	Fresh Stock	Demand	Sales Pcs.	Cl. Stock	Order Initiated	One Day Old Stock	R.N. of Old Cake	Sale of Old Cake Pcs.	Loss Pcs.
1	37	105	106	105	0	110	0	17	--	--
2	73	110	108	108	2	105	0	28	--	--

3	14	105	103	103	2	105	2	69	0	2
4	17	105	104	104	1	105	2	38	0	2
5	24	105	105	105	0	110	1	50	0	1
6	35	110	106	106	4	105	0	57	--	--
7	29	105	105	105	0	110	4	82	1	3
8	37	110	106	106	4	105	0	44	--	--
9	33	105	105	105	0	110	4	89	1	3
10	68	110	107	107	3	105	0	60	--	--
				1,054					2	11

Calculation of Vendor's Profit

	Amount (₹)
Sales of Fresh Cakes (1,054 Pcs. × ₹7)	7,378.00
Sale of One Day Old Cake (2 Pcs. × ₹2)	4.00
Total Sales Revenue	7,382.00
*Less:*Cost of Cakes Sold [₹4.50 × (1,054 + 2) Pcs.]	4,752.00
Less: Cost of Spoilt Cakes [₹4.50 × (11 + 3*) Pcs.]	63.00
Profit	2,567.00

☞

* It is assumed that 3 Cakes of Closing Stock is **not** saleable.

Problem-13

A cake vendor buys pieces of cake every morning at ₹4.50 each by placing his order one day in advance **(at the time of receiving his previous order)** and sale them at ₹ 7.00 each. Unsold cake can be sold next day at ₹2.00 per piece and there after it should be treated as no value. The pattern for demand of cake is given below:

Fresh Cake:

Daily Sale	100	101	102	103	104	105	106	107	108	109	110
Probability	.01	.03	.04	.07	.09	.11	.15	.21	.18	.09	.02

One day old cake:

Daily Sale	0	1	2	3
Probability	.70	.20	.08	.02

Use the following set of random numbers:

Fresh Cake	37	73	14	17	24	35	29	37	33	68
One day old cake	17	28	69	38	50	57	82	44	89	60

The vendor adopts the following rule.

If there is no stock of cake with him at the end of previous day, he orders for 110pieces otherwise he orders 100 or 105 pieces whichever is nearest actual fresh cake sale on the previous day.

Required

Starting with zero stock and a pending order of 105 pieces, simulate for 10 days and calculate vendor's profit.

Solution

Random No- Coding for Fresh Cake

No. of Cakes	Probability	Cumulative Probability	Random Numbers
100	0.01	0.01	00 – 00
101	0.03	0.04	01 – 03
102	0.04	0.08	04 – 07
103	0.07	0.15	08 – 14
104	0.09	0.24	15 – 23
105	0.11	0.35	24 – 34
106	0.15	0.50	35 – 49
107	0.21	0.71	50 – 70
108	0.18	0.89	71 – 88
109	0.09	0.98	89 – 97
110	0.02	1.00	98 – 99

Random No. Coding for One Day Old Cake

No. of Cakes	Probability	Cumulative Probability	Random Numbers
0	0.70	0.70	00 – 69

1	0.20	0.90	70 – 89
2	0.08	0.98	90 – 97
3	0.02	1.00	98 – 99

Let us simulate the sale of fresh and one day old cakes for the next ten days using the given random numbers / information.

Simulation Sheet

Day	R. No. of Fresh Cake	Fresh Stock	Demand	Sales Pcs.	Cl. Stock	Order Initiated	One Day Old Stock	R.N. of Old Cake	Sale of Old Cake Pcs.	Loss Pcs.
1	37	105	106	105	0	110	0	17	0	0
2	73	110	108	108	2	110	0	28	0	0
3	14	110	103	103	7	105	2	69	0	2
4	17	105	104	104	1	105	7	38	0	7
5	24	105	105	105	0	105	1	50	0	1
6	35	105	106	105	0	110	0	57	0	0
7	29	110	105	105	5	110	0	82	0*	0
8	37	110	106	106	4	105	5	44	0	5
9	33	105	105	105	0	105	4	89	1	3
10	68	105	107	105	0	110	0	60	0	0
				1051					1	18

Calculation of Vendor's Profit

	Amount (₹)
Sales of Fresh Cakes (1,051 Pcs. × ₹7)	7,357.00
Sale of One Day Old Cake (1 Pcs. × ₹2)	2.00
Total Sales Revenue	7,359.00
Less: Cost of Cakes Sold [₹4.50 × (1,051 + 1) Pcs.]	4,734.00
Less: Cost of Spoilt Cakes [₹4.50 × 18 Pcs.]	81.00
Profit	2,544.00

☞

Order for **Day 2's Sale** - Vendor will initiate order in day one's morning i.e. one day in advance ***at the time of receiving previous order.***

Vendor follows - *If there is no stock of cake with him at the end of previous day, he orders for 110 pieces otherwise he orders 100 or 105 pieces whichever is nearest actual fresh cake sale on the previous day.*

Accordingly to initiate order in day one's morning vendor has to consider previous day's stock i.e. Day 0's stock. But, there is no stock at the end of Day 0 or beginning of Day 1 (given in the problem). Accordingly Vendor will initiate order of 110 pieces in day 1's morning for day 2's sales.

(*)

On 7th Day Demand for 'One Day Old' cake is one piece (as per random no. 82). But there was nil stock at the end of the 6th Day. Accordingly, sale of one Day old cake is nil.

Book Store's Problem

Problem-14

A book store wishes to carry systems analysis and design in stock. Demand is probabilistic and replenishment of stock takes 2 days (i.e. if an order is placed in March 1, it will be delivered at the end of the day on March 3). The probabilities of demand are given below:

Demand (Daily)	*0*	*1*	*2*	*3*	*4*
Probability	*0.05*	*0.10*	*0.30*	*0.45*	*0.10*

Each time an order is placed, the store incurs an ordering cost of ₹ 10 per order. The store also incurs a carrying cost of ₹ 0.50 per book per day. The inventory carrying cost is calculated on the basis of stock at the end of each day. The manager of the book-store wishes to compare two options for his inventory decision:

A. *Order 5 books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books.*

B. *Order 8 books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books.*

Currently (beginning of the 1st day) the store has stock of 8 books plus 6 books ordered 2 days ago and expected to arrive next day.

Required

Using Monte-Carlo simulation for 10 cycles, recommend which option the manager should choose?

The two digits random numbers are given below:

89 34 78 63 61 81 39 16 13 73

Solution

First of all, random numbers 00-99 are allocated in proportion to the probabilities associated with demand as given below:

Demand	Probability	Cumulative Probability	Random Nos.
0	0.05	0.05	00 – 04
1	0.10	0.15	05 – 14
2	0.30	0.45	15 – 44
3	0.45	0.90	45 – 89
4	0.10	1.00	90 – 99

Based on the ten random numbers given, we simulate the demand per day in the table given below:

It is given that stock in hand is 8 units and stock on order is 6 units (expected to receive on next day).

Let us now consider both the options stated in the Problem.

Option-A

Order 5 Books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books:

Day	Random No.	Sales Demand	Op. Stock (in hand)	Qty. Order	Qty. Recd. at End of the Day	Total Qty. on Order	Closing Stock
1	89	3	8	---	---	6	5
2	34	2	5	---	6	---	9
3	78	3	9	---	---	---	6
4	63	3	6	5	---	5	3
5	61	3	3	---	---	5	0
6	81	3	0	---	5	---	5

7	39	2					
8	16	2					
9	13	1					
10	73	3					

Now on day 6, there is stock out position since 5 units will be received at the end of the day and demand occurring during the day cannot be met. Hence, it will not be possible to proceed further and we will have to leave the answer at this stage.

Option-B

Order 8 Books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books:

Day	Random No.	Sales Demand	Op. Stock (in hand)	Qty. Order	Qty. Recd. at End of the Day	Total Qty. on Order	Closing Stock
1	89	3	8	---	---	6	5
2	34	2	5	---	6	---	9
3	78	3	9	---	---	---	6
4	63	3	6	8	---	8	3
5	61	3	3	---	---	8	0
6	81	3	0	---	8	---	8
7	39	2					
8	16	2					
9	13	1					
10	73	3					

Now on day 6, there is stock out position since 8 units will be received at the end of the day and demand occurring during the day cannot be met. Hence, it is not possible to proceed further and we may leave the answer at this stage.

Alternatively

If we assume that the demand occurring during the day can be met out of stock received at the end of the day, the solution will be as follows:

Option-A

Order 5 books when the inventory at the beginning of the day plus orders outstanding is less than 8 books:

Day	Random No.	Sales Demand	Op. Stock (in hand)	Qty. Order	Qty. Recd. at End of the Day	Total Qty. on Order	Closing Stock
1	89	3	8	---	---	6	5
2	34	2	5	---	6	---	9
3	78	3	9	---	---	---	6
4	63	3	6	5	---	5	3
5	61	3	3	---	---	5	0
6	81	3	0	5	5	5	2
7	39	2	2	5	---	10	0
8	16	2	0	---	5	5	3
9	13	1	3	---	5	---	7
10	73	3	7	5	---	5	4

Carrying Cost = ₹19.50 (39 Books × ₹0.50)

Ordering Cost = ₹40.00 (4 Orders × ₹10)

Total Cost = ₹59.50 (₹19.50 + ₹40.00)

Option-B

Order 8 Books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books:

Day	Random No.	Sales Demand	Op. Stock (in hand)	Qty. Order	Qty. Recd. at End of the Day	Total Qty. on Order	Closing Stock
1	89	3	8	---	---	6	5
2	34	2	5	---	6	---	9
3	78	3	9	---	---	---	6
4	63	3	6	8	---	8	3
5	61	3	3	---	---	8	0
6	81	3	0	---	8	---	5
7	39	2	5	8	---	8	3
8	16	2	3	---	---	8	1
9	13	1	1	---	8	---	8
10	73	3	8	---	---	---	5

Carrying Cost	=	₹22.50 (45 Books × ₹0.50)
Ordering Cost	=	₹20.00 (2 Orders × ₹10)
Total Cost	=	₹42.50 (₹22.50 + ₹20.00)

Since Option B has *lower cost*, Manager should order 8 books.

Simulation for Defectives

Problem-15

A company manufactures a component which requires a high degree of precision. Each unit of the component is therefore subjected to a strict quality control test to ascertain whether there is any defect in it. The defects are classified into three categories viz. A, B and C. if defect A occurs in the output, it is scrapped. If defect B or C occurs in the output, it is reworked to rectify the defect. The machine time required to rework defect B component is 30 minutes and that for defect C is 45 minutes. The probabilities are as under:

	Defect A	***Defect B***	***Defect C***
Defect occurring	*0.15*	*0.20*	*0.10*
Defect not occurring	*0.85*	*0.80*	*0.90*

Required

Using the following random numbers, simulate a study of 10 items of output and determine the number of items with no defects, number of items scrapped due to occurrence of defect A and the total machine time required for rework due to occurrence of defect B or C :

Random number for defect A:

48 55 91 40 93 01 83 63 47 52

Random number of defect B:

47 36 57 04 79 55 10 13 57 09

Random number for defect C:

82 95 18 96 20 84 56 11 52 03

Solution

Random Number (R.N.) Allocation

Defect A		Defect B		Defect C	
Defect Exist or Not	**R. No. Allocation**	**Defect Exist**	**R. No. Allocation**	**Defect Exist**	**R. No. Allocation**
Yes	00 – 14	Yes	00 – 19	Yes	00 – 09
No.	15 – 99	No	20 – 99	No	10 – 99

Simulation Table

Item No.	Defect A	Defect B	Defect C	Whether Defect Exists?	Items Scrapped	Rework (minutes)
1	48	47	82	No	---	---
2	55	36	95	No	---	---
3	91	57	18	No	---	---
4	40	04	96	B	---	30
5	93	79	20	No	---	---
6	01	55	84	A	1	---
7	83	10	56	B	---	30
8	63	13	11	B	---	30
9	47	57	52	No	---	---
10	52	09	03	B & C	---	75
					Total	165

- No Defect exists in 5 items.
- Defect A exist in 1 item (item no.6), so it is scrapped.
- Defect B exists in 4 items and
- Defect C exists in 1 item, so they require rework.
- Rectification time required on reworking is 165 minutes.

Evaluation of Investment Projects

Problem-16

An Investment Corporation wants to study the investment projects based on four factors: market demand in units, contribution per unit, advertising cost and the investment required. These factors are felt to be independent of each other. In analyzing a new consumer product, the corporation estimates the following probability distributions:

Demand (units)		Contribution per unit		Advertising Cost	
No.	Probability	₹	Probability	₹	Probability
10,000	0.20	25	0.25	50,000	0.22
20,000	0.25	35	0.30	60,000	0.33
30,000	0.30	45	0.35	70,000	0.44
40,000	0.25	55	0.10	80,000	0.01

The data for proposed investments are as follows:

Investment (₹)	50,00,000	55,00,000	60,00,000	65,00,000
Probability	0.10	0.30	0.45	0.15

Required

Using simulation process, repeat the trials 5 times, compute the Return on Investment (ROI) for each trial and find the highest likely return.

Using the sequence (First 4 random numbers for the first trial, etc)

09 24 85 07 84 38 16 48 41 73 54 57 92 07 99 64
65 04 78 72

Solution

Allocation of Random Numbers

Demand (units)

Units	Probability	Cumulative Probability	Random Nos.
10,000	0.20	0.20	00 – 19
20,000	0.25	0.45	20 – 44
30,000	0.30	0.75	45 – 74
40,000	0.25	1.00	75 – 99

Contribution *per unit*

₹	Probability	Cumulative Probability	Random Nos.
25	0.25	0.25	00 – 24
35	0.30	0.55	25 – 54
45	0.35	0.90	55 – 89
55	0.10	1.00	90 – 99

Advertising Cost

₹	Probability	Cumulative Probability	Random Nos.
50,000	0.22	0.22	00 – 21
60,000	0.33	0.55	22 – 54
70,000	0.44	0.99	55 – 98
80,000	0.01	1.00	99 – 99

Investment

₹	Probability	Cumulative Probability	Random Nos.
50,00,000	0.10	0.10	00 – 09
55,00,000	0.30	0.40	10 – 39
60,00,000	0.45	0.85	40 – 84
65,00,000	0.15	1.00	85 – 99

Simulation Table

Random Number	Demand Units	Contribution Per unit (₹)	Adv. Cost (₹)	Return (₹)	Investment (₹)	Return on Investment
09, 24, 85, 07	10,000	25	70,000	1,80,000	50,00,000	3.60%
84, 38, 16, 48	40,000	35	50,000	13,50,000	60,00,000	22.50%
41, 73, 54, 57	20,000	45	60,000	8,40,000	60,00,000	14.00%
92, 07, 99, 64	40,000	25	80,000	9,20,000	60,00,000	15.33%
65, 04, 78, 72	30,000	25	70,000	6,80,000	60,00,000	11.33%

Highest Likely Return is 22.50% relating to trial 2.

Application of Simulation Technique in Project Management

Problem-17

The following table gives the activities in a construction project and the time durations with associated probability of each activity:

Activity	Predecessors	Time (in Days)	Probability
A	---	6	0.50
		8	0.50
B	---	4	0.30
		5	0.20
		6	0.50
C	A	8	0.50
		16	0.50
D	A, B	8	0.30
		10	0.70
E	C, D	2	0.20
		4	0.80

To simulate the project, use the following random numbers taking the first five random numbers digits (representing the five activities) for each trial and so on:

11, 16, 23, 72, 94; 83, 83, 02, 97, 99; 83, 10, 93, 4, 33; 53, 49, 94, 37, 7

Required

Determine the 'Critical Path' and the 'Project Duration' for each trial.

Solution

Random Numbers Allocation for *each activity*

Activity	Time (in Days)	Probability	Cumulative Probability	Allocated Random Number
A	6	0.50	0.50	00-49
	8	0.50	1.00	50-99
B	4	0.30	0.30	00-29
	5	0.20	0.50	30-49
	6	0.50	1.00	50-99
C	8	0.50	0.50	00-49
	16	0.50	1.00	50-99
D	8	0.30	0.30	00-29
	10	0.70	1.00	30-99
E	2	0.20	0.20	00-19
	4	0.80	1.00	20-99

Simulation Table

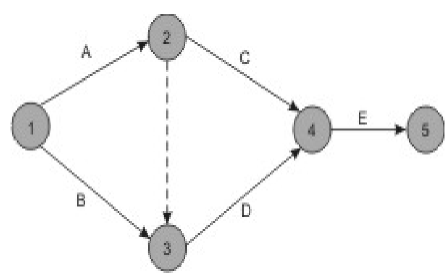
Trial	A		B		C		D		E	
	R. No.	Time	R. No.	Time	R. No.	Time	R. No.	Time	R. No.	Time
1	11	6	16	4	23	8	72	10	94	4
2	83	8	83	6	02	8	97	10	99	4
3	83	8	10	4	93	16	4	8	33	4
4	53	8	49	5	94	16	37	10	7	2

Determination of "Critical Path and Project Duration for *each trial*"

Trial	Project Duration			Critical Path
	1–2–4–5 (A–C–E)	**1–2–3–4–5 (A–D–E)**	**1–3–4–5 (B–D–E)**	
1	18 (6 + 8 + 4)	**20** (6 + 10 + 4)	18 (4 + 10 + 4)	1–2–3–4–5 (A–D–E)
2	20 (8 + 8 + 4)	**22** (8 + 10 + 4)	20 (6 + 10 + 4)	1–2–3–4–5 (A–D–E)
3	**28** (8 + 16 + 4)	20 (8 + 8 + 4)	16 (4 + 8 + 4)	1–2–4–5 (A–C–E)
4	**26** (8 + 16 + 2)	20 (8 + 10 + 2)	17 (5 + 10 + 2)	1–2–4–5 (A–C–E)

Working Note

The Network for the given problem:



16 Learning Curve Theory

Basic Concepts

Learning Curve	Learning curve is a geometrical progression, which reveals that there is steadily decreasing cost for the accomplishment of a given repetitive operation, as the identical operation is increasingly repeated. The amount of decrease will be less and less with each successive unit produced. The slope of the decision curve is expressed as a percentage. The other names given to learning curve are Experience Curve, Improvement Curve and Progress Curve.
Learning Curve Equation	Mathematicians have been able to express relationship in equations. The basic equation is $y = ax^b$ Where y = Average time per unit for x units a = Time required for first unit x = Cumulative number of units produced b = Learning coefficient
Logarithms Formulas	$\log_a (p \times q) = \log_a p + \log_a q$ $\log_a (p / q) = \log_a p - \log_a q$ $\log_a (p^n) = n \log_a p$ $\log_a 1 = 0$ $\log_a 10 = 1$ $\log_a 100 = 2$
The Learning Curve Ratio	In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summaries in the learning ratio or improvement ratio $\frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}$

SECTION - A

Learning Curve Theory

Question-1

Explain the learning curve ratio.

Answer

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. As the quantity produced doubles, the absolute amount of cost increase will be successively smaller but the rate of decrease will remain fixed.

In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summarized in the learning curve ratio or improvement ratio.

$$\text{Learning curve ratio} = \frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}$$

For example, if the average labour cost for the first 500 units is ₹25 and the average labour cost for the first 1,000 units is ₹20, the learning curve ratio is (₹20/25) or 80%. Since the average cost per unit of 1,000 units is ₹20, the average cost per unit of first 2,000 units is likely to be 80% of ₹20 or ₹16.

Question-2

Explain distinctive features of learning curve theory in manufacturing environment.

Answer

The production quantity of a given item doubled the cost of that item decrease at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. The distinctive features of a learning curve are:

(i) Better tooling methods are developed and used.

(ii) More productive equipments are designed and used to make the product.

(iii) Design bugs are detected and corrected.

(iv) Better design engineering reduces material and labour costs.

(v) Early teething problems are overcome. As production progresses management is prompted to achieve better planning and better management.

(vi) Rejections and rework tend to diminish over time.

Question-3

Bring out the main applications of Learning Curve.

Answer

Knowledge of learning curve can be useful both in planning and control. Standard cost for new operations should be revised frequently to reflect the anticipated learning pattern. The main applications are summarised below:

- **Helps to analyse CVP relationship during familiarisation phase:** Learning curve is useful to analyse cost-volume-profit relationship during familiarisation phase of product or process and thus it is very useful for cost estimates. Learning curve can be used as a tool for forecasting.
- **Helps in budgeting and profit planning:** Budget manager should select those costs which reflect learning effect and then he should be able to incorporate this effect in process of developing budgets or in the exercises relating to project planning.
- **Helps in pricing:** The use of cost data adjusted for learning effect helps in development of advantageous pricing policy.
- **Design makers:** It helps design engineers in making decisions based upon expected (predictable from past experience) rates of improvement.
- **Helps in negotiations:** It is very useful to Government in negotiations about the contracts.
- **Helps in setting standards:** The learning curve is quite helpful in setting standards in learning phase.

Question-4

What are the limitations of the learning curve theory?

Answer

(i) All activities of a firm are not subject to learning effect. (Activities that have not been performed in the present operational mode, those performed by new or unfamiliar employees are subjected to learning effect, while those performed by familiar or experienced workmen will not be subjected to learning effect)

(ii) It is correct that learning effect does take place and average time taken is likely to reduce. But in practice it is highly unlikely that there will be a regular consistent rate of decrease. Therefore any cost prediction based on conventional learning curves should be viewed with caution.

(iii) Considerable difficulty arises in obtaining valid data that will form basis for computation of learning effect.

(iv) Even slight change in circumstances quickly renders the learning curve obsolete. While the regularity of conventional learning curves can be questioned, it would be wrong to ignore learning effect altogether in predicting costs for decision purposes.

SECTION - B

Learning Curve - Estimating Labour Time

Problem-1

A company which has developed a new machine has observed that the time taken to manufacture the first machine is 600 hours.

Required

Calculate the time which the company will take to manufacture the second machine if the actual learning curve rate is (i) 80% and (ii) 90%. Explain which of the two learning rates will show faster learning.

Solution

(i) Actual learning curve rate is 80%

Time taken to produce the first machine	=	600 hours
Average time taken to produce two machines	=	600 × 80% hours
	=	480 hours.
Cumulative time taken to produce two machines	=	480 × 2 hours
	=	960 hours
Time taken to produce the second machine	=	(960 – 600) hours
	=	360 hours

(ii) Actual learning curve rate is 90%

Time taken to produce the first machine	=	600 hours
Average time taken to produce two machines	=	600 × 90% hours
	=	540 hours
Cumulative time taken to produce two machines	=	540 × 2 hours
	=	1,080 hours
Time taken to produce the second machine	=	(1,080 – 600) hours
	=	480 hours

The time taken to produce the second machine is lower at 80% learning rate and hence 80% learning rate shows faster learning rate.

Learning Curve - Estimating Labour Time

(Application of Logarithms Formulas)

Problem-2

The chief officer at manufacturing plant of Boeing 777-200LR aircraft *observed that workers performing manufacturing operations at the plant showed signs of a definite learning pattern. He noted that most aircraft manufacturing tasks experienced what he called an 80 percent learning rate, meaning that workers need 20 percent fewer hours to make a part each time their cumulative experience making that part doubled. Thus, if the first part took 100 minutes, the second would require 80 minutes, the fourth would require 64 minutes, and so on.*

Required

Calculate the time required for parts 41 to 60. [Note: learning coefficient is -0.322 for learning rate of 80%, log2=0.30103, log3=0.47712, log5=0.69897, Antilog of 1.484 =30.48, Antilog of 1.4274 =26.75]

Solution

The usual learning curve model is

$$y = ax^b$$

Where

y = Average time per part for x parts

a = Time required for first part (100 minutes)

x = Cumulative number of parts

b = Learning coefficient and is equal to –0.322 (learning rate 80%)

Calculation of total time for 40 parts:

$$y = 100 \times (40)^{-0.322}$$

$$\log y = \log 100 - 0.322 \times \log 40$$

$$\log y = \log 100 - 0.322 \times [3 \times \log 2 + \log 5]$$

$$\log y = 2 - 0.322 \times [3 \times 0.30103 + 0.69897]$$

$$\log y = 1.484$$

$$y = \text{antilog of } 1.484$$

$$y = 30.48 \text{ minutes}$$

Total time for 40 Parts = 40 Parts × 30.48 minutes

= 1,219 minutes (A)

Calculation of total time for 60 parts:

$$y = 100 \times (60)^{-0.322}$$

$$\log y = \log100 - 0.322 \times \log60$$

$$\log y = \log100 - 0.322 \times [2 \times \log2 + \log5 + \log3]$$

$$\log y = 2 - 0.322 \times [2 \times 0.30103 + 0.69897 + 0.47712]$$

$$\log y = 1.4274$$

$$y = \text{antilog of } 1.4274$$

$$y = 26.75 \text{ minutes}$$

Total Time for 60 Parts = 60 Parts × 26.75 minutes

= 1,605 minutes (B)

Calculation of total time for 41 to 60 parts (B) – (A):

= 1,605 minutes –1,219 minutes

= 386 minutes

Learning Curve – Steady State

Problem-3

AUD International Co. is a multiproduct firm. It is planning to launch a new product 'X-500' in coming months. Production will be in batches of 1,000 units throughout the life of the product. It is also possible to achieve 90% learning rate but the learning would cease after 64th batch. Other relevant data of product 'X-500' is as follows:

Expected Life	*2,56,000 units*
Selling Price per unit	*₹123*
Direct Material per unit	*₹36*
Direct Labour Cost first batch	*₹52,500*
Other Variable Costs	*₹24*
Specific Fixed Cost	*₹38,75,000*

Required

(i) Calculate the 'Expected Profit' to be earned from the product over its lifetime.

Note: The learning index for a 90% learning curve is -0.152; $(64)^{-0.152} = 0.5314$; $(63)^{-0.152} = 0.5327$

(ii) It is now thought that a learning effect will continue for all of the 256 batches that will be produced. Calculate the 'Rate of Learning' required to achieve a lifetime product profit of ₹1,00,00,000, assuming that a constant rate of learning applies throughout the product's life.

Solution

(i) Total Direct Labour Cost for **first 64 batches** based on learning curve of 90% (when the direct labour cost for the first batch is ₹52,500)

The usual learning curve model is

$$y = ax^b$$

Where

y = Average Direct Labour Cost *per batch* for x batches

a = Direct Labour Cost for *first batch*

x = Cumulative No. of batches produced

b = Learning Coefficient /Index

y = ₹52,500 × (64) $^{-0.152}$

= ₹52,500 × 0.5314

= ₹27,898.50

Total Direct Labour Cost for first 64 batches

= 64 batches × ₹27,898.50

= ₹17,85,504

Total Direct Labour Cost for **first 63 batches** based on learning curve of 90% (when the direct labour cost for the first batch is ₹52,500)

y = ₹52,500 × (63) $^{-0.152}$

= ₹52,500 × 0.5327

= ₹27,966.75

Total Direct Labour Cost for first 63 batches

= 63 batches × ₹27,966.75

= ₹17,61,905

Direct Labour Cost for **64th batch** = ₹17,85,504 - ₹17,61,905

= ₹23,599

Total Labour Cost over the Product's Life

= ₹17,85,504 + (192 batches × ₹23,599)

= ₹63,16,512

Statement Showing "Life Time Expected Profit"

Particulars	Amount (₹)
Sales (₹123 × 2,56,000 units)	3,14,88,000
Less: Direct Material (₹36 × 2,56,000 units)	92,16,000
Less: Direct Labour	63,16,512
Less: Other Variable Cost (₹24 × 2,56,000 units)	61,44,000
Less: Specific Fixed Cost	38,75,000
Profit	59,36,488

(ii) In order to achieve a Profit of ₹1,00,00,000 the Total Direct Labour Cost over the Product's Lifetime would have to equal ₹22,53,000.

Statement Showing "Life Time Direct Labour Cost"

Particulars	Amount (₹)
Sales (₹123 × 2,56,000 units)	3,14,88,000
Less: Direct Material (₹36 × 2,56,000 units)	92,16,000
Less: Other Variable Cost (₹24 × 2,56,000 units)	61,44,000
Less: Specific Fixed Cost	38,75,000
Less: Profit	1,00,00,000
Direct Labour	22,53,000

Average Direct Labour Cost *per batch* for 256 batches is ₹8,800.78 (₹22,53,000 / 256 batches).

Total Direct Labour Cost for **256 batches** based on learning curve of r% (when the direct labour cost for the first batch is ₹52,500)

$$y = ₹52{,}500 \times (256)^{b}$$

$$₹8{,}800.78 = ₹52{,}500 \times (256)^{b}$$

$$0.1676 = (256)^{b}$$

$$\log 0.1676 = b \times \log 2^{8}$$

$$\log 0.1676 = b \times 8 \log 2$$

$$\log 0.1676 = \left(\frac{\log r}{\log 2}\right) \times 8 \log 2$$

$$\log 0.1676 = \log r^{8}$$

$$0.1676 = r^{8}$$

$$r = \sqrt[8]{0.1676}$$

$$r = 80\%$$

Learning Curve – Sensitivity Analysis

Problem-4

B-Parts Inc., USA based firm, has just invented a new part 'B-20'. New part has a budgeted total profit of ₹75,000 from the first 256parts. The time taken to produce the first part was 112.50 hours. The labour rate is ₹20 per hour. A 90% learning curve is expected to apply indefinitely.

Required

Calculate the sensitivity of the budgeted total profit from the first 256 parts to changes in the learning rate.

Solution

Cumulative Average Time for 256 parts	=	48.43 hrs.*
		[112.50 × (0.90^8)]
Total Time for 256 parts	=	12,398.08 hrs.
		[48.43 hrs.× 256 parts]
Total Labour Cost of 256 parts	=	₹ 2,47,961.60
		[12,398.08 hrs.× ₹ 20]
Revised Labour Cost for *zero profit*	=	₹ 3,22,961.60
		[₹ 2,47,961.60 + ₹ 75,000]
Total Time for 256 parts (Revised)	=	16,148.08 hrs.
		[₹ 3,22,961.60/₹ 20]
Cumulative Average Time for 256 parts (Rev.)	=	63.08 hrs.
		[16,148.08/256]

The usual learning curve model is

$$y = ax^b$$

Where

y = Cumulative Average Time per part for x parts

a = Time required for first part

x = Cumulative number of parts

b = Learning coefficient (log r/log 2)

Accordingly

$\Rightarrow$ $63.08 = 112.50 \times (256)^b$

$\Rightarrow$ $0.5607 = 2^{8b}$

$\Rightarrow$ $\log 0.5607 = \log 2^{8b}$

$\Rightarrow$ $\log 0.5607 = 8 \times b \times \log 2$

$\Rightarrow$ $\log 0.5607 = 8 \times \frac{\log r}{\log 2} \times \log 2$

$\Rightarrow$ $\log 0.5607 = 8 \log r$

$\Rightarrow$ $\log 0.5607 = \log r^8$

$\Rightarrow$ $0.5607 = r^8$

$\Rightarrow$ $r = \sqrt[8]{0.5607}$

$\Rightarrow$ $r = 0.9302$

Learning Rate (r) = 93.02%.

Therefore

Sensitivity = 3.02/90

= 3.36%

☞

Students may also take 48.38 hrs. (112.50 × 0.43)

Problem-5

XL India Ltd. has just invented a new part 'XL-85'. New part has a budgeted total profit of ₹ 93,750 from the first 256parts. The time taken to produce the first part was 112.50 hours. The labour rate is ₹25 per hour. A 90% learning curve is expected to apply indefinitely.

Required

Calculate the sensitivity of the budgeted total profit from the first 256 parts to changes in the learning rate.

Note: The learning index for a 90% learning curve is -0.152

✍ **Solution**

Cumulative Average Time for 256 parts = 48.43 hrs.*

[$112.50 \times (0.90^8)$]

Total Time for 256 parts = 12,398.08 hrs.

[48.43 hrs.× 256 parts]

Total Labour Cost of 256 parts = ₹3,09,952.00

[12,398.08 hrs. × ₹25]

Revised Labour Cost for *zero profit* = ₹4,03,702.00
[₹3,09,952.00 + ₹93,750]

Total Time for 256 parts (Revised) = 16,148.08 hrs.
[₹4,03,702.00/ ₹25]

Cumulative Average Time for 256 parts (Rev.) = 63.08 hrs.
[16,148.08/256]

The usual learning curve model is

$$y = ax^b$$

Where

y = Cumulative Average Time per part for x parts

a = Time required for first part

x = Cumulative number of parts

b = Learning coefficient (log r/log 2)

Accordingly

$\Rightarrow$ $63.08 = 112.50\times (256)^{b}$

$\Rightarrow$ $0.5607 = 2^{8b}$

$\Rightarrow$ $\log 0.5607 = \log 2^{8b}$

$\Rightarrow$ $\log 0.5607 = 8 \times b \times \log 2$

$\Rightarrow$ $\log 0.5607 = 8 \times \frac{\log r}{\log 2} \times \log 2$

$\Rightarrow$ $\log 0.5607 = 8 \log r$

$\Rightarrow$ $\log 0.5607 = \log r^8$

$\Rightarrow$ $0.5607 = r^8$

$\Rightarrow$ $r = \sqrt[8]{0.5607}$

$\Rightarrow$ $r = 0.9302$

Learning Rate (r) = 93.02%.

Therefore

Sensitivity = 3.02/90
= 3.36%

☞

Students may also take 48.38 hrs. (112.50 $\times$ 0.43)

Application of Learning Curve in Marginal Costing

Problem-6

The Gifts Company makes mementos for offering chief guests and other dignitaries at functions. A customer wants 4 identical pieces of hand-crafted gifts for 4 dignitaries invited to its function.

For this product, the Gifts Company estimates the following costs for the 1st unit of the product.

Particulars of Costs	*₹ / unit*
Direct Variable Costs (excluding labour)	*2,000*
Direct Labour (20 hours @ ₹ 50 hour)	*1,000*

90 % learning curve ratio is applicable and one labourer works for one customer's order.

Required

(i) What is the price per piece to be quoted for this customer if the targeted contribution is ₹ 1,500 per unit?

(ii) If 4 different labourers made the 4 products simultaneously to ensure faster delivery to the customer, can the price at (i) above be quoted? Why?

Solution

(i)

	₹ / u **Avg. / unit (4 units)**
Variable Cost	2,000
Labour	810
Target Contribution	1,500
Price to be Quoted	4,310

(ii) No, the company cannot quote this price for varying products because the learning curve Ratio does not apply to non-repeated jobs. Each product will carry a different price according to its direct labour hours.

Problem-7

M Ltd. Manufactures a special product purely carried out by manual labour. It has a capacity of 20,000 units. It estimates the following cost structure:

Direct Material	*30 ₹/ unit*
Direct Labour (1 hour / unit)	*20 ₹/ unit*
Variable Overhead	*10 ₹/ unit*

Fixed Overheads at maximum capacity is ₹ 1,50,000.

It is estimated that at the current level of efficiency, each unit requires one hour for the first 5,000 units. Subsequently it is possible to achieve 80% learning rate. The market can absorb the first 5,000 units at ₹ 100 per unit.

Required

What should be the minimum selling price acceptable for an order of 15,000 units for a prospective client?

Solution

Working Note-1

	5,000 units	**20,000 units**
Material	1,50,000	6,00,000
Direct Labour	1,00,000	2,56,000 (Refer to W.N.II)
Variable Overhead	50,000	2,00,000
Total Variable Cost	3,00,000	10,56,000
Fixed Cost	1,50,000	1,50,000
Total Cost	4,50,000	12,06,000
Total Cost *per unit*	90.00	60.30
Sales (₹100 × 5,000 units)	5,00,000	5,00,000
(₹x × 15,000 units) [Assumed Selling Price 'x']	.	15,000x
Profit	50,000	15,000x – 7,06,000

Working Note-2

Units	**Hours**
5,000	5,000
10,000	8,000 hours (10,000 units × 1 hr × 0.80)
20,000	12,800 hours (20,000 units × 1 hr × 0.80 × 0.80)

Working Note-3

15,000x – 7,06,000	>	50,000
15,000x	>	7,56,000
Or x	>	50.40

Minimum Selling Price

Total Cost *per unit* at Capacity 20,000	=	₹ 60.30
Weighted Average Selling Price	>	₹ 60.30
$\frac{5{,}000\text{ units} \times ₹100 + 15{,}000\text{ units} \times ₹x}{20{,}000\text{ units}}$	>	60.30
15,000x	>	7,06,000
x	>	47.06..

Minimum Price *to cover*

Production Cost	=	₹ 47.06…

Minimum Price *to cover*

Same Amount of Profit	=	50.40

Verification

(–₹47.06… + ₹50.40) × 15,000 units	=	₹50,000

Problem-8

An electronics firm which has developed a new type of fire-alarm system has been asked to quote for a prospective contract. The customer requires separate price quotations for each of the following possible orders:

Order	*Number of fire-alarm systems*
First	*100*
Second	*60*
Third	*140*

The firm estimates the following cost per unit for the first order:

Direct Materials	*₹ 500*
Direct Labour	
Deptt. A (Highly automatic)	*20 hours at ₹ 10 per hour*
Deptt. B (Skilled labour)	*40 hours at ₹ 15 per hour*
Variable Overheads Absorbed	*20% of direct labour*

Fixed Overheads Absorbed

Deptt. A………………………………………………………………………………………₹ 8 per hour

Deptt. B……………………………………………………………………………………....₹ 5 per hour

Required

Determine a price per unit for each of the three orders, assuming the firm uses a mark up of 25% on total costs and allows for an 80% learning curve.

Extract from 80% learning curve table:

X ………………..	*1.0*	*1.3*	*1.4*	*1.5*	*1.6*	*1.7*	*1.8*	*1.9*	*2.0*
Y (%)……………	*100.0*	*91.7*	*89.5*	*87.6*	*86.1*	*84.4*	*83.0*	*81.5*	*80.0*

X represents the cumulative total volume produced to date expressed as a multiple of the initial order.

Y is the learning curve factor, for a given X value, expressed as a percentage of the cost of the initial order.

Solution

(i) Price per Unit for First 100 Units

	₹	₹
Direct Material		500
Direct Labour		
Deptt. A (20 hrs. @ 10)	200	
Deptt. B (40 hrs. @ 15)	600	800
Variable Overheads (20% of ₹800)		160
Fixed Overheads		
Deptt. A (20 hrs. @ 8)	160	
Deptt. B (40 hrs. @ 5)	200	360
Total Cost		1,820
Profit (25% of ₹1,820)		455
Selling Price		2,275

(ii) Price per Unit for Second Order of 60 Units

Workings:

Learning will be applicable only in Dept. B

Cumulative output becomes 100 units + 60 units	=	160 units
(1.6 times for which learning is 86.1% from the table)		
Total hours for 160 units	=	5,510.40 hrs (160 units × 40 hrs × 0.861)
Hours for 60 units	=	Hrs for 160 units – Hrs for 100 units
	=	5,510.40 – 4,000 hrs
	=	1,510.40 hrs
Hours *per unit*	=	1,510.40 hrs / 60 units
	=	25.17

Calculation of Selling Price *per unit*

	₹	₹
Direct Materials		500.00
Direct Labour		
Deptt. A (20.00 hrs @ 10)	200.00	
Deptt. B (25.17 hrs @ 15)	377.55	577.55
Variable Overheads (20% of ₹577.55)		115.51
Fixed Overheads		
Deptt. A (20.00 hrs @ 8)	160.00	
Deptt. B (25.17 hrs @ 5)	125.85	285.85
Total Cost		1,478.91
Profit (25% of ₹1,478.91)		369.73
Selling Price		1,848.64

(iii) Price per Unit for Third Order of 40 Units

Workings:

Cumulative Output becomes	=	200 units
(2 times for which Learning is 80% from the table)		
Total hours for 200 units	=	6,400 hrs (200 units × 40 hrs × 0.80)
Hours for 40 units	=	Hrs for 200 units– Hrs for 160 units
	=	6,400 – 5,510.40

	=	889.60 hrs.	
Hours per unit	=	889.60 hrs. / 40 units	
	=	22.24 hrs	

Calculation of Selling Price *per unit*

	₹	₹
Direct Material		500.00
Direct Labour		
Deptt. A (20.00 hrs @ 10)	200.00	
Deptt. B (22.24 hrs @ 15)	333.60	533.60
Variable Overheads (20% of ₹ 533.60)		106.72
Fixed Overheads		
Deptt. A (20.00 hrs @ 8)	160.00	
Deptt. B (22.24 hrs @ 5)	111.20	271.20
Total Cost		1,411.52
Profit (25% of ₹1,411.52)		352.88
Selling Price		1,764.40

Problem-9

A company has 10 direct workers, who work for 25 day a month of 8 hours per day. The estimated down time is 25% of the total available time. The company received on order for new product. The first unit of the new product required 40 direct labour hours to manufacture the product. The company expects 80% (index is – 0.322) learning curve for this type of work. The company uses standard absorption costing and the cost data on a under:

Direct Materials…………………………. ₹ 60 per unit

Direct Labour……………………………. ₹ 6 per direct labour hour

Variable Overheads……………………... ₹ 1 per direct labour hour

Fixed Overheads………………………… ₹ 7,500 per month

Required

(i) *Calculated the cost per unit of the first order of 30 units.*

(ii) *If the company receives a repeat order for 20 units, what price will be quoted to yield a profit of 25% on selling price?*

Solution

Working Notes

(1) **The usual learning curve model is**

$y = ax^b$

Where

y = Average time per unit for x units

a = Time required for first unit

x = Cumulative number of units produced

b = Learning coefficient and is equal to –0.322 (learning rate 80%)

(2) **Time required for 30 units order** (when the time required for the first unit is 40 hours)

$y = 40 \times (30)^{-0.322}$

$\log y = \log 40 - 0.322 \times \log 30$

$\log y = 1.6021 - 0.322 \times 1.4771$

$\log y = 1.1265$

y = antilog of 1.1265

y = 13.38 hours

Total time for 30 units = 30 units × 13.38 hours

= 401.40 hours

(3) **Time required for 50 units order** (when the time required for the first unit is 40 hours)

$y = 40 \times (50)^{-0.322}$

$\log y = \log 40 - 0.322 \times \log 50$

$\log y = 1.6021 - 0.322 \times 1.6990$

$\log y = 1.055$

y = antilog of 1.055

y = 11.35 hours

Total time for 50 units = 50 units × 11.35 hours

= 567.50 hours

(4) **Fixed overhead recovery rate per labour hour**

Total labour hours [10 men × 25 days × 8 hours]	2,000
Less: 25% downtime (hrs)	500
Total effective hours	1,500
Total fixed overheads per month (₹)	7,500
Fixed overhead recovery rate per labour hour (₹) [₹ 7,500 / 1,500 hours]	5

Computation of Requirements of Problem

(i) **Computation of cost per unit of the first order of 30 units**

	₹
Direct Material Cost (30 units × ₹60)	1,800.00
Direct Labour Cost (401.40 hours × ₹6)	2,408.40
Variable Overheads (401.40 hours × ₹1)	401.40
Fixed Overheads (401.40 hours × ₹5)	2,007.00
Total Cost of 30 units	6,616.80
Cost per unit (₹6,616.80 / 30 units)	220.56

(ii) **Cost per unit, when a repeat order for 20 units is also placed**

	₹
Direct Material Cost (20 units × ₹ 60)	1,200.00
Direct Labour [(567.50 hours – 401.40 hours) × ₹ 6]	996.60
Variable Overheads (166.10 hours × ₹1)	166.10
Fixed Overheads (166.1 hours × ₹ 5)	830.50
Total Cost of 20 additional units	3,193.20
Cost per unit (₹3,193.20 / 20 units)	159.66

Price to be quoted to yield a profit of 25% on selling price

If selling price is ₹100 then profit is ₹25 and cost is ₹75

Hence selling price per unit = $₹100.00 \text{x} \frac{₹159.66}{₹75.00} = ₹212.88$

Problem-10

A Company has two production departments KTS and KTW. Standards for the forthcoming year is as follows:

Particulars	*Department KTS*	*Department KTW*
Direct labour hours available per period	*12,000*	*8,000*
Standard wage rate per hour	*₹ 3*	*₹ 2.5*
Expected learning curve	*80%*	*70%*
Standard variable overheads per hour	*₹ 10*	*₹ 6*
Standard fixed overheads per hour	*₹ 11*	*₹ 7*
Direct labour hours required for first 100 units	*36*	*18*

The direct materials are introduced in Department KTS. The company has following quote for purchase of direct material:

Level of Outputs (Units)	*Price of direct material per unit of output*
100	*₹ 36.00*
200	*₹ 32.40*

Overtime, if required is paid at the time and half. The overhead rates as given above do not include overtime premium.

It is the policy of the company to add profit margin as under in quoting the prices:

Department	*Percentage*
KTS	*10% of labour & 15% overhead cost*
KTW	

The company has received a special order. Special tooling costs of the order amount to ₹ 5,500. If this order is for 200 units or less, it will be executed in the period which has a workload of 7,680 direct labour hours in Department KTS and 4,200 direct labour hours in Department KTW.

Required

If the company decides to get the work executed entirely within the company, what price, on cost-plus basis, should be quoted for the order, if it consists of 100 Units, 200 units.

Solution

Statement Showing "Recommended Selling Price"

	100 Units (per Unit)		200 units (per Unit)	
Department KTS:				
Direct Labour	36hrs. × ₹3	108.00	36Hrs. × 0.80 × ₹3	86.40
Overtime Premium#		0.00		10.80
Total Labour Cost ...(A)		**108.00**		**97.20**
Variable Overheads	36hrs. × ₹ 10	360.00	36 Hrs. × 0.80 × ₹ 10	288.00
Fixed Overheads	36hrs. × ₹ 11	396.00	36 Hrs. × 0.80 × ₹11	316.80
Total Overheads ...(B)		**756.00**		**604.80**
Department KTW:				
Direct Labour	18hrs. × ₹ 2.5	45.00	18 Hrs. × 0.70 × ₹2.5	31.50
Overtime Premium		0.00		0.00
Total Labour Cost ...(C)		**45.00**		**31.50**
Variable Overheads	18hrs. × ₹ 6	108.00	18 Hrs. × 0.70 × ₹6	75.60
Fixed Overheads	18hrs. × ₹ 7	126.00	18 Hrs. × 0.70 × ₹7	88.20
Total Overheads ...(D)		**234.00**		**163.80**
Special Tool ...(E)	₹ 5,500 / 100	**55.00**	₹ 5,500 / 200	**27.50**
Direct Material ...(F)		**36.00**		**32.40**
Profit on Labour (10%)	₹ (108 + 45) × 10%	15.30	₹(97.20 + 31.50) × 10%	12.87
Profit on Overheads (15%)	₹ (756+234) ×15%	148.50	₹ (604.80 +163.80) × 15%	115.29
Total Profit ...(G)		**163.80**		**128.16**
Recommended Selling Price [(A) +(B)+(C)+(D)+(E)+(F)+(G)]		**1,397.80**		**1,085.36**

#Statement Showing "Overtime Premium"

	Department KTS	Department KTW
Direct Labour Hours Available	12,000	8,000
Present workload	7,680	4,200
Balance Direct Labour Hours	4,320	3,800
Hours Required to produce 100 units:	3,600	1,800
Hours Required to produce 200 units:	5,760 (200 x 36 x 0.80)	2,520 (200 x 18 x 0.70)
Overtime Required to produce 100 units	---	---
Overtime Required to produce 200 units	1,440 Hrs	---
Overtime Premium	10.8 per Unit (1,440 Hrs × 3 × 50% / 200 Units)	---

Problem-11

Marketing manager of Arnav Ltd. has conducted a market research on the price-demand relationship for its consumer durable product 'Leo-9'. Leo-9 is a recently launched product. The price-demand pattern will be as follows:

Price per unit (₹)	***Demand (units)***
11,100	*1,000*
10,700	*2,000*
9,600	*3,000*
8,700	*4,000*

Leo-9 is produced in batches of 1,000 units. Production manager of Arnav Ltd. has also researched and studied the production pattern and has believe that 50% of the variable manufacturing cost would have learning and experience curve effect. This learning & experience curve effect will be continued upto 4,000 units of production at a constant rate. But after 4,000 units of production, unit variable manufacturing cost would be equal to the unit cost at the 4th batch. The manufacturing unit cost of the first batch will be ₹4,400 of which only 50% is subjected to learning and experience curve effect. The average unit variable cost of all 4 batches will be ₹4,120.

Required

(i) Calculate the rate of learning that has been expected by the Production manager.

(ii) Calculate the price at which Arnav Ltd. should sell the Leo-9 in order to maximise its contribution.

Note:

log0.93 = -0.0315, log2 = 0.3010, $2^{-0.1047} = 0.9299$, $3^{-0.1047} = 0.8913$, $4^{-0.1047} = 0.8649$

Solution

(i) Variable cost per unit that will be effected by learning and experience curve is ₹2,200 (₹4,400 – 50% of ₹ 4,400).

Let, 'r' be the learning curve rate.

No. of Batch (x)	Cumulative Average Cost *per unit* (y)
1	2,200
2	2,200 r
4	2,200 r^2

If 2,200 r^2	=	₹1,920 (₹4,120 – 50% of ₹ 4,400)
r^2	=	0.8727
r	=	0.934
Therefore, Learning Curve Effect	=	93% (rounded off)

(ii) Calculation of Optimum Price

Price *per unit* (₹)	Demand (units)	Variable Cost *per unit* * [W.N.] (₹)	Variable Cost *per unit* ** (₹)	Total Variable Cost *per unit* (₹)	Contribution *per unit* (₹)	Total Contribution (₹)
11,100.00	1,000	2,200.00	2,200.00	4,400.00	6,700.00	67,00,000
10,700.00	2,000	2,046.00	2,200.00	4,246.00	6,454.00	1,29,08,000
9,600.00	3,000	1960.86	2,200.00	4,160.86	5,439.14	1,63,17,420
8,700.00	4,000	1,902.78	2,200.00	4,102.78	4,597.22	1,83,88,880

(*) This represents variable cost part which is affected by the learning and experience curve effect.

(**) This represents variable cost part which is not affected by the learning and experience curve effect.

Working Note [W.N.]

Variable Cost *per unit*

Output in Batches (x)	Average Cost of the First Unit (a)	$x^{-0.1047}$	Cumulative Average Cost *per unit* (y)
1	2,200	1.0000	2,200.00
2	2,200	0.9299	2,046.00
3	2,200	0.8913	1,960.86
4	2,200	0.8649	1,902.78

$$y = ax^b$$

Where,

y = Cumulative average unit costs

a = Average cost of the first unit

x = Cumulative number of batches

b = Log of learning ratio ÷ Log of 2

= log 0.93 ÷ log 2

= −0.0315 ÷ 0.3010

= −0.1047

Problem-12

AB Ltd. makes and sells a labour-intensive product. Its labour force has a learning rate of 80%, applicable only to direct labour and not to variable overhead.

The cost per unit of the first product is as follows:

	₹
Direct Materials	*10,000*
Direct Labour (@ ₹ 4 per hour)	*8,000*
Variable Overhead	*2,000*
Total Variable Cost	*20,000*

AB Ltd. has received an order from P Ltd. for 4 units of the product. Another customer, Q Ltd. is also interested in purchasing 4 units of the product. AB Ltd. has the capacity to fulfill both the orders. Q Ltd. presently purchases this product in the market for ₹ 17,200 and is willing to pay this price per unit of AB's product. But for P Ltd. lets AB choose one of the following options:

(i) A price of ₹16,500 per unit for the 4 units it proposes to take from AB.

Or

(ii) Supply P Ltd.'s idle labour force to AB, for only 4 units of production, with AB having to pay only ₹ 1 per labour hour to P Ltd.'s workers. P Ltd.'s workers will be withdrawn after

the first 4 units are produced. In this case, AB need not use its labour for producing P Ltd.'s requirement. P Ltd. assures AB that its labour force also has a learning rate of 80%. In this option, P Ltd. offers to buy the product from AB at only ₹ 14,000 per unit.

P and Q shall not know of each other's offer.

Required

If both orders came before any work started, what is the best option that AB may choose?

Present suitable calculations in favour of your argument.

Solution

Workings

Units	Average hrs. /unit
1	2,000
2	1,600
4	1,280
8	1,024

Variable Cost excluding Labour:

		₹
Material Cost / unit	=	10,000
Variable Overheads	=	2,000
Variable Cost	=	12,000

Option-I

If both the orders came together, learning rate 80% applies and 8 units can be made, with average time of 1,024 hours per unit.

Cost to AB		₹
Variable Cost excluding Labour	=	12,000
Labour Cost (1,024 hrs. × 4₹/hr)	=	4,096
	=	16,096

In this case,

Particulars	Q	P	Total
Selling Price p. u. (₹)	17,200	16,500	33,700
Variable Cost p. u. (₹)	16,096	16,096	32,192
Contribution p. u. (₹)	1,104	404	1,508
No. of Units	4	4	
Contribution (₹)	4,416	1,616	6,032

Option- II

If P Ltd supplies its labour. 80% learning curve will apply to 4 units each of AB & P.

Hence: hrs / u = 1,280

Particulars	Q	P	Total
Selling Price p. u. (₹)	17,200	14,000	31,200
Variable Cost p. u. (₹) (Excluding Labour)	12,000	12,000	24,000
Labour Cost p. u. (₹)			
1,280 hrs. × ₹4	5,120	–	5,120
1,280 hrs. × ₹1	–	1,280	1,280
Total Variable Cost p. u. (₹)	17,120	13,280	30,400
Contribution p. u. (₹)	80	720	800
Units	4	4	
Contribution (₹)	320	2,880	3,200

Decision

AB should not take labour from P Ltd. It should choose Option-I.

Application of Learning Curve in Standard Costing

Problem-13

Genting Mfg Co. has developed a product for which the following standard cost estimates have been made for the first batch to be manufactured in Jan'13:

	₹
Direct Materials (100 Kgs. @ ₹ 55 per Kg.)	*5,500*
Direct Labour (100 hours @ ₹ 40 per hour)	*4,000*
Variable Overhead (100 hours @ ₹ 75 per hour)	*7,500*
	17,000

From experience the firm knows that labour will benefit from a learning effect and labour time will be reduced. This is expected to approximate to an 80% learning curve. In addition, the growing expertise of labour is expected to improve the efficiency with which materials are used. The usage of materials is expected to approximate to a 95% learning curve.

The actual production for Jan'13 to Jun'13 was 320 batches. During Jun'13 following results were recorded for the 320th batch made:

	₹
Direct Materials (80 Kgs.)	*4,000*
Direct Wages (20 hours)	*1,000*
Variable Overhead	*1,800*

Required

Calculate variances in connection with 320th batch.

[Note: Learning Coefficient is -0.322 and -0.074 for learning rate of 80% and 95% respectively, log2=0.30103, log5=0.69897, log319=2.50379, Antilog of 1.81462 =65.26, Antilog of 1.81472 =65.27, Antilog of 1.19334 =15.61, Antilog of 1.19378 =15.62]

Solution

Working Note

(1) Working note showing Standard Quantity of Material for 320th Batch.

Cumulative Number of Batches = 320

Average Kgs. of Material *per batch* = $100 \text{x} 320^{-0.074}$

$t = 100 \text{x} 320^{-0.074}$

$\log t = \log 100 - 0.074 \times \log 320$

$\log t = \log 100 - 0.074 \times \log (2\text{x}2\text{x}2\text{x}2 \text{ x}2\text{x}2\text{x}5)$

$\log t = \log 100 - 0.074 \times [\log 2^6 + \log 5]$

$\log t = \log 100 - 0.074 \times [6 \times \log 2 + \log 5]$

$\log t = 2 - 0.074 \times [6 \times 0.30103 + 0.69897]$

$\log t = 1.81462$

$t = \text{Antilog } (1.81462)$

$t = 65.26$

Cumulative Number of Batches = 319

Average Kgs. of Material *per batch* = $100 \text{x} 319^{-0.074}$

$t = 100 \text{x} 319^{-0.074}$

$\log t = \log 100 - 0.074 \times \log 319$

$\log t = \log 100 - 0.074 \times \log 319$

$\log t = 2 - 0.074 \times 2.50379$

log t	=	1.81472
t	=	Antilog (1.81472)
t	=	65.27
Standard Quantity for 320th Batch	=	320 × 65.26 – 319 × 65.27
	=	62.07 Kgs.

(2) Working note showing Standard Hours for 320th Batch.

Cumulative Number of Batches	=	320
Average Labour Hours *per batch*	=	$100x320^{-0.322}$
t	=	$100x320^{-0.322}$
log t	=	log100 – 0.322 × log320
log t	=	log100 – 0.322 × log (2x2x2x2x2 x2x5)
log t	=	log100 – 0.322 × [$\log 2^6$ + log 5]
log t	=	log100 – 0.322 × [6 × log2 + log 5]
log t	=	2 – 0.322 × [6 × 0.30103 + 0.69897]
log t	=	1.19334
t	=	Antilog (1.19334)
t	=	15.61
Cumulative Number of Batches	=	319
Average Labour Hours *per batch*	=	$100x319^{-0.322}$
t	=	$100x319^{-0.322}$
log t	=	log 100 – 0.322 × log319
log t	=	2 – 0.322 × 2.50379
log t	=	1.19378
t	=	Antilog (1.19378)
t	=	15.62
Standard Hours for 320th Batch	=	320 × 15.61 – 319 × 15.62
	=	12.42 hours

Statement Showing "Standard Cost and Actual Cost of 320th Batch"

Standard Data			Actual Data			
Material						
SQ	**SP**	**SQ × SP**	**AQ**	**AP**	**AQ × AP**	**SP × AQ**
62.07 Kgs. (Refer W.N.1)	₹55	₹3,414	80 Kgs.	₹ 50.00	₹ 4,000.00	₹ 4,400.00
Labour						
SH	**SR**	**SH × SR**	**AH**	**AR**	**AH × AR**	**SR × AH**
12.42 hours (Refer W.N.2)	₹ 40	₹ 497	20 hours	₹ 50.00	₹ 1,000.00	₹ 800
Variable Overhead						
SH	**SR**	**SH × SR**	**AH**	**AR**	**AH × AR**	**SR × AH**
12.42 hours (Refer W.N.2)	₹75	₹932	20 hours	₹90.00	₹1,800.00	₹1,500

Computation of Variances

Material Variances

Cost Variance = Standard Material Cost – Actual Material Cost
= SQ × SP – AQ × AP
= ₹ 3,414 – ₹ 4,000
= ₹ 586 (A)

Usage Variance = Standard Cost of Standard Quantity – Standard Cost of Actual Quantity
= SQ × SP – AQ × SP
= ₹3,414 – ₹4,400
= ₹986 (A)

Price Variance = Standard Cost of Actual Quantity – Actual Material Cost
= AQ × SP – AQ × AP
= ₹4,400 – ₹4,000
= ₹400 (F)

Labour Variances

Cost Variance = Standard Cost of Labour – Actual Cost of Labour

	= SH × SR – AH × AR
	= ₹497 – ₹1,000
	= ₹503 (A)
Efficiency Variance	= Standard Cost of Standard Time – Standard Cost for Actual Time
	= SH × SR – AH × SR
	= ₹497 – ₹800
	= ₹303 (A)
Rate Variance	= Standard Cost for Actual Time – Actual Cost of Labour
	= AH × SR – AH × AR
	= ₹800 – ₹1,000
	= ₹200 (A)

Variable Overhead Variances

Cost Variance	= Standard Variable Overheads for Production – Actual Variable Overheads
	= ₹932 – ₹1,800
	= ₹868 (A)
Efficiency Variance	= Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours
	= ₹932 – 20 Hours × ₹75
	= ₹568 (A)
Expenditure Variance	= Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
	= 20 Hours × ₹75 – ₹1,800
	= ₹ 300 (A)

Problem-14

City International Co. is a multiproduct firm and operates standard costing and budgetary control system. During the month of June firm launched a new product. An extract from performance report prepared by Sr. Accountant is as follows:

Particulars	***Budget***	***Actual***
Output	*30 units*	*25 units*
Direct Labour Hours	*180.74 hrs.*	*118.08 hrs.*
Direct Labour Cost	*₹1,19,288*	*₹ 79,704*

Sr. Accountant prepared performance report for new product on certain assumptions but later on he realized that this new product has similarities with other existing product of the company. Accordingly, the rate of learning should be 80% and that the learning would cease after 15 units. Other budget assumptions for the new product remain valid.

The original budget figures are based on the assumption that the labour has learning rate of 90% and learning will cease after 20 units, and thereafter the time per unit will be the same as the time of the final unit during the learning period, i.e. the 20th unit. The time taken for 1st unit is 10 hours.

Required

Show the variances that reconcile the actual labour figures with revised budgeted figures in as much detail as possible.

Note:
The learning index values for a 90% and a 80% learning curve are −0.152 and −0.322 respectively.
[log 2 = 0.3010, log 3 = 0.47712, log 5 = 0.69897, log 7 = 0.8451, antilog of 0.6213 = 4.181, antilog of 0.63096 = 4.275]

Solution

Working Note

The usual learning curve model is

$$y = ax^b$$

Where

y = Average time per unit for x units

a = Time required for first unit

x = Cumulative number of units produced

b = Learning coefficient

W.N.1

Time required for first 15 units based on revised learning curve of 80% (when the time required for the first unit is 10 hours)

$$y = 10 \times (15)^{-0.322}$$

$$\log y = \log 10 - 0.322 \times \log 15$$
$$\log y = \log 10 - 0.322 \times \log (5 \times 3)$$
$$\log y = \log 10 - 0.322 \times [\log 5 + \log 3]$$
$$\log y = 1 - 0.322 \times [0.69897 + 0.47712]$$
$$\log y = 0.6213$$
$$y = \text{antilog of } 0.6213$$
$$y = 4.181 \text{ hours}$$
$$\text{Total time for 15 units} = 15 \text{ units} \times 4.181 \text{ hours}$$
$$= 62.72 \text{ hours}$$

Time required for first 14 units based on revised learning curve of 80% (when the time required for the first unit is 10 hours)

$$y = 10 \times (14)^{-0.322}$$
$$\log y = \log 10 - 0.322 \times \log 14$$
$$\log y = \log 10 - 0.322 \times \log (2 \times 7)$$
$$\log y = \log 10 - 0.322 \times [\log 2 + \log 7]$$
$$\log y = 1 - 0.322 \times [0.3010 + 0.8451]$$
$$\log y = 0.63096$$
$$y = \text{antilog of } 0.63096$$
$$y = 4.275 \text{ hrs}$$
$$\text{Total time for 14 units} = 14 \text{ units} \times 4.275 \text{ hrs}$$
$$= 59.85 \text{ hrs}$$

Time required for 25 units based on revised learning curve of 80% (when the time required for the first unit is 10 hours)

Total time for first 15 units = 62.72 hrs

Total time for next 10 units = 28.70 hrs [(62.72 − 59.85) hours × 10 units]

Total time for 25 units = 62.72 hrs + 28.70 hrs

= 91.42 hrs

W.N.2

Computation of Standard and Actual Rate

$$\text{Standard Rate} = \frac{₹1,19,288}{180.74 \text{ hrs.}}$$

= ₹ 660.00 per hr.

Actual Rate = $\frac{₹79,704}{118.08 \text{ hrs.}}$

= ₹ 675.00 per hr.

W.N.3

Computation of Variances

Labour Rate Variance = Actual Hrs × (Std. Rate – Actual Rate)

= 118.08 hrs × (₹660.00 – ₹675.00)

= ₹1,771.20 (A)

Labour Efficiency Variance = Std. Rate × (Std. Hrs – Actual Hrs)

= ₹660 × (91.42 hrs – 118.08 hrs)

= ₹17,595.60 (A)

Statement of Reconciliation (Actual Figures Vs Budgeted Figures)

Particulars	**₹**
Actual Cost	79,704.00
Less: Labour Rate Variance (Adverse)	1,771.20
Less: Labour Efficiency Variance (Adverse)	17,595.60
Budgeted Labour Cost (Revised)*	60,337.20

Budgeted Labour Cost (Revised)*

= Std. Hrs. × Std. Rate

= 91.42 hrs. × ₹660

= ₹ 60,337.20

SECTION - C

Application of Learning Curve in Miscellaneous Scenario

Problem-1

State whether the learning curve theory can be applied to .the following independent situations briefly justifying your decision:

(i) A labour intensive sculpted product is carved from the metal provided to the staff. The metal is sourced from different suppliers since it is scarce. The alloy composition of the input metal is quite different among the suppliers.

(ii) Pieces of hand-made furniture are assembled by the company in a far off location. The labourers do not know anything about the final product which utilizes their work. As a matter of further precaution, rotation of labour is done frequently.

(ill) Skilled workers have been employed for a long time. The company has adequate market for the craft pieces done by these experts.

(iv) A company funds that it always has an adverse usage of indirect material. It wants to apply learning curve theory to improve the way standards have been set.

Solution

(i) 'Learning Curve Theory' will not be applicable as alloy combination of the input metal is quite different among the suppliers hence learning experience with one type of metal may not be beneficial for the workers to deal with other metal with separate alloy composition.

(ii) 'Learning Curve Theory' will not be applicable as in this situation rotation of labour is done frequently, labours will not be able to get the benefit of learning and apply their learning. Hence, learning curve theory can not be applied.

(iii) 'Learning Curve Theory' will not be applicable as in this situation as workers are skilled and employed for a long time, they have already achieved maximum level of expertise by taking advantage of learning. Hence, at this point of time learning curve theory can not be applied.

(iv) 'Learning Curve Theory' will not be applicable as indirect materials are the materials which are not used directly in the production (not directly proportionate with volume of output) and usually used machines (e.g. lubricants, spares parts etc.) with less human interactions. Adverse usage of indirect materials can be controlled through proper monitoring and appropriate standard settings and not from applying learning curve theory.

Problem-2

The following information is provided by a firm. The factory manager wants to use appropriate average learning rate on activities, so that he may forecast costs and prices for certain levels of activity.

(i) A set of very experienced people feed data into the computer for processing inventory records in the factory. The manager wishes to apply 80% learning rate on data entry and calculation of inventory.

(ii) A new type of machinery is to be installed in the factory. This is patented process and the output may take a year for full fledged production. The factory manager wants to use a learning rate on the workers at the new machine.

(iii) An operation uses contract labour. The contractor shifts people among various jobs once in two days. The labour force performs one task in 3 days. The manager wants to apply an average learning rate for these workers.

Required

Advise to the manager with reasons on the applicability of the learning curve theory on the above information.

Solution

The learning curve does not apply to very experienced people for the same job, since time taken can never tend to become zero or reduce very considerably after a certain range of output. This is the limitation of the learning curve.

(i) Data entry is a manual job so learning rate theory may be applied. Calculation of inventory is a computerized job. Learning rate applies only to manual labour.

(ii) Learning rate should not be applied to a new process which the firm has never tried before.

(iii) The workers are shifted even before completion of one unit of work. Hence learning rate will not apply.

Problem-3

State whether and why the following are valid or not for learning curve theory:

(i) Learning curve theory applies to a division of a company which is fully automated.

(ii) Learning curve theory helps in setting standards.

(iii) Learning curve helps in pricing decisions.

(iv) Experienced workmen are more prone to learning effect.

Solution

Valid or Invalid

Sl. No.	Situation	Valid or Not Valid	Reason
(i)	Learning curve theory applies to a division of a company which is fully automated	Not Valid	It can be very effective in labour oriented industry but not in fully automated company.
(ii)	Learning curve theory helps in setting standards	Valid	If budgets and standards are set without considering the learning effect, meaning less variances are likely to occur. The learning curve is quite helpful in setting standards in learning phase.
(iii)	Learning curve helps in pricing decisions	Valid	The use of cost data adjusted for learning effect helps in development of advantageous pricing policy.
(iv)	Experienced workmen are more prone to learning effect	Not Valid	Activities being performed by experienced workmen, who are thoroughly familiar with those activities, will not be subject to learning effect.