STRATEGIC COST MANAGEMENT - DECISION MAKING



GROUP - III
PAPER - XV

THE INSTITUTE OF COST ACCOUNTANTS OF INDIA
(Statutory body under an Act of Parliament)
www.icmai.in

SYLLABUS - 2016

WORK BOOK

STRATEGIC COST MANAGEMENT-DECISION MAKING

FINAL

GROUP – III

PAPER – 15

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Preface

Professional education systems around the world are experiencing great change brought about by the global demand. Towards this end, we feel, it is our duty to make our students fully aware about their curriculum and to make them more efficient.

Although it might be easy to think of the habits as a set of behaviours that we want students to have so that we can get on with the curriculum that we need to cover. It becomes apparent that we need to provide specific opportunities for students to practice the habits. Habits are formed only through continuous practice. And to practice the habits, our curriculum, instruction, and assessments must provide generative, rich, and provocative opportunities for using them.

The main purpose of this volume is to disseminate knowledge and motivate our students to perform better, as we are overwhelmed by their response after publication of the first edition. Thus, we are delighted to inform our students about the **e-distribution of the second edition of our 'Work book'.**

This book has been written to meet the needs of students as it offers the practising format that will appeal to the students to read smoothly. Each chapter includes unique features to aid in developing a deeper under-standing of the chapter contents for the readers. The unique features provide a consistent reading path throughout the book, making readers more efficient to reach their goal.

Discussing each chapter with illustrations integrate the key components of the subjects. In the second edition, we expanded the coverage in some areas and condensed others.

It is our hope and expectation that this second edition of work book will provide further an effective learning experience to the students like the first edition.

The Directorate of Studies,

The Institute of Cost Accountants of India

Suggested Marks Distribution from Examination Point of View

Only for Practice Purpose

Total 100 Marks	3 Hours	MCQ = 20 Marks
		Others = 80 Marks

Objective Question

20 Marks (2 Marks each questions)	MCQ	1 mark for correct answer
		1 mark for justification

Short Notes / Case Study

Minimum Marks for each Questions	3 Marks
Maximum Marks for each Questions	10 Marks

Practical Problem

Minimum Marks for each Questions	4 Marks
Maximum Marks for each Questions	16 Marks

Study Note – 1

COST MANAGEMENT

Learning Objective: *To understand and implement different cost and management techniques/processes/methods to analyse, ascertain and control costs.*

OBJECTIVE TYPE QUESTIONS:

1. **'B' manufacturing Company sells its product at ₹ 1,000 per unit. Due to competition, its competitors are likely to reduce the price by 15%. B wants to respond aggressively by cutting down its price by 20% and expects that the present volume of 1,50,000 units p.a. will increase to 2,00,000. B wants to earn a 10% target profit on sales. Per unit Target cost for the product will work out to:**

   (i) ₹ 1000 (ii) ₹ 800 (iii) ₹ 720 (iv) None of the above

2. **Desktop Co. manufactures and sells 7,500 units of a product. The full cost per unit is ₹100. The Company has fixed Its price so as to earn a 20% return on an Investment of ₹ 9,00,000. Target selling price will be**

   (i) ₹ 100 (ii) ₹ 124 (iii) ₹ 200 (iv) None of the above

3. **Company 'B' uses throughput accounting system. The details of product X per unit are as follows:**

Selling price	₹ 50
Material cost	₹ 16
Conversion costs	₹ 20
Time on bottleneck resource	8 minutes

   The throughput return per hour for product X is:

   (i) ₹ 105 (ii) ₹ 225 (iii) ₹ 255 (iv) ₹ 375

4. **In calculating the life cycle costs of a product, which of the following items would be included?**

   (A) Planning and concept design costs

   B) Preliminary and detailed design costs

   C) Testing costs

   D) Production costs

   E) Distribution costs

   (i) All of the above (ii) D and E (iii) B, D and E (iv) D

5. Om Ltd., has the capacity of production of 80,000 units and presently sells 20,000 units at ₹ 100 each. The demand is sensitive to selling price and it has been observed that with every reduction of ₹ 10 in selling price, the demand is doubled. What should be the target cost at full capacity if profit margin on sale is taken as 25%?

(i) ₹ 67.50 (ii) ₹ 60.00 (iii) ₹ 45.00 (iv) None of the above

6. Back flush costing is most likely to be used when

(i) Management desires sequential tracking of costs

(ii) A Just-in-Time inventory philosophy has been adopted

(iii) The company carries significant amount of inventory

(iv) Actual production costs are debited to work-in-progress

7. Which of the following is not a term normally used in value analysis?

(i) Resale value (ii) Use value (iii) Esteem value (iv) Cost value

8. Life Cycle Cost considers

(i) Cradle to grave cost (ii) Only Future Cost (iii) Only present cost (iv) None of the above

9. Target costing is the answer to

(i) Market driven prices (ii) Sellers' market (iii) No Profit situation (iv) None of the above

Answers:

1. (iii)

Target selling price (₹ 1,000 less 20%)	₹ 800
Less: Target profit margin (10%)	₹ 80
Target costs per unit	₹720

2. (ii)

Target Sale Price per unit = Full Cost + Target Profit = ₹ 100 + {(9,00,000X 20%)}/7500 = 100 + 24

3. (iii)

Return per minute = (Selling price - material cost)/Time on bottleneck resource = (50-16)/8 = 4.25; Return per hour = 4.25 × 60 = 255

4. (i) All of the above.

5. (ii) ₹ 60.

Demand	Price (₹)
20,000	100
40,000	90
80,000	80

6. (ii) A Just-in-Time inventory philosophy has been adopted

7. (i) Resale value

8. (i) Cradle to grave cost

9. (i) Market driven prices

DESCRIPTIVE QUESTIONS:

10. Write notes on:

(a) Life Cycle Costing

(b) Target Costing

(c) Value Analysis

(d) Value Engineering

(e) Principles of Business Process Re-engineering.

(f) Lean Accounting.

(g) Socio Economic Costing

(h) Cost Control

Answer:

(a) Life Cycle Costing

CIMA defines Life-Cycle Costing as ' Maintenance of physical asset cost records over entire asset lives, so that decisions concerning the acquisition, use or disposal of assets can be made in a way that achieves the optimum asset usage at the lowest possible cost to the entity. The term may be applied to the profiling of cost over a product's life, including the pre-production stage (*terotechnology*), and to both company and industry life cycles'.

Many a product are observed to possess a distinctive life cycle comprising six clearly defined phases comprising:

(i) Development

(ii) Introduction

(iii) Growth

(iv) Maturity

(v) Decline

(vi) Extinction

Each phase has its own characteristics. Older, long-established products eventually become less popular, while in contrast, the demand for new, more modern goods usually increases quite rapidly after they are launched. The time line commencing from the innovation of a new product and ending with its degeneration into a common product and the eventual extinction is termed as the life cycle of a product.

Life Cycle Cost (LCC) may, thus, be stated as "The total cost throughout the life of an asset including planning, design, acquisition and support costs and any other costs directly attributable to owning or using the asset". Life Cycle Cost (LCC) of any item represents costs of its acquisition, operation, maintenance and disposal.

Production Costs are accounted and recognized by the routine accounting system. However non-production costs like R&D, design, marketing, distribution, customer service, etc. are less visible on a product-by-product basis. Product Life Cycle Costing focuses on recognizing both production and non-production costs.

Product life cycle thinking can promote long-term rewarding in contrast to short-term profitability rewarding. It provides an overall framework for considering total incremental costs over the entire life span of a product, which in turn facilitates analysis of parts of the whole where cost effectiveness might be improved.

Life Cycle Budgeting, i.e. Life Cycle Costing with Target Costing principles, facilitates scope for cost reduction at the design stage itself. Since costs are avoided before they are committed or locked in, the Company is benefited.

Life Cycle Costing aids decision makers in considering all present and future costs related to new construction, renovation, equipment replacement, or any other project that involves upfront and ongoing expenditure thereby covering the period from 'Cradle to Grave'.

The concept of Life-Cycle Costing may be explored in relation to a product, project or an industry as such.

(b) Target Costing

Target Costing is considered as a philosophy in which product development is based on what the customer wants and is willing to pay for and not what it costs to produce. Hence it starts with the market determined price; then deducts the desired profit margin; and works back the target cost. Peter Drucker calls this "price-led costing." And that is how the formulation: "Target Cost = Target Price – Target Profit" in place of the traditional approach of "Cost + Profit = Selling Price".

The stages in the process of target costing may be summarised as:

1. Selling Price
2. Target Profit
3. Target Cost
4. Cost Comparison
5. Iteration
6. Launching the Product
7. Product Cost Management
8. Consumption Cost Management

The distinct features of target costing may be stated as:

1. Price-Led Costing
2. Focus on Customers
3. Focus on Design
4. A Multidisciplinary Process
5. An Iterative Process
6. Life Cycle Orientation
7. Extended Enterprise

For process businesses, the focus of target costing shifts from the product to the process, and for service businesses the focus is the service delivery system.

(c) Value Analysis (VA)

Value Analysis (VA) is one of the important techniques of cost reduction and control. It is a scientific approach that ensures all the functions of a product or service are carried out at the minimum cost without compromising quality, reliability, performance and appearance.

Value Analysis may consist of the following seven phases.

(i) Origination

(ii) Information

(iii) Functional Analysis

(iv) Innovation

(v) Evaluation

(vi) Choice

(vii) Implementation

The core advantage of using value analysis is its potential for reducing costs, which is a benefit that permeates all advantages of the system. Because of the fact that value analysis breaks down a product or service into components, it enables the analysis of each of the components on its own, evaluating its importance and efficiency.

(d) Value Engineering (VE)

'VA' and 'VE' are closely related terms so much so that they are, frequently, used interchangeably. Though the philosophy of understanding the two is the same, the difference lies in the time and stage at which the technique is applied.

"Value Analysis" is the application of a set of techniques to an existing product with a view to improve its value. Thus, it is a remedial process. "Value Engineering" is the application of exactly the same set of techniques to a new product at the design stage to ensure that bad features are not added. Thus, it is a 'preventive' measure. In that sense, 'VE' is fundamental and VA is collateral because 'prevention is better than cure."

(e) Business Process Re-engineering (BPR)

Business Process Re-engineering (BPR) refers to the fundamental rethinking and redesign of business processes to achieve improvement in critical measures of performance such as costs, quality, efficiency, service, speed and customer satisfaction. It (BPR) is the practice of rethinking and redesigning the process to support an organization's mission and reduce costs.

The stepwise process of BPR consists of:

(i) Creation of Vision

(ii) Selection of Team

(iii) Analysis of the Existing Process

(iv) Development of a New Process

(v) Implementation of the New Process

(vi) Evaluation

The key benefits include:

Key Benefits

(i) Reduction in Costs and Cycle Times

(ii) Improvement in Quality

(iii) Customer Focus

Business Process Reengineering is a strategic tool towards cost reduction as also for increased customer focus and enhanced competitive advantage.

(f) Lean Accounting

Lean accounting is the application of lean principles to the accounting and associated functions within the enterprise. Lean Accounting facilitates the changes that are required to a company's accounting, control, measurement, and management processes to support lean manufacturing and lean thinking.

Lean Accounting enables identification and elimination of non-value adding waste in the accounting and reporting processes; Improves visual reporting on product lines; and realigns accounting activities to a consulting role rather than a transaction role.Lean accounting empowers the finance and accounting functions to partner with the evolving lean enterprise. When the finance department revamps its processes in line with the lean methods, the time savings and communication gains are substantial.

The purpose of lean accounting is to tell us about the flow through the Value Stream; to tell us about the capacity for extra work in the Value stream; and to tell us about the incremental costs of alternative decisions and actions. Lean accounting provides a stage that enables the accounting team to move from a transaction focus to a new high value role of consulting within other areas of the company.

Enterprises using Lean accounting have better information for decision-making, have simple and timely reports that are clearly understood by everyone in the company, They understand the true financial impact of lean changes; they focus the business around the value created for the customers, and accounting actively drives the lean transformation. This helps the company to grow, to add more value for the customers, and to increase cash flow and value for the stock-holders and owners.

(g) Socio Economic Cost Benefit analysis (SCCBA)

Socio Economic Cost Benefit analysis (SCCBA) is the predominant tool used in welfare economics in order to assess whether an intervention – be it a project or policy – should be undertaken or not. It is an extension of Economic Cost Benefit Analysis, adjusted to take into account the full spectrum of costs and benefits, including social and environmental effects, borne by society as a whole.

The process of Socio Economic Cost Benefit Analysis may comprise of eight vital steps.

1. Identification of the Project
2. Technical and Demand Analyses
3. Financial Effects
4. Fiscal Effects
5. Externalities
6. Opportunity Costs

7. Economic Return on Investment (EROI)
8. Social Return on Investment (SROI)

Items 1 to 3 are part of the traditional Financial Analysis; Items 4 to 7 go beyond the private interests and look at the Economic Analysis; whereas item 8 moves forward and addresses the Social Concerns. Fiscal Effects refer to Fiscal Transfers and consist of the Fiscal Income such as Rates, Taxes and Other Duties that may be generated by the project as also the Fiscal Costs such as Subsidies and Incentives that may have to be extended to the project.

Externalities refer to calculation of External Effects of the Project. Opportunity Costs refer to the Opportunity Costs relating to both the Inputs and Outputs wherein shadow prices are adopted if market prices are not available. EROI refers to computation of the Economic Net Present Value (ENPV) and the Economic Internal Rate of Return (EIRR). SROI recognises that economic, environmental and social outcomes are all critical factors in achieving quality lives and well-being and should be included in a 'Triple Bottom Line' approach.

(h) Cost Reduction

The term 'Cost Reduction' refers to the attempts to reduce the costs. Cost reduction may be defined as the real and permanent reduction in the unit costs of goods manufactured or services rendered without impairing their suitability for the use intended. Cost reduction would mean maximization of profits by reducing cost through economics and savings in costs of manufacture, administration, selling and distribution.

The goal of cost reduction can be achieved either by reducing the cost per unit or by increasing the productivity or doing both at the same time. Reducing wastages, improving efficiency, searching for alternative materials, and a constant drive to reduce costs, can lead to cost reduction.

A research study by PWC puts forward the following five steps for strategic cost reduction to ensure that the business can sustain competitive relevance and maximise its potential.

1. Start with strategy: Have a clear view of cost reduction strategy and ensure it is consistently understood across the organisation.
2. Align costs to strategy: Look across the whole organisation and differentiate the strategically-critical 'good costs' from the non-essential 'bad costs'.
3. Aim high: Be bold, be brave and be creative – use technology, innovation and new ways of working to radically optimise the cost base.
4. Set direction and show leadership: Deliver cost optimisation as a strategic, business transformation programme.
5. Create a culture of cost optimisation: Ensure that a culture of ownership is embedded and continuous improvement is incentivised.

There are several tools and techniques that are adopted in achieving cost reduction. Some of the vital ones which are normally used are listed below.

(i) Value Analysis

(ii) Simplification & Standardisation

(iii) Business Process Re-engineering.

(iv) Benchmarking

(v) Financial Restructuring

(vi) Work Study

(vii) Job Evaluation

(viii) Quality Control

(ix) Inventory Control

(x) Credit Control

11. Explain the concepts of Throughput Accounting.

Answer:

Throughput Accounting (TA): Variable cost accounting presentation based on the definition of throughput (sales minus material and component costs). Sometimes, it is referred to as super variable costing because only material costs are treated as variable.--- CIMA

Throughput Accounting is a management accounting technique used as a performance measure in the theory of constraints. It is the business intelligence used for maximizing profits. It seeks to increase the velocity or speed of production of products and services keeping in view of constraints. It is based on the concept that a company must determine its overriding goal and then it should create a system that clearly defines the main capacity constraint that allows it to maximize that goal. The changes that this concept causes are startling.

Throughput Concepts:

(i) **Throughput:** Throughput is the excess of sales value over the totally variable cost.

(ii) **Totally Variable Cost:** This cost is incurred only if a product is produced. in many cases only direct materials are considered as totally variable cost. Direct labour is not totally variable, unless piece rate wages are paid.

(iii) **Bottleneck Resource: I**t is a resource within a company, that limits its total output. For example, it can be a machine that can produce only a specified amount of a key component in a given time period, thereby keeping overall sales from expanding beyond the maximum capacity of that machine. There may be more than one capacity constraint in a company.

(iv) **Throughput (or Cycle) Time:** Throughput (or cycle) time is the average time required to convert raw materials into finished goods ready to be shipped to customer. It includes the time required for activities such as material handling, production processing, inspecting and packaging.

(v) **Throughput Time Ratio:** It is the ratio of time spent adding customer value to products and services divided by total cycle time. It is also known as the 'ratio of work content to lead time'.

(vi) **Total Factory Cost:** With the exception of material costs, in the short run, most factory costs (including direct labour) are fixed. These fixed costs can be grouped together and called total factory costs (TFC).

PRACTICAL PROBLEMS:

12. A2Z p.l.c supports the concept of tero technology or life cycle costing for new investment decisions covering its engineering activities. The financial side of this philosophy is now well established and its principles extended to all other areas of decision making. The company is to replace a number of its machines and the Production Manager is torn between Machine 'A', a more expensive machine with a life of 12 years, and machine 'B' with an estimated life of 6 years. If Machine 'B' is chosen it is likely that it would be replaced at the end of 6 years by another machine 'B'. The pattern of maintenance and running costs differs between the two types of machine and relevant data are shown below:

		Machine A		Machine B
Purchase price		**₹19,000**		**₹ 13,000**
Trade-in value/breakup/scrap		**₹ 3,000**		**₹ 3,000**
Annual repair costs		**₹ 2,000**		**₹ 2,600**
Overhaul costs	**(at year 8)**	**₹ 4,000**	**(at year 4)**	**₹ 2,000**

Estimated financing costs average to 10% over machine life for both the machines.

You are required to recommend, with supporting figures, which machine to purchase stating any assumptions made.

Solution:

Computation of present value of outflows and equivalent annual Cost

		Machine A		Machine B
Initial cost (₹)		19,000.00		13,000.00
Less : scrap at the end of the life (₹)	(3000 × 0.32)	960.00	(3000 ×0.56)	1,680.00
		18,040.00		11,320.00
Present value of total annual cost (₹)	(2000 × 6.81)	13,620.00	(2600 × 4.36)	11,336.00
Overhaul cost (₹)	(4000 × .47)	1,880.00	(2000 × 0.68)	1,360.00
		33,540.00		24,016.00
Capital recovery factor	(1/8.81)	0.15	(1/4.36)	0.23
equivalent annual cost (₹)		4,925.00		5,508.00

As the equivalent annual cost is less for Machine A, it is better to purchase the same.

13. You the manager of a paper mill (M. Ltd.) and have recently come across a particular type of paper, which is being sold at a substantially lower rate (by another company-ABC Ltd.) than the price being charged by your own mill. The value chain for one of MT of such paper for ABC Ltd is follows: "ABC Ltd. ---- - Merchant ------ Printer ------ Customer".

ABC Ltd sells this particular paper to the merchant at the rate of ₹30,400 per MT. ABC Ltd pays for the freight which amounts to ₹600 per MT. Average returns and allowances amount to 4% of sales and approximately equal to ₹1200 per MT.

The value chain of your company, through which the paper reaches the ultimate customer is similar to that of ABC Ltd. However, your mill does not sell directly to the merchant. The latter receives the paper from a huge distribution center maintained by your company at Haryana. Shipment costs from the mill to the Distribution Center amount to ₹200 per MT while the operating costs in the Distribution Center have been estimated to be ₹125 per MT. The return on investments required by the Distribution Center for the investments made amount to an estimated ₹ 120 per MT.

You are required to compute the "Mill Manufacturing Target Cost" for this particular paper for your company. You may assume that the return on the investment expected by your company equals ₹ 120 per MT of such paper.

Solution:

Computation of Target Cost

Per MT (in ₹)

ABC Ltd selling price to the merchant		30400
Less: freight paid by ABC Ltd	600	
Less normal sales returns and allowances	1200	
M Ltd's Capital charge	120	1920
Target cost for XYZ Ltd		28480
Less: Shipment cost Distribution Centre	200	
Operating cost in the Distribution Centre	125	325
		28155
Distribution centre capital charge		120
Target manufacturing cost of the Mill		28035

14. CELO Company has the capacity of production of 80,000 units and presently sells 20,000 units at ₹100 each. The demand is sensitive to Selling Price and it has been observed that for every reduction of ₹10 in Selling Price, the demand is doubled.

Required:

1. What should be the Target Cost at full capacity, if Profit Margin on Sale is 25%?

2. **What should be the Cost Reduction Scheme if at present 40% of cost is variable, with same % of profit as at (1)?**
3. **If Rate of Return desired is 16%, what will be the maximum investment at full capacity?**

Solution:

1. Target Cost at Full Capacity

Selling Price per unit	₹100	₹ 90	₹ 80
Demand(units)	20,000	40,000	80,000 = Full Capacity

Hence, Target Cost at Full Capacity = Sale Price less Profit Margin = ₹80 less 25% thereon = ₹60 p.u.

2. Determination of Target Cost Reduction

(a) Since Present Price is ₹100 p.u. and Profit is 25% thereon, Present Cost p.u. =75, of which 40% is variable. So, Fixed Cost is 60% of 75 = 45 p.u. So, Total Fixed Cost =	45 × 80,000 = ₹36 Lakhs
(b) Variable Cost at Full Capacity = (40% of ₹75 p.u.) × 80,000 units =	₹24 Lakhs
(c) Estimated Cost at Full Capacity = Fixed Cost (constant at all levels) +Variable Cost (a + b)	₹60 Lakhs
(d) Target Cost at Full Capacity = ₹60 p.u. for 80,000 units =	₹48 Lakhs
(e) Cost Reduction Target/Scheme =Estimated Cost less Target Cost = (c - d)	₹12 Lakhs

3. Computation of Investment required

(a) Profit at full capacity = 25% of ₹80 = ₹20 p.u.× 80,000 units	₹16 Lakhs
(a) Since ROCE desired is 16%, Maximum Required Investment = ₹16 Lakhs/ 16%	₹100 Lakhs

15. K & Co. manufactures and sells 15,000 units of a product. The Full Cost per unit is ₹ 200. The Company has fixed its price so as to earn a 20% Return on an Investment of ₹ 18,00,000.

Required:

1. **Calculate the Selling Price per unit from the above. Also, calculate the Mark-up % on the Full Cost per unit.**
2. **If the Selling Price as calculated above represents a Mark-up of 40% on Variable cost per unit, calculate the Variable cost per unit.**

3. **Calculate the Company's Income if it had increased the Selling Price to ₹ 230. At this price, the company would have sold 13,500 units. Should the Company have increased the Selling price to ₹ 230?**

4. **In response to competitive pressures, the Company must reduce the price to ₹ 210 next year, in order to achieve sales of 15,000 units. The Company also plans to reduce its investment to ₹ 16,50,000. If a 20% Return on Investment should be maintained, what is the Target Cost per unit for the next year?**

Solution:

1.	Target Sale Price per unit = Full Cost + Target Profit = ₹200 + 18,00,000×20% 15,000 units	₹ 224
	So, Mark-up on Full Cost = ₹ 24 / ₹ 200	12%
2.	Above Sale Price ₹224 = VC + 40% thereon, i.e. 140% on VC. So, Var. Cost = 224 /140%	₹ 160
3.	Present Contribution at 15,000 units = (₹ 224 – ₹160) x 15,000 units =	₹ 9,60,000
	Revised Contribution at 13,500 units = (₹230 – ₹160) x 13,500 units =	₹ 9,45,000
	Hence, Increase in Sale Price is not beneficial, due to reduction in contribution by	₹ 15,000
4.	Target Profit for next year = 16,50,000×20% /15,000 units = ₹22 So, Target Cost for next year = New Sale Price - Target Profit = ₹210 – ₹22	₹ 188

16. ABC Enterprises has prepared a draft budget for one of its products for the next year as follows:

Quantity	**10,000 units**
Sales price per unit	**300**
Variable costs per unit:	
Direct materials	**80**
Direct labour (2 hrs x 30)	**60**
Variable overhead (2 hrs × 5)	**10**
Contribution per unit	**150**
Budgeted contribution	**15,00,000**
Budgeted fixed costs	**14,00,000**
Budgeted profit	**1,00,000**

The Board of Directors is dissatisfied with this budget, and asks working party to come up with alternate budget with higher target profit figures.

The working party reports back with the following suggestions that will lead to budgeted profit of ₹2,50,000. The company should spend ₹2,46,000 on advertising, & set the target sales price up to ₹316.75 per unit. It is expected that the sales volume will also rise, in-spite of the price rise, to 12,000 units.

In order to achieve the extra production capacity, however, the workforce must be able to reduce the time taken to make each unit of the product. It is proposed to offer a pay and productivity deal in which the wage rate per hour is increased to ₹40. The hourly rate for variable overhead will be unaffected.

Ascertain the target labour time required to achieve the target profit.

Solution:

	₹
Target profit	2,50,000
Add: Fixed cost	14,00,000
Add: Additional Advertisement	2,46,000
Total contribution	18,96,000
Sales volume	12,000
Contribution per unit (18,96,000/12,000)	158.00
Target Selling price per unit	316.75
Less: Contribution per unit	158.00
Target variable cost p.u.	158.75
Less: Material cost p.u.	80.00
Labour + Variable overhead p.u.	78.75

(1) Let the Target time required per unit be x

Labour cost per hour = x hour x ₹40 per hour = ₹ 40x

Variable overhead per hour = x hour x ₹ 5 per hour = ₹5x

Total Labour cost + Variable overheads = 40x +5x = 45x

(2) Time required to achieve the target profit = x= (Labour + Variable overheads) 45 = 78.75/45= 1.75 hours per unit

So, for 12,000 units = 12,000 × 1.75 hour = 21,000 hours

(3) Target Time/Unit 1.75 Hrs

Present Time / unit 2.00 Hrs

Time Reduced /unit 0.25 Hrs

17. Modern Co. produces 3 products, A, B and C, details of which are shown below:

Particulars	A	B	C
Selling price per unit (₹)	120	110	130
Direct material cost per unit (₹)	60	70	85
Variable overhead (₹)	30	20	15
Maximum demand (units)	30,000	25,000	40,000
Time required on the bottleneck resource (hours per unit)	5	4	3

There are 3,20,000 bottleneck hours available each month.

Required:

Calculate the optimum product mix based on the throughput concept.

Solution:

Particulars	A	B	C
Selling price per unit (₹)	120	110	130
Direct material cost per unit (₹)	60	70	85
Throughput per unit (₹)	60	40	45
Time required on the bottleneck resource (hours per unit)	5	4	3
Return per factory hour (₹)	12	10	15
Ranking	2	3	1

Total hours available = 3,20,000

Hours needed for C = (40,000 x 3) = 1,20,000

Hours used for A = (30,000 x 5) = 1,50,000

Hours used for C and A = (1,20,000+1,50,000) = 2,70,000

Balance hours available for B = (3,20,000 – 2,70,000) = 50,000

No. of units that can be made in balance hours = 50,000/4 = 12,500 units.

Optimum Mix

A: 30,000 units

B: 12,500 units

C: 40,000 units

18. CAT Co. makes a product using three machines – X, Y and Z. The per week capacity of each machine is 800, 600 and 500 units respectively. The demand for the product is 1,000 units per week. For every additional unit sold per week, profit increases by ₹50,000.

CAT Co. is considering the following possible purchases (they are *not* mutually exclusive):

Purchase 1: Replace machine X with a newer model. This will increase capacity to 1,100 units per week and costs ₹60 Lakhs.

Purchase 2: Invest in a second machine Y, increasing capacity by 550 units per week. The cost of this machine would be ₹68 Lakhs.

Purchase 3: Upgrade machine Z at a cost of ₹75 Lakhs, thereby increasing capacity to 1,050 units.

Required:

Which is CAT Co's best course of action under throughput accounting?

Solution:

Bottleneck resource in order of preference is firstly machine 'Z', secondly machine 'Y' and lastly machine 'X' because of the existing capacity.

Particulars	X	Y	Z	Demand
Current capacity per week	800	600	500*	1,000
Buy Z	800	600*	1,050	1,000
Buy Z & Y	800*	1,150	1,050	1,000
Buy Z, Y & X	1,100	1,150	1,050	1,000*

* = bottleneck resource

All the three machines, to be purchased, in the above order to meet the existing demand.

19. K. MNF.Ltd. produces three products, X, Y and Z. The capacity of K. MNF. Ltd's plant is restricted by process alpha. Process alpha is expected to be operational for eight hours per day and can produce 1,200 units of X per hour, 1,500 units of Y per hour, and 600 units of Z per hour. Selling prices and material costs for each product are as follows:

Product	Selling price (₹ per unit)	Material cost (₹ per unit)	Throughput contribution (₹ per unit)
X	150	80	70
Y	120	40	80
Z	300	100	200

Conversion costs are ₹ 7,20,000 per day.

Required:

(i) Calculate the profit per day if daily output achieved is 6,000 units of X, 4,500 units of Y and 1,200 units of Z.

(ii) Calculate the TA ratio for each product.

(iii) In the absence of demand restrictions for the three products, advise K MNF. Ltd's management on the optimal production plan.

Solution :

(a) Profit per day = throughput contribution – conversion cost

= [(₹70 × 6,000) + (₹80 × 4,500) + (₹200 × 1,200)] – ₹7,20,000

= ₹3,00,000

(b) TA ratio = throughput contribution per factory hour / conversion cost per factory hour

Conversion cost per factory hour = ₹720,000 / 8 = ₹90,000

Product	Throughput contribution per factory hour	Cost per factory hour	TA ratio
X	₹ 70 × 1,200 = ₹ 84,000	₹90,000	0.93
Y	₹ 80 × 1,500 = ₹120,000	₹90,000	1.33
Z	₹ 200 × 600 = ₹120,000	₹90,000	1.33

(c) An attempt should be made to remove the restriction on output caused by process alpha's capacity. This will probably result in another bottleneck emerging elsewhere. The extra capacity required to remove the restriction could be obtained by working overtime, making process improvements or product specification changes. Until the volume of throughput can be increased, output should be concentrated upon products Y and Z (greatest TA ratios), unless there are good marketing reasons for continuing the current production mix.

Product X is losing money every time it is produced so, unless there are good reasons why it is being produced, for example it has only just been introduced and is expected to become more profitable, A Ltd should consider ceasing production of X.

20. A factory has a key resource (bottleneck) of Facility A which is available for 31,300 minutes per week. Budgeted factory costs and data on two products, X and Y, are shown below:

Product	Selling Price/Unit	Material Cost/Unit	Time in Facility A
X	**₹35**	**₹20.00**	**5 minutes**
Y	**₹35**	**₹17.50**	**10 minutes**

Budgeted factory costs per week: in ₹

Budgeted labour	**25,000**
Indirect labour	**12,500**
Power	**1,750**
Depreciation	**22,500**
Space costs	**8,000**
Engineering	**3,500**
Administration	**5,000**

Actual production during the last week is 4,750 units of product X and 650 units of product Y. Actual factory cost was ₹ 78,250.

Calculate:

(i) Total factory costs (TFC)

(ii) Cost per Factory Minute

(iii) Return per Factory Minute for both products

(iv) TA ratios for both products

(v) Throughput cost per the week

(vi) Efficiency ratio

Solution:

(i) Total Factory Costs = Total of all costs except materials.

= ₹25,000 + ₹12,500 + ₹1,750 + ₹22,500 + ₹8,000 + ₹3,500 + ₹5000.

= ₹78,250

(ii) Cost per Factory Minute = Total Factory Cost/Minutes available

= ₹78,250 /31,300 = ₹2.50

(iii) (a) Return per bottleneck minute for product X

= Selling Price - Material Cost / Minutes in bottleneck

= (35 – 20) /5 = ₹3

(b) Return per bottleneck minute for product Y

= Selling Price - Material Cost / Minutes in bottleneck

= (35 – 17.5) / 10 = ₹1.75

(iv) Throughput accounting (TA) Ratio for Product X = = (3 / 2.5) = ₹ 1.2

Throughput Accounting (TA) Ratio for Product Y = = (1.75 / 2.5) = ₹ 0.7

Based on the review of the TA ratios relating to two products, it is apparent that if we only make product Y, the enterprise would suffer a loss, as its TA ratio is less than 1. Advantage will be achieved, when product X is made.

(v) Standard minutes of throughput for the week: =

[4,750 x 5] + [650 x 10] = 23,750 + 6,500 = 30,250 minutes

Throughput cost per week: = 30,250 x `2.5 per minutes = 75,625

(vi) Efficiency % = (throughput cost / Actual TFC) % = (₹75,625 / ₹78,250) x 100 = 96.6%

The bottleneck resource of Facility A is available for 31,300 minutes per week but produced only 30,250 standard minutes. This could be due to: (a) The process of a "wandering" bottleneck causing facility A to be underutilized. (b) Inefficiency in facility A.

21. A Company is considering the purchase of a machine for ₹ 3,50,000. It feels quite confident that it can sell the goods produced by the machine so as to yield an annual cash surplus of ₹1,00,000. There is however an uncertainty as to the machine's working life. A recently published Trade Association Survey shows that members of the association have between them owned 250 of these machines and have found the lives of the machines vary as under:

No. of year of machine life	3	4	5	6	7	Total
No. of machines having given life	20	50	100	70	10	250

Assuming discount rate of 10% the net present value for each different machine's life is as follows:

Machine life	3	4	5	6	7
NPV (₹)	(1,01,000)	(33,000)	29,000	86,000	1,37,000

You required to advice whether the company should purchase the machine or not.

Solution:

Computation of NPV of an asset considering the probability of life of machine.

Year	Probability (a) ₹	NPV (b) ₹	Expected value (a × b)
3	20/250	(1,01,000)	(8,080)
4	50/250	(33,000)	(6,600)
5	100/250	29,000	11,600
6	70/250	86,000	24,080
7	10/250	1,37,000	5,480
			26,480

So, Assets should be purchased.

Study Note – 2

DECISION MAKING TECHNIQUES

Learning Objective: *To be able to analyse and evaluate costs that would enable the management in better decision making.*

OBJECTIVE TYPE QUESTIONS:

1. A Ltd. manufactures 4 products A,B,C & D with sales value mix of 33 1/3%, 41 2/3%, 16 2/3% & 8 1/3% and variable cost of 60%, 68%, 80% & 40% of selling price respectively. Budgeted sale value is ₹60000. Overall P/V ratio is

   (i) 40%, (ii) 35%, (iii) 28% (iv) 32%

2. Four products viz. A, B, C & D are sold in the ratio of 25:40:30:5 and their P/V Ratio is 40%, 32%, 20% & 60% respectively. Budgeted sale is ₹60,000/-& fixed cost ₹15000/-.Break even sales will be:

   (i) 48000 (ii) 45555 (iii) 28800 (iv) 47170

3. B Ltd. has earned a net profit of ₹ 1 lakh, and its overall P/V ratio and margin of safety are 25% and 50% respectively. What is the total fixed cost of the Company?

   (i) 2,50,000 (ii) 2,00,000 (iii) 3,00,000 (iv) 1,00,000

4. A Company fixes the inter-divisional transfer prices for its products on the basis of cost, plus a return on investment to the division. The Budgeted Capital Investment is ₹10.00 lakhs, fixed cost is ₹8.00 lakhs and expected sales volume is 4.00 lakh units per annum. Selling price is ₹12.70 per unit and variable cost ₹10 per unit. ROI would be

   (i) 24%, (ii) 20%, (iii) 28% (iv) 32%

5. A Company makes a single product which it sells at ₹10 per unit. Fixed costs are 48,000 per month and the product has a contribution to sales ratio of 40%. In a period when actual sales were ₹1,40,000, the Company's margin of safety in units is:

   (i) 2000 (ii) 3000, (iii) 3500 (iv) 4000

6. The following details relate to product P-1 of a manufacturing company:

Level of activity (units)	1000	2000
Cost per unit (₹):		
Direct materials	4.00	4.00
Direct labour	3.00	3.00
Production overheads	3.50	2.50
Selling overheads	1.00	0.50
Total Cost	11.50	10.00

The total fixed cost and variable cost per unit are:

	Total Fixed Cost (₹)	Variable Cost per unit (₹)
I	2,000	7.00
Ii	2,000	8.50
Iii	3,000	7.00
Iv	3,000	8.50

7. A company is to market a new product. It can produce up to 1,50,000 units of this product. The following are the estimated cost data:

Probability	Fixed Cost	Variable Cost
For production up to 75,000 units	₹ 8,00,000	60%
Exceeding 75,000 units	₹ 12.00,000	50%

Sale price is expected to be ₹ 25 per unit. How many units must the company sell to break even?

(i) 1,00,000 units (ii) 1,11,000 units (iii) 1,27,000 units (iv) 75,000 units

8. A Company makes components and sells internally to its subsidiary and also to external market. The external market price is ₹ 24 per component, which gives a contribution of 40% of sales. For external sales, variable costs include ₹ 1.50 per unit towards distribution costs. This is, however not incurred in internal sales. There are no capacity constraints. To maximize company's profit, the transfer price to subsidiary should be:

(i) ₹ 9.60 (ii) ₹ 12.90 (iii) ₹ 14.40 (iv) None of these

9. Which of the following is NOT a method of transfer pricing?

(i) Cost plus transfer price (ii) Internal price plus transfer price

(iii) Market-based transfer price (iv) Two part transfer price

10. When is market skimming pricing appropriate?

(i) If demand is very elastic (ii) If the product is new and different

(iii) If there is little chance of achieving economies of scale

(iv) If demand is inelastic (v) If there is little competition and high barriers to entry

Answer:

1. (ii)

Product	A	B	C	D	Total
Sale value	20000	25000	10000	5000	60000
Variable cost	12000	17000	8000	2000	39000
Contribution					21000

P/V ratio = 21000/60000 X 100 = 35%

2. (iv)

		A	B	C	D	Total
Sales	₹	15000	24000	18000	3000	60000
P/V ratio	%	40%	32%	20%	60%	
Contribution	₹	6000	7680	3600	1800	19080
Variable cost	₹	9000	16320	14400	1200	40920
Fixed cost	₹					15000
P/V ratio	%					(19080/60000) x 100 = 31.8%
Break even sales	₹					15000 / 31.8% = 47,170

3. (iv)

Profit = Total sales x P/V ratio x M/S ratio

Let sale be S

100000 = S X 25% X 50%

Sale = 800000

Profit = (Sales x P/V ratio) – Fixed cost

100000 = (800000 X 25%) – FC

FC = 100000

4. (iii)

Variable cost		10.00
Fixed cost per unit	8,00,000 ÷ 4,00,000	2.00
Total cost per unit		12.00
Transfer price		12.70
Balance towards cost of capital		0.70

Total amount available towards	Return on Investment = 0.70 × 400000 = 280000
Return on investment = 280000/10,00,000 ×100 = 28%	

5. (i)

BEP = FC/CS ratio = 48000/0.40 = ₹ 120000 or 12000 units

When sales is ₹140000,

Margin of safety = (140000- 120000) = ₹20000 or 2000 units

6. (iv)

Explanation: Variable cost per unit = 4.00 + 3.00 = ₹ 7.00

Total FC (included in Production Overheads and Selling Overheads) is as follows:

Units	1,000	2,000
Total OH	4.50 × 1,000 = 4,500	3.00 × 2,000 = 6,000

Difference in Overhead = ₹ 1,500

Difference in Volume = 1,000

Variable per unit = ₹1.50

Add this to Variable cost per unit of ₹ 7.00

The Total variable cost = ₹ 1.50 + ₹ 7.00 = ₹ 8.50

Fixed Cost = ₹4,500 - (1,000 × 1.50) = ₹ 4,500 - ₹ 1,500 = ₹ 3,000

7. (ii)

1,11,000 units

At a production of 75,000 units or less the contribution is ₹ 10 per unit (₹ 25 – 60% of 25) and works out to ₹ 7.50 lakhs as against the fixed costs of ₹ 8 lakhs. Therefore, has to be more than this level.

Total fixed cost is then ₹ 12 lakhs.

Contribution for first 75,000 units = ₹ 7,50,000

Hence, to meet ₹12 lakh fixed cost, further ₹ 4,50,000 contribution is required.

Contribution beyond 75,000 units is ₹ 12.5 (₹ 25 – 50% of 25).

Additional units to be sold = ₹4,50,000 /₹12.50 = 36,000 units

Total units = 75,000 + 36,000 = 1,11,000 units.

8. (ii)

₹ 12.90

Transfer Price = Marginal Cost – Opportunity Cost = ₹24 × 60% - 1.50 = 12.90.

9 (ii) The internal price is just another name for the TP. So it is not a method of transfer pricing.

10. (ii) Here market skimming would be more appropriate. A high price could be changed to the 'opinion leaders' who want to be seen to have the new product and are prepared to pay a high price.

DESCRIPTIVE TYPE QUESTIONS:

11. Write notes on :

(a) Difference between absorption costing and marginal costing

(b) Differential cost analysis

(c) Relevant Costs

(d) Sunk Costs

(e) Make or buy decisions

(f) Transfer pricing

(g) Methods of transfer pricing

Answer:

(a) Difference between Absorption costing and Marginal costing

	Absorption Costing	Marginal Costing
1.	Both fixed and variable costs are considered for product costing and inventory valuation.	Only variable costs are considered for product costing and inventory valuation.
2.	Fixed costs are charged to the cost of production. Each product bears a reasonable share of fixed costs and thus the profitability of a product is influenced by the apportionment of fixed costs.	Fixed costs are regarded as period costs. The profitability of different products is judged by their P/V ratio.
3.	Cost data are presented in conventional pattern. Net profit of each product is determined after subtracting fixed cost along with their variable cost.	Cost data are presented to highlight the total contribution of each product.
4.	The difference in the magnitude of opening stock and closing stock affects the unit cost of production due to the impact of related fixed costs.	The difference in the magnitude of opening stock and closing stock does not affect the unit cost of production.
5.	In case of absorption costing, as the production increases, the cost per unit reduces s because fixed cost per unit reduces, whereas, the variable cost remains the same per unit.	In case of marginal costing the cost per unit remains the same, irrespective of the production as it is valued at variable cost.

(b) **Differential Cost** is the change in the costs which results from the adoption of an alternative course of action. The alternative actions may arise due to change in sales volume, price, product mix (by increasing, reducing or stopping the production of certain items), or methods of production, sales, or sales promotion, or they may be due to 'make or buy' or 'take or refuse' decisions. When the change in costs occurs due to change in the activity from one level to another, differential cost is referred to as incremental cost or decremental cost, if a decrease in output is being considered, i.e. total increase in cost divided by the total increase in output.

The computation of differential cost provides a useful method of analysis for the management for anticipating the results of any contemplated changes in the level or nature of activity. When policy decisions have to be taken, differential costs worked out on the basis of alternative proposals are of great assistance.

The determination of differential cost is simple. Differential cost represents the algebraic difference between the relevant costs for the alternatives being considered. Thus, when two levels of activities are being considered, the differential cost is obtained by subtracting the cost at one level from the cost of another level.

(c) **Relevant Costs** are costs appropriate to aiding the making of specific management decisions (CIMA). They are estimated future costs that differ among alternatives. Similarly, relevant revenues and expected future revenues differ among alternatives. The two key aspects of relevance are:

i. The costs and revenues must occur in future, and

ii. They must differ among alternatives.

In decision making process, the decision maker must be aware of some pitfalls on account of various costs.

Examples are:

i. Sunk costs - be ignored as not relevant.

ii. Fixed Costs - if they change for the decision at hand, the changed portion only becomes relevant.

ii. Opportunity costs - They need not be overlooked (e.g., to outsource an activity when there is no idle capacity). An opportunity cost is the cost of an opportunity foregone by not using a limited resource in its next best alternative use.

(d) **Sunk costs** are costs that were incurred in the past. Sometimes, accountants use the term "sunk costs" to encompass committed costs as well. **Committed costs** are costs that will occur in the future, but that cannot be changed. Practically speaking, sunk costs and committed costs are not relevant with respect to any decision, because they cannot be changed. Experiments have been conducted that identify situations in which individuals, including professional managers, incorporate sunk costs in their decisions. One common example from business is that a manager will often continue to support a project that the manager initiated, long after any objective examination of the project seems to indicate that the best course of action is to abandon it. A possible explanation for why managers exhibit this behaviour is that

there may be negative repercussions to poor decisions, and the manager might prefer to attempt to make the project look successful, than to admit to a mistake.

(e) Make or Buy decisions refer to the decision making in relation to whether to produce a component/ product internally, or to buy it from outside. Marginal Costing and Opportunity Costing approaches are adopted in such decision-making. The following are the relevant considerations in Make or Buy decisions.

Relating to Suppliers	1. Quality of goods supplied by Supplier. 2. Reasonable certainty of the Supplier meeting the delivery dates, i.e. timeliness. 3. Availability of more than one Supplier to reduce the risk involved in buying. 4. Lead Time involved in receiving the materials versus time involved in own production. 5. Supplier Stability, i.e. whether the Supplier will support the Firm in the long-run also.
Relating to Labour	6. Availability of skilled labour, technical know-how and capability to make the product /component. 7. Labour relations - any adverse effect on labour relations if it is decided to buy instead of making. 8. Cost of labour redundancies, if any.
Relating to Capacity	9. Cost of Special Machineries to be installed in making the component. 10. Possible use of released capacity and facility as a result of buying instead of making. 11. Possibility of expanding the existing capacity or creating extra capacity (e.g. Overtime Work, Second Shift) 12. Process of making - whether confidential or patented or a general process. 13. Technical obsolescence associated with the component- whether investment in machinery is risky or not.
Other Factors	14. Seasonal demand of Components, leading to costs of inventory holding. 15. Price Stability and possibility of escalations in the Price of Components purchased. 16. Possibility of adverse Foreign Exchange Rate Fluctuations in respect of Imported Components. 17. Availability of transport and other infrastructure facilities for procuring the component from outside. 18. Behaviour of cost of make and cost of buy in the long run.

Cost Comparison

Cost of Making	Cost of Buying
Variable Costs + Specific Fixed Cost (if any) + Opportunity Cost (in case of full capacity operations)	Direct Purchase Costs + Purchase Related Costs like Buying Commission, Transportation, etc. + Opportunity Cost if any (e.g. Purchase of different quality Raw Material, leading to reduction in Selling Price of Finished Product).

Decision will be as under-

- If Cost of Making < Cost of Buying, then MAKE.
- If Cost of Making = Cost of Buying, the Firm is indifferent. (Non-cost factors to be considered)
- If Cost of Making > Cost of Buying, then BUY.

(f) Transfer Pricing:

Transfer price is the price that one segment (sub unit, department, division etc.,) of an organization charges for a product or services supplied to another segment of the same organization. Transfer prices are used when individual entities of a larger multi entity firm are treated and measured as separately run entities.

The benefits of Transfer Pricing Policy are as under:

i. Divisional performance evaluation is made easier.

ii. It will develop healthy inter-divisional competitive spirit.

iii. Management by exception is possible.

iv. It helps in co-ordination of divisional objectives in achieving organizational goals.

v. It provides useful information to the top management in making policy decisions like expansion, sub-contracting, closing down of a division, make or buy decisions, etc,

vi. Transfer Price will act as a check on supplier's prices.

vii. It fosters economic entity and free enterprise system.

viii. It optimizes the allocation of company's financial resources based on the relative performance of various profit centres, which in turn, are influenced by transfer pricing policies.

(g) Methods of Transfer Pricing

It is the notional value of goods and services transferred from one division to other division. In other words, when internal exchange of goods and services take place between the different divisions of a firm, they have to be expressed in monetary terms. The monetary amount for those inter divisional exchanges is called as 'Transfer Price'. The determination of transfer prices is an extremely difficult and delicate task as lot of complicated issues are involved in the same. Inter division conflicts are also possible. There are several methods of fixation of 'Transfer Price'. They are discussed below.

i. Pricing based on cost. In these methods, "cost" is the base and following methods fall under this category

   - Actual cost
   - Cost Plus
   - Standard Cost
   - Marginal Cost

ii. Market price as transfer price – Under this method, transfer price will be determined according to the prevailing market price

iii. Negotiated pricing – Under this method, the transfer prices are fixed through negotiations between the selling and buying divisions.

iv. Pricing based on opportunity cost – This pricing recognizes the minimum price that the selling division is ready to accept and the maximum price that the buying division is ready to pay.

12. Explain how CVP based Sensitivity Analysis, can help managers with uncertainty.

Answer:

(a) Sensitivity Analysis refers to analysis of the change in one factor on the other related factors. For example, what will be the effect of a 10% increase in Selling Price, on Sales Volume and Profits?

(b) Sensitivity Analysis focuses on how a result will be changed if the original estimates of the underlying assumptions change.

(c) CVP-based Sensitivity analysis will help top Management to get answers to questions like - What will be the Total Profit if the Sales Mix is changed to include more of Product L and less of Product M? or What will be the Profit if Fixed Costs increase by 30% and Variable Costs decline by 5%?, etc.

(d) CVP-based Sensitivity analysis can be performed in a Spreadsheet package, i.e. computerized CVP Models. Computers will quickly show changes both graphically and numerically based on data keyed in.

(e) 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 MIS Reports from the Financial Officer.

Thus, use of CVP-based Sensitivity analysis, helps Managers to cope up with uncertainty.

13. What is Penetration Pricing? What are the circumstances in which this policy can be adopted?

Answer:

Penetration Pricing is a policy of using a low price as the principal instrument for penetrating mass markets quickly. This method is used for pricing a new product and to popularize it initially. under this method Profits may not be earned in the initial stages. However, Prices may be increased as and when the product is established and its demand picks up.The low price policy is introduced for the purpose of long-term survival and profitability. Hence, careful analysis of the scope for market expansion and considerable amount of research and forecasting are necessary before determining the price under this strategy.

The circumstances in which Penetrating Pricing can be adopted are –

(i) **Elastic demand:** The demand of the product is high when price is low. Hence, lower prices mean large volume and so more profits.

(ii) **Mass Production:** When there are substantial savings in large-scale production, increase in demand is sustained by the adoption of low pricing policy.

(iii) **Frighten off competition:** The prices fixed at a low-level act as an entry barrier to the prospective competitors. The use of this policy by existing Firms will discourage the new firms to enter the market. The pricing policy is also known as "Stay-out-pricing".

14. Why is Transfer Pricing (TP) necessary in the organization? Show the impact of transfer prices to the 'selling' and 'buying' profit centers.

Answer:

'Transfer Pricing (TP)' is needed to monitor the flow of goods and services among the divisions of a company and to facilitate the divisional performance measurement. The main use of transfer pricing is to measure the notional sales of one division to another division. Thus the transfer prices used in the organization will have a significant effect on the performance evaluation of various divisions. It becomes necessary when there is internal transfer of goods or services and it is required to appraise the separate performances of the divisions/ departments involved.

If profit centers are to be used, transfer prices become necessary in order to determine the separate performances of both the 'buying' and 'selling' profit centers. If transfer prices are set too high, the 'selling center' will be favoured. On the other hand, if transfer prices are set too low, the 'buying center' will receive an unwarranted proportion of the profits.

PRACTICAL PROBLEMS:

15. The income statement of Ashok Gears Ltd. is summarized as below:

Net Revenue ……	**₹ 80,00,000**
Less: Expenses (including ₹ 40,00,000 of Fixed Cost) ……	**₹ 88,00,000**
Net Loss ……	**₹ 8,00,000**

The manager believes that an increase of ₹ 20,00,000 as fixed expenditure in advertising outlays will increase the sales substantially. His plan was approved by the Board.

You are required to calculate:

(i) At what sales volume will the Company have break even?

(ii) What sales volume will result in a Net Profit of ₹4,00,000?

Solution:

(i) Variable Expenses = ₹ (88,00,000 - 40,00,000) = ₹ 48,00,000

The Ratio of Variable Expenses and Total Revenue = 48,00,000 / 80,00,000 = 0.60

The Contribution Margin Ratio = (1 – 0.60) = 0.40

Let, Break Even Sales = S

Therefore, S = Variable Expenses + Fixed Expenses + Net Profit

= 0.60S (₹ 40,00,000 + ₹ 20,00,000) + 0

Or, S - 0.60S = ₹ 60,00,000

Or, 0.40 S = ₹ 60,00,000

Therefore, S = ₹ (60,00,000 / 0.40 = ₹ 150,00,000

Alternative Method: PV ratio = 40/100 = 40%

BE point = F. Cost/PV ratio

Therefore, Break Even Sales = 60,00,000 / 40% = ₹150,00,000

(ii) Computation of sales level to earn a Net Profit of ₹ 4,00,000

Required Sales = (Fixed Expenses + Target Net Profit) / Contribution Margin Ratio = ₹ (60,00,000 + 4,00,000)/ 0.40 = ₹ 160,00,000

16. MN Agarwal owns a Glft-5hop, a Restaurant and a Lodge in Shillong. Typically, he operates these only during the season period of 4 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-

(Amounts in ₹)

	Gift-Shop		Restaurant		Lodge	
	Amount	**%**	**Amount**	**%**	**Amount**	**%**
1. Receipts/ Sales	**48,000**	**100**	**64,000**	**100**	**1,80,000**	**100**
2. 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 Salaries	**2,880**	**6**	**8,000**	**12.50**	**39,600**	**22**
Electricity Charges	**4,800**	**10**	**4,800**	**7.50**	**25,200**	**14**
	960	**2**	**3,200**	**5**	**13,500**	**7.50**
Total	**39,360**	**82**	**64,000**	**100**	**1,28,700**	**71.50**
3. Profit	**8,640**	**18**	**-**	**-**	**51,300**	**28.50**

Additional information:

(a) 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.

(b) Insurances and Taxes and Depreciation are for the entire period of twelve months.

(c) Salaries paid are for the season period except a Chowkidar for the Lodge who is paid for the full year at ₹400 per month.

(d) Electricity Charges include Fixed Charges of ₹640, ₹1,920 and ₹9,900 for Gift-5hop, 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 Charges 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. Agarwal is interested in increasing his Net Income. The following options are under consideration -

(a) 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).

(b) To continue operations throughout the entire period of twelve months comprising season period of four months and offseason 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 rates during offseason period. The level of activity of Gift-Shop and Restaurant is expected at 80% and 30% during season and offseason period respectively but 5% discount on the original rates will have to be offered during off-season period.

Which option is profitable? As a Cost Accountant would you like to suggest him any other alternative based upon the above figures, which can be adopted to earn more net profit? (Use Incremental Revenue and Cost Approach.)

Solution:

Additional Revenues and Costs under Option (a): Operate during Season only (₹)

Particulars	Gift Shop	Restaurant	Lodge	Total
1. Additional Revenue	Given: 48,000 at 80%. So, for extra 10% = 48,000 x (10/80) = 6,000	Given: 64,000 at 80%. So, for extra 10% = 64,000 x (10/80)= 8,000	Given: 1,80,000 at 90%. So, for extra 10% = 180,000 x (10/90) = 20,000	34,000
2. Addnl. Costs (a) Cost of Sales (b) Supplies (c) Electricity Charges (d) Advertisement	 6,000 × 55% = 3,300 6,000 × 5% = 300 (960 - 640) × (10/ 80) =40	 8,000x55% =4,400 8,000 x 10% = 800 (3,200- 1,920)× (10/80) = 160	 Nil 20,000 X 8% = 1,600 (13,500- 9,900) x (10/90)= 400	 7,700 2,700 600 12,000
Sub-Total				23000
3. Addnl Profit				11000

(b) Additional Revenues and Costs under Option 2: Operate during all 12 months (amounts in ₹)

Particulars	Gift Shop	Restaurant	Lodge	Total
1. Additional Revenue	48,000 × 2 × (30%/80%)× 95% = 34,200	64,000 × 2 × (30%/80%)× 95% = 45,600	1,80,000 x 2 × (40%/90%) × 50% = 80,000	1,59,800
2. Addnl. Cost (a) Cost of Sales (b) Supplies (c) Salaries (d) Eiectricity - Fixed (e) Eiectricity - Variable	 36,000× 55% =19,800 36,000×5% = 1,800 4,800 × 2 = 9,600 640 x 2 = 1,280 (960-640) x 2 x (30%/80%) = 240	 48,000×55% = 26,400 48,000x10% = 4,800 4,800 x 2 = 9,600 1,920 × 2 = 3,840 (3,200 -1,920) x 2 x (30%/80%) = 960	 Nil 1,60,000 x 8% =12,800 (25200-4800) x 2 = 40,800 6,900 x 2 = 13,800 (13500- 9900) × 2 × (40%/90%) = 3,200	 46,200 19,400 60,000 18,920 4,400
Sub-Total				1,48,920
3. Addnl Profit				10,880

(c) Decision: Both options are desirable since there is an Additional Net Income. Option 1 is slightly better than Option 2 by ₹120. However, it is suggested that the Firm should adopt a combination of both options in which case, the Total Additional Profit will be ₹11,000 + ₹10,880 = ₹21,880.

17. S. H. Ltd., a cycle manufacturing company, has drawn up a programme for the manufacture of a new product for the purpose of fuller utilization of its capacity. The scheme envisages the manufacture of baby tricycle fitted with a bell. The company estimates the sales of tricycles at 10,000 during the first year and expects that from the second year onwards the sales estimates will stabilize at 20,000 tricycles. Since the company has no provision for the manufacture of the small bells specially required for the tricycles, the requirement of the bells is initially proposed to be met by way of purchase from the market at ₹8 each. However, if the company desires to manufacture the bell in its factory by installation of new equipment, it has two alternative proposals as under

	Installation of Super X Machine	Installation of Janta Machine
Initial Cost of Machine	**₹ 3.00 Lacs**	**₹ 2.00 Lacs**
Life	**10 Years**	**10 Years**
Fixed Overheads p.a. other than depreciation	**₹ 54000**	**₹ 28000**
Variable expenses per unit	**₹ 4.00**	**₹ 5.00**

Depreciation on machine should be charged on straight line basis.

Required:

(a) For each of the two levels of output namely 10,000 and 20,000 bells state with suitable workings whether the company should purchase the bells from market or install new equipment for manufacture of bells. If your decision is in favour of the installation of new equipment, which of the two new machines should be installed?

(b) What would be your decision in case the forecast of requirement from the second year onwards is estimated at 40,000 bells instead of 20,000 bells?

(c) At what volume of bells will the installation of the two machines break even.

Solution :

(a) Cost-Benefit Analysis of two machines at Output Level of 10,000 and 20,000 units

Output	**10000 units**		**20000 units**	
Details	**Super X**	**Janta**	**Super X**	**Janta**
Cost of buying @ ₹ 8	80000	80000	160000	160000
Cost of Manufacturing				
Variable cost	40000	50000	80000	100000
Depreciation on Machine	30000	20000	30000	20000
Fixed overheads	54000	28000	54000	28000
Total cost	124000	98000	164000	148000
Decision	Buy from	Market	Install Janta	Machine

(b) Buy/ manufacture decision at level of 40000 units

	Super X	**Janta**
Cost of Buying @ ₹ 8	3,20,000	3,20,000
Cost of Manufacturing		
Variable Cost	1,60,000	2,00,000
Depreciation on Machine	30,000	20,000
Fixed Overheads	54,000	28,000
Total Cost	2,44,000	2,48,000
Cost Saving on Manufacture	76,000	72,000

Decision – As Super X machine gives better saving, it should be installed at an estimated volume of 40000 units

(c) **Break – even volume of two machines**

It is that volume of production at which a manufacturer is indifferent as to which machine he should install as total cost on both machine is the same. This point is known as cost indifference point.

Let Break-even volume = x units

Cost on super-X Machine for x units = 54,000 + 30,000 + 4x = 84,000 + 4x …(1)

Cost on Janata Machine for x units = 20,000 + 28,000 + 5x = 48,000 + 5x …(2)

At cost indifference point total cost under two alternatives will be equal.

Therefore,

84,000 + 4x = 48,000 + 5x or x = 36,000 units.

So at 36,000 units, the installation of the two machines will break even.

18. A Company can produce any of its 4 products, A, B, C and D. Only one product can be produced in a production period and this has to be determined at the beginning of the production run. The production Capacity is 1,000 hours. Whatever is produced has to be sold and there is no Inventory build-up to be considered beyond the production period. The following information is given:

Particulars	A	B	C	D
Selling Price (₹ Per unit)	40	50	60	70
Variable Cost (₹ Per unit)	30	20	20	30
No. of units that can be sold	1,000	600	900	600
No. of production hours required per unit of product	1 hour	1 hour and 15 minutes	1 hour and 15 minutes	2 hours

What are the Opportunity Costs of A, B, C and D?

Solution:

Particulars	A	B	C	D
1. Contribution per unit (SP-VC)	40-30 = ₹10	50-20 = ₹30	60-20 = ₹40	70-30 = ₹40
2. Time Required	1 Hr	1.25 Hr	1.25 Hr	2 hrs
3. Possible Production Qty (1000/2)	1000 units	800 units	800 units	500 units
4. Possible Sales Qty	1000 units	600 units	900 units	600 units
5. Sales qty. lost due to production constraint	Nil	Nil	100 units	100 units
6. Opportunity Cost (5 x 1)	Nil	Nil	₹4000	₹4000

19. MNC Company assembles bicycles. This year's expected production is 10,000 units. MNC makes the Chains for Its bicycles. Its Accountant reports the following costs for making 10,000 Bicycle Chains-

Particulars	Costs per unit	Total for 10,000 units
Direct Materials	4.00	40,000
Direct Manufacturing Labour	2.00	20,000
Power and Utilities (variable)	1.50	15,000
Inspection, Set-Up and Materials Handling		2,000
Machine Rent		3,000
Allocated Fixed Costs of Plant Administration, Insurance,etc.		30,000
Total Costs		1,10,000

MNC received an offer from an outside vendor for the supply of any number of chains at ₹8.20 per Chain. The following additional information is available on MNC's operations –

- **Inspection, Set-up and Materials Handling Costs vary with the number of batches in which the Chains are produced. MNC currently produces the Chains in batches of 1000 units. It estimates that 10 batches are required for meeting the expected production requirements.**
- **MNC rents the machine used to make the Chains. If it chooses to outsource the Chains, machine rent can be avoided.**

Required:

a. Should MNC accept the Vendor's offer for 10,000 units? What is the net gain/ (loss)? What is the maximum price payable to the Vendor?

b. Suppose the Chains were purchased from outside, the facilities where the Chains are currently made will be used to upgrade the bicycles by adding Mud Flaps and Reflectors. As a result, the Selling Price of the Bicycles can be increased marginally by ₹ 20. The Variable Costs of the upgrade would be 18 and additional Tooling Costs of ₹ 16,000 would be incurred. Should MNC make or buy the Chains, at the anticipated production level of 10,000 units? What is the maximum price payable to the Vendor in this situation?

c. MNC's Sales Manager is concerned that the estimate of 10,000 units may be high and believes that only 6,200 units can be sold. Production will be cut back, freeing up work facilities and space. This space can be used to add the Mud Flaps and Reflectors whether MNC outsources the Chains or makes them in-house. At this lower output, MNC will produce the chains in 8 batches of 775 units each. Should MNC purchase the Chains from the Outside Vendor?

Solution :

(a) Computation of Relevant Costs of own production

Particulars	**Nature and Computation**	**Rupees**
Direct Materials	Variable and Relevant = ₹4 x 10,000 Variable and Relevant = 2	40,000
Direct Manufacturing labour	× 10,000 Variable and Relevant = 1.50 × 10,000 Batch Related	20,000
Power and Utilities	Production Costs= Specific and Relevant (given) Specifically	15,000
Inspection, Set up etc.	incurred = relevant Allocated and Irrelevant	2,000
Machine Rent		3,000
Fixed Costs		Nil
Total Relevant Costs for own production		80,000

Average Relevant Cost per unit for own production = (₹ 80,000/10,000) = ₹ 8 per unit

Since Cost of Buying ₹ 8.20 p.u. is higher than Average Relevant Cost ₹ 8, own production is preferable. Hence, the Company should not accept the Vendor's offer.

Maximum Price Payable = Relevant Cost = ₹ 8.00 per unit.

(b) Effect of Alternative use of facilities:

Additional Benefit from upgradation = 10,000 units x (`20 - 18) = ₹20,000

Less: Fixed Costs incurred specifically = ₹16,000

Net Additional Benefit = ₹4,000

Since this benefit will be foregone due to own production of Chains, the relevant cost of own production will then be 80,000 (as per WN 1) + ₹4,000 (Opportunity Cost) = ₹ 84,000.

Average Relevant Cost per unit for own production = ₹ 84,000/10,000 units = ₹ 8.40 per unit

Since Cost of Buying ₹ 8.20 p.u. is less than Average Relevant Cost ₹ 8.40, buying the chains is preferable now.

Maximum Price Payable = Relevant Cost = ₹ 8.40 per unit.

(c) Computation of Relevant Costs of Own Production, with Revision in Production Estimates

Particulars	**Nature and Computation**	**Rupees**
Direct Materials	Variable and Relevant = ₹ 4 x 6,200 units	24,800
Direct Manufacturing labour	Variable and Relevant = ₹ 2 x 6,200 units	12,400
Power and Utilities	Variable and Relevant = ₹ 1.50 × 6,200 units	9,300
Inspection, Set up etc.	Batch Related Costs = (2,000 + 10 batches)× 8 batches	1,600 3,000
Machine Rent	Specifically incurred = relevant	Nil
Fixed Costs	Allocated and Irrelevant	
Total Relevant Costs for own production		51,100

- Average Cost per unit for own production = (₹ 51,100/6,200 units) = ₹ 8.24 per unit
- Since Cost of Buying ₹ 8.20 p.u. is less than Average Relevant Cost ₹ 8.24, buying the chains is preferable.

Maximum Price Payable = Relevant Cost = ₹ 8.24 per unit

20. A machine which originally cost ₹12,000 has an estimated life of 10 years and it depreciated at the rate of ₹1,200 per year. It has been unused for some time, however, as expected production orders did not materialise. A special order has now been received which would require the use of the machine for two months. The current net realisable value of the machine is ₹ 8,000. If it is used for the job, its value is expected to fall to ₹ 7,500. The net book value of the machine is ₹ 8,400. Routine maintenance of the machine currently costs ₹ 40 per month. With use, the cost of maintenance and repairs would increase to ₹60 per month. What would be the relevant cost of using the machine for the order so that it can be charged as the minimum price for the order?

Solution :

Computation of relevant cost of using the machine for the order

Fall in sale value, if used (8000- 7500)	500.00
incremental maintenance cost [(60 - 40)× 2]	40.00
Total Relevant Cost	**540.00**

21. A Ltd has a system of assessment of Divisional performance on the basis of residual income, has two divisions A & B. Division A has an annual capacity to manufacture 15 lac numbers of a special component that it sells to outside customers, but has idle capacity. The budgeted residual income of Division A & B is ₹ 100 lacs and ₹120 lacs respectively. Other relevant budgeted details for Division A for the current year are :

Sale (outside customers)	**12 lac units @ ₹180/ unit**
Variable Cost per unit	**₹160**
Divisional Fixed Cost	**₹80 lac**
Capital Employed	**₹750 lac**
Cost of Capital	**12%**

Division B has just received a special order for which it requires components similar to the ones made by Division A. Owing to idle capacity of Division A, Division B has asked to quote for manufacture and supply of 3 Lac numbers of the components with a slight modification during final processing. Division A & B agree that additional variable cost will be ₹5 per unit.

Calculate the transfer price to be quoted to achieve the budgeted residual income by Division A

Solution :

Contribution required at budgeted residual income

	₹
Fixed cost	80,00,000
Profit on 750 lac x 12 %	90,00,000
Residual income	1,00,00,000
Total Contribution required (A)	**2,70,00,000**
Contribution derived from existing sale (B)	**2,40,00,000**
Contribution required on additional 3 lac units (A-B)	30,00,000

Contribution per unit (3000000/300000) = ₹ 10

Increase in variable cost per unit ₹ 5

Transfer price = Variable cost + Residual income + increase in variable cost

= 160+10+5 = ₹ 175 per unit

22. AB Ltd. Has two divisions Alfa & Beta. Alfa produces components, two units of which are required for one unit of final product produced by Beta. Alfa has a capacity to produce 20000 units and entire quantity is supplied to Beta @ ₹ 200/unit. Variable cost component at Alfa is ₹ 190 & fixed cost ₹ 20 per unit. For final product of Beta, per unit variable cost excluding component is ₹ 700, fixed cost ₹ 200 and selling price is ₹ 1500.

Alfa has placed a proposal for increasing the transfer price to ₹ 220 i.e. the market price.

Facility at Alfa can be rented out @ ₹ 3.00 Lacs p.a. Manager at Alfa wants to opt for this alternative

- **Beta can buy this component from outside market @ ₹210**
- **If capacity of Alfa is augmented to 40000 units with an additional investment of ₹15 lacs, it can sell 20000 units to external market and balance to Beta @₹210 per unit. Fixed cost for Alfa will be up by ₹1.00 lac. Evaluate and give you opinion**

a. Facility of Alfa is rented out and Beta buys from market @ ₹210 per unit

b. Alfa sells to outside market @ ₹ 220 and Beta buys @ 210 per unit from market

c. Capacity enhancement at the cost of capital @12%

Solution:

Present position on transfer of component @ ₹ 200:

Particulars	Division Alfa	Division Beta
Units sold	20000	10000
Selling price/unit	₹ 200	₹ 1,500
Variable cost/unit	₹ 190	₹ 1,100
Contribution /unit	₹ 10	₹ 400
Fixed cost /unit	₹ 20	₹ 200
Profit/unit	₹ - 10	₹ 200
Total Profit/ Loss	₹ -2,00,000	₹ 20,00,000

Overall profit for the company is ₹1800000.

a. Facility of Alfa is rented out and Beta buys from market @ ₹210 per unit

Particulars	Division Alfa	Division Beta
Units sold	0	10000
Selling price/unit		₹ 1,500
Variable cost/unit		₹ 1,120
Contribution /unit		₹ 380
Total Contribution		₹ 38,00,000
Fixed Cost		₹ 20,00,000
Rental Income	₹ 3,00,000	
Total Profit	₹ 3,00,000	₹ 18,00,000

Overall Profit for the Company is ₹ 21,00,000

b. Alfa sells to outside market @ ₹220 and Beta buys @ 210 per unit from market

Particulars	Division Alfa (Sale)	Division Beta
Units sold	20000	10000
Selling price/unit	₹ 220	₹ 1,500
Variable cost/unit	₹ 190	₹ 1,120
Contribution /unit	₹ 30	₹ 380
Total Contribution	₹ 6,00,000	₹ 38,00,000
Fixed Cost	₹ 4,00,000	₹ 20,00,000
Total Profit	₹ 2,00,000	₹ 18,00,000

Overall Profit for the Company is ₹ 20,00,000

c. Capacity enhancement at the cost of capital @12%

Particulars	Division Alfa (Sale)	Division Alfa (transfer)	Division Beta
Units sold	20000	20000	10000
Selling price/unit	₹ 220	₹ 210	₹ 1,500
Variable cost/unit	₹ 190	₹ 190	₹ 1,120
Contribution /unit	₹ 30	₹ 20	₹ 380
Total Contribution	₹ 6,00,000	₹ 4,00,000	₹ 38,00,000
Fixed Cost	₹ 4,00,000	₹ 1,00,000	₹ 20,00,000
Cost of Capital		₹ 1,80,000	
Total Profit	₹ 2,00,000	₹ 1,20,000	₹ 18,00,000

Overall profit for the company is ₹ 21,20,000

Since overall profit is the highest in option 'C', it can be adopted.

23. SV Ltd engaged in the manufacture of four products has prepared the following budget for 2015.

Products	A	B	C	D
Production Units	**20,000**	**5,000**	**25,000**	**15,000**
Selling Price ₹/unit	**21.75**	**36.75**	**44.25**	**64.00**
Direct Materials ₹/unit	**6.00**	**13.50**	**10.50**	**24.00**
Direct Wages ₹ /unit	**7.50**	**10.00**	**18.00**	**24.00**
Variable Overheads ₹ /unit	**5.00**	**6.00**	**6.50**	**2.25**
Fixed Overheads ₹ p.a.	**75,000**	**25,000**	**2,25,000**	**1,80,000**

When the budget was discussed, it was proposed that the production should be increased by 10,000 units for which capacity existed in 2015.

It was also decided that for the next year i.e. 2016, the production capacity should be further increased by 25,000 units over and above the increase of 10,000 units envisaged as above for 2015. The additional production capacity of 25,000 units should be used for the manufacture of product 'B' for which new production facilities were to be created at an annual fixed overhead cost of ₹35,000. The direct material costs of all the four products were expected to increase by 10% in 2016 while the other costs and selling prices would remain the same.

Required:

(a) Find the profit of 2015 on the assumption that the existing capacity of 10,000 units is utilised to maximize the profit.

(b) Prepare a statement of profit for 2016.

(c) Assuming that the increase in the output of product 'B' may not fully materialise in the year 2016, find the number of units of product B to be sold in 2016 to earn the same overall profit as in 2015.

Solution:

(a) Statement showing computation of profit for the year 2015

Sr	Particulars		A	B	C	D	Total
i	No. of Units		20000	30000	35000	15000	
ii	Selling Price	₹/unit	21.75	36.75	44.25	64.00	
iii	Variable Cost	₹/unit	16.35	28.50	34.50	54.50	
iv	Contribution	₹/unit	6.00	8.25	9.75	9.50	
v	Total Contribution	₹	1,20,000	41,250	3,41,250	1,42,500	6,45,000
vi	Fixed Cost	₹	75,000	25,000	2,25,000	1,80,000	5,05,000
vii	Profit	₹					1,40,000

(b) Statement showing computation of profit for the year 2016

Sr	Particulars		A	B	C	D	Total
i	No. of Units		20000	5000	35000	15000	
ii	Selling Price	₹/unit	21.75	36.75	44.25	64.00	
iii	Contribution	₹/unit	5.40	6.90	8.70	7.10	
iv	Total Contribution	₹	1,08,000	2,07,000	3,04,500	1,06,500	7,26,000
v	Fixed Cost	₹	75,000	60,000	2,25,000	1,80,000	5,40,000
vi	Profit	₹					1,86,000

(c) In order to get profit of 2015, the contribution to be recovered as follows

Particulars	₹
Profit for the year 2015	1,40,000
Revised fixed cost	5,40,000
Total contribution required	6,80,000
Contribution of A, C & D	5,19,000
Contribution to be recovered from B	1,61,000

No. of units required to be sold of B – 161000/6.90 = 23,333 units.

Additional units required = 23333 - 5000 = 18333

24. AB Cycles Ltd. has two divisions A & B. Division A produces bicycle frame and Division B assembles rest of the bicycle on the frame. There is a market for subassembly 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 the final product	**₹ 3,000/unit**
Long run market price of sub assembly	**₹ 2,000/unit**
Incremental cost of completing sub assembly	**₹ 1,500/unit**
Incremental cost in Division A	**₹ 1,200/unit**

Required:

a. If division A's maximum capacity is 1000 units pm and sales to the intermediate are now 800 units, should 200 units be transferred to B on long term average price basis

b. What would be the transfer price, if manager of Division B should be kept motivated

Solution:

The Company is having two options, option (a) to sell the product at sub assembly stage and option (b) at final stage. The contribution will be as follows

	Option (a)	Option (b)
Selling price	₹ 2,000	₹ 3,000
Incremental cost in Division A	₹ 1,200	₹ 1,200
Incremental cost in Division B		₹ 1,500
Total Variable Cost	₹ 1,200	₹ 2,700
Contribution	₹ 800	₹ 300

a. If Division B receives the sub assembly at market price of ₹ 2,000/- plus incremental cost of ₹ 1,500 will make the total cost of product ₹ 3,500, thereby yielding a loss of ₹ 500 per unit for Division B. Whereas the Company makes a profit of ₹ 300 per unit. So it is not advisable to transfer the sub assembly to Division B at long term average price.

b. In order to keep the manager of Division B motivated, the profit earned of ₹ 300 per unit should be shared between Division A & B.

Hence transfer price for Division B should be = Variable cost of Division A + 50% of profit per unit = 1200 + 50% x 300 = 122 + 150 = 1350 per unit

25. As a part of its rural upliftment programme, the Government has put under cultivation a farm of 96 hectors to grow tomatoes of four varieties: Royal Red, Golden Yellow, Juicy Crimson and Sunny Scarlet. Of the total 96 hectors, 68 hectors are suitable for all four varieties, but the remaining 28 hectors are suitable for growing only Golden Yellow and Juicy Crimson. Labour is available for all kinds of farm work and there is no constraint. The market requirement is that all four varieties of tomato must be produced with a minimum of 1,000 boxes of any one variety.

The farmers engaged have decided that the area devoted to any crop should be in terms of complete hectors and not in fractions of a hector. The other limitation is that not more than 22,750 boxes of any one variety should be produced. The following data are relevant.

Annual Yield	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet
Boxes per hector	350	100	70	180
Costs	₹	₹	₹	₹
Direct:				
Material per hector	476	216	196	312
Labour:				
Growing per hector	896	608	371	528
Harvesting & packing per box	3.60	3.28	4.40	5.20
Transport per box	5.20	5.20	4.00	9.60
Market price per box	15.38	15.87	18.38	22.27

Fixed overheads per annum

Growing	₹ 11,200
Harvesting	₹ 7,400
Transport	₹ 7,200
General Administration	₹ 10,200

Find out:

(i) within the given constraints, the area to be cultivated with each variety of tomatoes, if the largest total profit has to be achieved.

(ii) The amount of such profit in rupees.

A nationalized bank has come forward to help in the improvement programme of the 28 hectors in which only Golden Yellow and Juicy Crimson used to grow, with a loan of ₹5,000 at a very nominal interest of 6% per annum. When this improvement is carried out, there will be a saving of ₹1.25 per box in the harvesting cost of Golden Yellow and the 28 hectors will become suitable for growing Royal Red in addition to the existing Golden Yellow and Juicy Crimson varieties. Assuming that other constraints continue, find the maximum total profit that would be achieved when the improvement programme is carried out.

Solution:

Statement showing contribution per hectare and determination of priority for profitability.

Amount (₹)

	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet
(i) Sales realised per hectare	5383	1587	1286.6	4008.6
(ii) Variable cost:				
a. direct material	476	216	196	312
b. growing cost per hectare	896	608	371	528
c. harvesting and packing	1260	328	308	936
d. transport	1820	520	280	1728
	4452	1672	1155	3504
(iii) Contribution per hectare	931	-85	131.6	504.6
(iv) Priority	1	4	3	2

Statement showing optimum product mix under the given conditions and computation of profit at that mix

	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet	Total
Minimum boxes to be produced (Units)	1,000.00	1,000.00	1,000.00	1,000.00	
Area required for this minimum (hectors)	3.00	10.00	14.00	6.00	33.00
Remaining land Apportioned on the basis of given data according to priority (hectors)	59.00		4.00		63.00
(i) No. of hectares	62.00	10.00	18.00	6.00	96.00
(ii) Contribution per hectare (₹)	931.00	(85.00)	131.60	504.60	
(iii) Total contribution (₹)	57,722.00	(850.00)	2,368.80	3,027.60	62,268.40
(v) Fixed cost (₹)					36,000.00
(v) Profit (₹)					26,268.40

Statement showing optimum mix after the improvement programme and computation of profit

	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet	Total
Area required for this minimum (hectors)	3.00	10.00	14.00	6.00	33.00
Remaining land Apportioned on the basis of given data according to priority(hectors)	62.00			1.00	63.00
(i) No. of hectares	65.00	10.00	14.00	7.00	96.00
(ii) Contribution per hectare (₹)	931.00	40.00	131.60	504.60	
(iii) Total contribution (₹)	60,515.00	400.00	1,842.40	3,532.20	66,289.60
(iv) Fixed cost (₹)					36,300.00
(v) Profit (₹)					29,989.60

26. PH Ltd. manufactures and sells two products, namely BXE and DXE. The company's investment in fixed assets is ₹2 lakhs. The working capital investment is equivalent to three months' cost of sales of both the products. The fixed capital has been financed by term loan lending institutions at an interest of 11% p.a. Half of the working capital is financed through bank borrowing carrying interest at the rate of 19.4%, the other half of the working capital being generated through internal resources.

The operating data anticipated for 2016-17 is as under:

Product	**BXE**	**DXE**
Production per annum (in units)	**5,000**	**10,000**
Direct Material/unit:		
Material A (Price ₹ 4 per kg)	**1Kg**	**0.75Kg**
Material B (Price ₹ 2 per kg)	**1Kg**	**1Kg**
Direct labour hour	**5**	**3**

Direct wage rate is ₹ 2 per hour. Factory overheads are recovered at 50% of direct wages. Administrative overheads are recovered at 40% of factory cost. Selling and distribution expenses are ₹ 2 and ₹ 3 per unit respectively of BXE and DXE. The company expects to earn an after tax profit of 12% on capital employed. The income tax rate is 50%.

Required:

(i) Prepare a cost sheet showing the element wise cost, total cost, profit and selling price per unit of both the products.

(ii) Prepare a statement showing the net profit of the company after taxes for the 2016-17.

Solution:

(a) Cost sheet

	BXE		DXE		TOTAL
	PER UNIT	TOTAL	PER UNIT	TOTAL	
	₹	₹	₹	₹	₹
Direct material	6	30000	5	50000	80000
Direct wages	10	50000	6	60000	110000
Prime cost	16	80000	11	110000	190000
Factory OHs	5	25000	3	30000	55000
Factory cos	21	105000	14	140000	245000
Office OHs	8.40	42000	5.60	56000	98000
Cost of production	29.40	147000	19.60	196000	343000
Selling & dist. OHs	2	10000	3.00	30000	40000
Cost of sales	31.40	157000	22.60	226000	383000
Interest		14807		16481	31288
Profit		33420		37560	70980
Sales / S.P	**41.0454**	**205227**	**28.0041**	**280041**	**485268**

Working notes:

A. Return after tax [{383000 x 0.25} + 200000] 12% ₹ 35490

∴ Sales 383000 + 31288+35490 x (1/50%) = 485268

	BXE	DXE	Total
A. Interest	{(157000x0.25x0.50x19.4%) +(100000x11%)} = 14807	{(226000x0.25x0.50x19.4%) +(100000x11%)} = 16481	31288
B. Profit	{(157000x0.25)+100000}x12%x 1/50% = 33420	{(226000x0.25)+100000}x12%x1/50% = 37560	70980

(b) Statement showing net profit:

Sales	485268
(-) cost of sales	(383000)
Gross profit	102268
(-) interest {22000 + (95750/2) 19.4%}	(31288)
profit before tax	70980
(-) tax @ 50%	(35490)
Profit after tax	35490

Study Note – 3

STANDARD COSTING IN PROFIT PLANNING

Learning Objective: *To be able to implement better cost control by establishing standards and to be able to implement better profit planning through analysis of variances, within the organisation and Inter firm.*

OBJECTIVE TYPE QUESTIONS:

1. **Standard cost and budgeted cost are**
   - **(i) Interrelated but not interdependent.**
   - **(ii) Interdependent but not interrelated.**
   - **(iii) Interrelated and interdependent.**
   - **(iv) None of the above.**

2. **Which of the following statements is true?**
   - **(i) If the actual cost is more than the standard, we call it adverse variance and if the difference is less than the standard, we call it favorable variance.**
   - **(ii) In case of sales and profit, if the standard is more than actual, it is adverse variance and if the standard is less than the actual, it is favorable variance.**
   - **(iii) Both (i) and (ii).**
   - **(iv) None of the above.**

3. **Which of the following may be the cause of Material Price Variance?**
   - **(i) Change in quantity of purchase or uneconomical size of purchase order.**
   - **(ii) Failure to take advantage of off-season price or failure to purchase when price is cheaper.**
   - **(iii) Change in basic purchase price of material.**
   - **(iv) All of the above**

4. **Which of the following statements is correct?**
   - **(i) Standard costing facilitates the integration of accounts so that reconciliation between cost accounts and financial accounts may be eliminated.**
   - **(ii) Standard costs are planned costs determined on a scientific basis and they are based upon certain assumed conditions of efficiency and other factors.**
   - **(iii) Standard costing is defined as the preparation and use of standard cost, their comparison with actual cost and the measurement and analysis of variances to their cause and points of incidence.**
   - **(iv) All of the above.**

5. A standard costing system consists of the following key elements

(i) Setting standards for each of the operations.

(ii) Comparing the actual performance with the standard performance.

(iii) Analyzing and reporting variances arising from the difference between actual and standard performance.

(iv) All of the Above.

6. Variance analysis involves breaking down and analyzing the total variance to explain

(i) How much of the variance is caused by using the resources that are different from the standards, i.e. the quantity variance.

(ii) How much of the variance is caused by using the cost of the resources being different from the standards, i.e. the rate variance.

(iii) All of the Above.

(iv) None of the above

7. A factory operates at standard cost system, where 2,000 kgs of raw materials @ 12 per kg were used for a product, resulting in price variance of 6,000(F) and usage variance of 3,000(A). Then what will be the standard material cost of actual production?

(i) ₹3,000

(ii) ₹21,000

(iii) ₹30,000

(iv) ₹27,000

8. XYZ Ltd is a manufacturing company involved in the production of automobiles. Information from its last budget period is as follows:

Actual production 2, 75,000 Units

Budgeted Production 2, 50,000 Units

Actual fixed production Overheads ₹52, 60, 00,000

Budgeted fixed production Overheads ₹50, 00, 00,000

Then fixed overhead volume variance and expenditure variance will be:

(i) ₹5,00,00,000 (A), ₹2,60,00,000 (F)

(ii) ₹5,00,00,000 (F), ₹2,60,00,000 (F)

(iii) ₹5,00,00,000 (F), ₹2,60,00,000 (A)

(iv) ₹5,00,00,000 (A), ₹2,60,00,000 (A)

9. DM is a denim brand specializing in the manufacture and sale of hand-stitched jeans trousers. DM manufactured and sold 10,000 pairs of jeans during a period. Information relating to the direct labour cost and production time per unit is as follows:

	Actual Hours Per Unit	Standard Hours Per Unit	Actual Rate Per Hour	Standard Rate Per Hour
Direct Labour	0.65	0.60	₹120	₹100

During the period, 800 hours of idle time was incurred. In order to motivate and retain experienced workers, DM has devised a policy of paying workers the full hourly rate in case of any idle time.

Note: 0.65 hours per unit of actual time includes the idle time.

The idle time variance and labour efficiency variance will be:

(i) ₹80,000 (A), ₹30,000 (A)

(ii) ₹80,000 (A), ₹30,000 (F)

(iii) ₹80,000 (F), ₹30,000 (F)

(iv) ₹80,000 (F), ₹30,000 (A)

10. Direct Labour Efficiency Variance is calculated by the formula:

(i) (SH-AH) SR

(ii) (SH –AH) AR

(iii) (SR-AR) SH

(iv) (SQ-AQ) SR

11. Uniform costing is

(i) a separate method of costing

(ii) a type of costing

(iii) a technique of costing

(iv) None of the above

12. Efficiency Ratio is

(i) Available working days/ Budgeted working days x100

(ii) Budgeted hours / Maximum hours in budgeted period x 100

(iii) Standard hours / Actual hours x 100

(iv) None of the above

Answer:

1. (i) Interrelated but not interdependent.

2. (iii) Both (i) and (ii).

3. (iv) All of the above.

4. (iv) All of the above.

5. (iv) All of the above.

6. (iii) All of the above.

7. (iv) ₹ 27000.

Solution:

Total material cost variance = Material price variance + Material usage variance

= 6,000(F) + 3,000(A)

= 3,000(F)

Actual material cost = 2,000 x 12 = ₹24,000

Hence, the standard material cost of actual production = 24,000 + 3,000(F) = ₹27,000

8. (iii) ₹ 5,00,00,000 (F), ₹ 2,60,00,000 (A)

$$\text{Fixed Overhead Absorption Rate} = \frac{\text{budgeted fixed overheads}}{\text{budgeted output}}$$

$$= \frac{₹\ 50,00,00,000}{2,50,000\ \text{units}} = ₹\ 2,000 \text{ per unit}$$

Fixed Overhead Volume Variance:

Budgeted Fixed Overheads	₹ 50,00,00,000
Less: Absorbed Fixed Overheads (275000x2000)	₹ 55,00,00,000
Variance	₹ 5,00,00,000 (F)

The variance is favourable because XYZ Ltd. yielded a higher output than anticipated in the budget.

Fixed Overhead Expenditure Variance:

Actual fixed production overheads	₹ 52,60,00,000
Less: Budgeted fixed production overheads	₹ 50,00,00,000
Variance	₹ 2,60,00,000 (A)

The variance is adverse because XYZ Ltd. incurred greater expense than provided for in the budget.

9. (ii) ₹ 80,000 (A), ₹ 30,000 (F)

(a) Idle Time Variance:

Idle time variance = number of idle hours x standard rate

= 800 hours x ₹ 100

= ₹ 80,000 (A)

(b) Labour Efficiency Variance:

Total Hours = 10,000 units x 0.65 hours per unit

= 6,500 hours.

Active Hours = 6,500 hours - 800 idle hours

= 5,700 hours.

Standard Cost of Active Hours = Active Hours x Standard Rate

= 5,700 hours x ₹ 100 per hour

= ₹ 5, 70,000

Standard Hours = 10,000 units x 0.60 hours per unit

= 6,000 hours.

Standard Cost = Standard Hours x Standard Rate

= 6,000 hours x ₹ 100 per hour

= ₹ 6, 00,000

Labour Efficiency Variance = Standard Cost of Active Hours - Standard Cost

= ₹ 5, 70,000 – ₹ 6, 00,000

= ₹ 30,000 (F)

10. (i) (SH-AH) SR

11. (iii) a technique of costing

12. (iii) Standard hours / Actual hours x 100

DESCRIPTIVE QUESTIONS:

13. What are the advantages of Standard Costing?

Answer:

The advantages derived from a system of standard costing are stated below:

(a) Standard Costing system establishes yard-stick against which the efficiency of actual performance is measured.

(b) This system increases all round efficiency and productivity.

(c) At the very stage of setting the standards, waste of time and materials is eliminated. This assists in managerial planning for efficient operation and benefits all the divisions of the concern.

(d) Costing procedure is simplified.

(e) Cost data is available for various management purposes like fixation of selling prices, transfer price and valuation of stocks i.e. work-in-progress and finished stock and determining idle capacity.

(f) Standard costing is a planning exercise - in helps in budgetary controls.

(g) Standard costing system facilitates the fixation of responsibility for each department or individual.

(h) Variance analysis and reporting is based on the principles of management by exception. Variance analysis provides the ground for corrective measures to be taken in time.

(i) When constantly reviewed, the standards provide means for achieving cost reduction.

(j) Standard costs assist in performance analysis by providing ready means for preparation of information.

(k) Production and pricing policies may be formulated in advance before production starts. This helps in prompt decision-making.

(l) Standard costing facilitates the integration of accounts so that reconciliation between cost accounts and financial accounts may be eliminated.

(m) Standard costing helps in optimizing the use of plant capacities, current assets and working capital.

14. What is the Difference between Standard Costing and Budgetary Control?

Answer:

Like Budgetary Control, principles of Standard Costing assume that costs are controllable along definite lines of supervision and responsibility and it aims at managerial control by comparison of actual performances with suitable predetermined yardsticks. The basic principles of cost control, viz., setting up of targets or standards, measurement of performance, comparison of actual with the targets and analysis and reporting of variances are common to both standard costing and budgetary control systems. Both techniques are of importance in their respective fields and are complementary to each other. Thus, conceptually there is not much of a difference between standard costs and budgeted and the terms budgeted performance and standard performance mean, for many concerns one and the same thing.

Despite the similarity in the basic principles of Standard Costing and Budgetary Control, the two systems vary in scope and in the matter of detailed techniques. The difference may be summarized as follows:

(a) A system of Budgetary Control may be operated even if no Standard Costing system is prevailing in the concern.

(b) While standard is a unit concept, budget is a total concept.

(c) Budgets are the ceilings or limits of expenses above which the actual expenditure should not normally rise; if it does, the planned profits will be reduced. Standards are minimum targets to be attained by actual performance at specified efficiency.

(d) Budgets are complete in as much as they are framed for all the activities and functions of a concern such as production, purchase, selling and distribution, research and development, capital utilization, etc. Standard Costing relates mainly to the function of production and the related manufacturing costs.

(e) A more intensive analysis of the variances from standards is necessary than in the case of variations from the budget.

(f) Budgets are indices, adherence to which keeps a business out of difficulties. Standards are pointers for further possible improvements.

15. What is Fixed Overhead Variance?

Answer:

Fixed overhead cost variance is the difference between the standard costs of fixed overhead allowed for the actual output achieved and the actual fixed overhead cost incurred. The fixed overhead variance may be analyzed as below:

(a) Budget (or) Expenditure (or) Spending Variance:

Fixed overhead variance which arises due to the difference between the budgeted fixed overheads and the actual fixed overheads incurred during a particular period. It shows the efficiency in spending. Expenditure variance arises due to the following:

- Rise in general price level.
- Changes in production methods.
- Ineffective control.

Fixed Overhead Expenditure or Budget Variance = Budgeted Fixed Overhead – Actual Fixed Overhead

(b) Volume Variance:

Fixed overhead volume variance is the difference between standard costs of fixed overhead allowed for actual output and the budgeted fixed overheads for the period. This variance shows the over (or) under absorption of fixed overheads during a particular period. If the actual output is more than the budgeted output then there will be over recovery of fixed overheads and volume variance will be favorable and vice-versa. This is so because fixed overheads are not expected to change with the change in output. Volume variance arises due to the following reasons:

- Poor efficiency of workers & machinery
- Shortage of Orders & power.
- Ineffective supervision.
- More or less working days.

Volume variance (Fixed Overhead) = Recovered Fixed Overhead – Budgeted Fixed Overhead

Volume variance can be further sub divided into three variances namely:

(i) Capacity Variance:

It is that portion of the volume variance which is due to working at higher or lower capacity than the standard capacity. In other words, the variance is related to the under and over utilization of plant and equipment and arises due to idle time, strikes and lock-out, breakdown of the machinery, power failure, shortage of materials and labour, absenteeism, overtime, changes in number of shifts. In short, this variance arises due to more or less working hours than the budgeted working hours.

Capacity Variance = Standard Fixed Overhead Rate per Hour x(Actual Hour Worked–Budgeted hours)

Or = Standard Overhead – Budgeted Overhead

(ii) Calendar Variance:

It is that portion of the volume variance which is due to the difference between the number of working days in the budget period and the number of actual working days in the period to which the budget is applicable. If the actual working days are more than the budgeted working days the variance will be favorable and vice-versa.

Calendar Variance = Standard Rate per Hour or Per Day x Excess or Deficit Hours or Days Worked

(iii) Efficiency Variance:

It is that portion of the volume variance which is due to the difference between the budgeted efficiency of production and the actual efficiency achieved.

Efficiency Variance = Standard Fixed Overhead Rate per Hour x (Standard Hour for Actual Production – Actual hours)

Or = Recovered Fixed Overhead – Standard Fixed Overhead

16. Explain the problems concerning control of operations that a manufacturing company can be expected to experience in using a standard costing system during periods of rapid inflation.

Answer:

The problems concerning control of operations that a manufacturing company can be expected to experience in using a standard costing system during periods of rapid inflation are as follows:

(a) The formulations/setting of material standards makes assumptions about the inflation, which will prevail in future. If this assumption is not stated clearly then it is difficult to determine how much of price variance is due to inflation and how much is due to buying efficiency.

(b) Price indices tend to reflect average price changes. Consequently, it is difficult for a company to predict future costs and interpret variances if the specific rate of inflation for its inputs is considerably different from the general rate of inflation.

(c) Inflation may result in relative changes in the prices of inputs. Therefore, standard mixes requiring different inputs may no longer be the most efficient mix.

(d) If the standard prices are not adjusted then the efficiency variances will be understated.

(e) Sharp rise in prices will raise questions as to whether unadjusted standards can be used in the decision making process (e.g. pricing decisions).

(f) Administrative work involved in maintaining upto-date standards when prices are constantly changing will increase.

17. What is Uniform costing? Explain the desired situations for its implementation?

Answer:

Uniform costing is a technique of costing and can be applied to any industry. It may be defined as the application and use of the same costing principles and procedures by different organizations under the same management or on a common understanding between members of an association. Main features –

- Uniform systems are used across the industry
- Reports generated can be comparable across the industry or group.

Situations for implementation of Uniform Costing

The success of Uniform Costing system will depend upon the following:

- There should be free exchange of ideas and methods
- There should be a spirit of mutual trust, cooperation and a policy of give and take amongst the participating members
- The bigger units should be ready to pass on the information relating to improvements, efficiency enhancement and research & know how to smaller units
- There should be complete transparency and no sense of rivalry amongst the group members

18. What is Inter Firm comparison?

Answer:

Inter firm comparison is a technique of evaluating the performances, efficiencies, deficiencies, costs and profits of similar nature of firms engaged in the same industry. It consists of exchange of information relating to production, sales, cost and its break up, prices and profits etc. amongst the participating firms. The basic purpose is to find out the points of improvement by taking appropriate measures to wipe out the weakness gradually over a period of time.

Use of this technique helps in developing cost consciousness amongst the member industry and reduces the time and efforts taken for analyzing the information and making it useful for management decision making.

PRACTICAL PROBLEMS:

19. A company manufacturing a special type of fencing tile 12" × 8" × 1/2" used a system of standard costing. The standard mix of the compound used for making the tiles is:

1,200 kg. of material A @ ₹ 0.30 per kg.

500 kg. of Material B @ ₹ 0.60 per kg

800 kg. of Material C @ ₹ 0.70 per kg

The compound should produce 12,000 square feet of tiles of 1/2" thickness. During a period in which 1,00,000 tiles of the standard size were produced, the material usage was:-

Kg		₹
7,000	**Material A @ ₹ 0.32 per kg.**	**2,240**
3,000	**Material B @ ₹ 0.65 per kg.**	**1,950**
5,000	**Material C @ ₹ 0.75 per kg.**	**3,750**
15,000		**7,940**

Present the cost figures for the period showing Material price, Mixture, Sub-usage Variance.

Answer:

Area of tile =12" x 8 " = 2/3 sq ft

No of tiles that can be laid in 12000 sq ft is 12000/(2/3) = 18000

	Standard Data			Actual Data		
	Quantity	**Price**	**Value**	**Quantity**	**Price**	**Value**
A	6,666.67	0.30	2,000	7,000	0.32	2,240
B	2,777.77	0.60	16,667	3,000	0.65	1,950
C	4,444.44	0.70	3,111	5,000	0.75	3,750
	13,888.89		6,778	15,000		7,940

Q for A = 1200*1,00,000/18,000 = 6,666.67

Q for B = 500*1,00,000/18,000 = 2,777.77

Q for C = 800*1,00,000/18,000 = 4,444.44

	SQSP	RSQSP	AQSP	AQAP
A		7,200 x 0.3	7,000 x 0.3	
B		3,000 x 0.6	3,000 x 0.6	
C		4,800 x 0.7	5,000 x 0.7	
A		2,160	2,100	
B		1,800	1,800	
C		3,360	3,500	
	₹ 6,778	₹ 7,320	₹ 7,400	₹ 7,940

- RSQ for A = (15000/13888.89) x 666667
- Material sub usage variance = ₹ 542(A)
- Material mix variance = ₹ 80(A)
- Material usage variance = ₹ 622(A)
- Material price variance = ₹ 540(A)
- Material cost variance = ₹ 1162(A)

20. GLOBAL Ltd. is engaged in marketing of wide range of consumer goods. A, B, C and D are the zonal sales officers for four zones. The company fixes annual sales target for them individually. You are furnished with the followings.

- **The standard costs of sales target in respect of A, B, C, D are ₹ 5,00,000, ₹ 3,75,000, ₹ 4,00,000 and ₹ 4,25,000 respectively.**
- **A, B, C, D 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.**
- **The relevant variances as computed by a qualified cost accountant are as follows.**

	A	B	C	D
	₹	₹	₹	₹
Sales price variance	**4000(F)**	**6000(A)**	**5000(A)**	**2000(A)**
Sales volume variance	**6000(A)**	**6000(F)**	**15000(F)**	**8000(F)**

(A) = Adverse variance and (F) = Favorable variance

You are required to compute the amount of target sales and margin fixed in case of each of the zonal sales officers.

Answer:

	A	B	C	D
Actual Sale	5,98,000 (29900/5%)	4,70,000 (23500/5%)	4,90,000 (24500/5%)	5,16,000 (25800/5%)
Sales Value Variance	2000 A (6000A-4000F)	0 (6000F-6000A)	10000 F (15000F-5000A)	6000 F (8000F-2000A)
Budgeted Sales	6,00,000 (598000-(2000))	4,70,000 ((470000-0)	4,80,000 (490000-10000)	5,10,000 (516000-6000)
Budgeted Margin	1,00,000 (600000-500000)	95,000 (470000-375000)	80,000 (480000-400000)	85,000 (510000-425000)

21. ABC 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 government)	**10.00**

The actual production and sales for the period were 14,400 units. There has been no price revision by the Government during the period.

The following are the variances worked out at the end of the period.

Direct Material		Favorable (₹)	Adverse (₹)
	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
Administration Overheads			
	Expenditure		400
	Volume		1,680

You are required to:

(a) Ascertain the details of actual costs and prepare a Profit and Loss Statement for the period showing the actual Profit/Loss. Show the workings clearly.

(b) Reconcile the actual Profit with standard profit.

Answer:

Statement showing the actual profit and loss statement:

Particulars		Amount	Amount
		₹	₹
1.	Standard Material Cost (14400 x 4.50)	64800	
	Add: Price Variance	4250	
	Less: Usage Variance	(1050)	68000
2.	Standard Labour Cost (14400 x 3)	43200	
	Add: Rate Variance	4000	
	Less: Efficiency Variance	(3200)	44000
3.	Direct Expenses (14400 x 0.50)		7200
4.	Factory Overhead:		
4.a.	Variable (14400 x 0.25)	3600	
	Less: Expenditure Variance	(400)	3200
4.b.	Fixed (14400 x 0.30)	4320	
	Add: Volume Variance	1680	
	Less: Expenditure Variance	(400)	5600
4.c.	Administration Overhead (14400 x 0.3)	4320	
	Add: Volume Variance	1680	
	Add: Exp. Variance	400	6400
5.	Total Cost		134400
6.	Profit (B/F)		9600
7.	Sales		144000

Statement showing reconciliation of standard profit with actual profit

Particulars	Amount (₹)	Amount (₹)
Standard Profit (14400 x 1.15)		16,560
Add: Material usage variance	1,050	
Labour efficiency variance	3,200	
Variable overhead expenditure variance	400	
Fixed overhead expenditure variance	400	5,050
		21,610
Less: Material price variance	4,250	
Labour rate variance	4,000	
Fixed overhead volume variance	1,680	
Administration expenditure variance	400	
Administration volume variance	1,680	12,010
Actual Profit		**9,600**

22. In a company 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:

	STANDARDS (₹)	ACTUALS (₹)
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**
Standard hours 50,000		
Actual hours 40,500		

- **The Standard material content of each unit is estimated at 25 kg. at ₹ 1 per kg, actual figures were 26 kg at ₹1.10 per kg.**
- **Semi-variable Overhead consists of FIVE - NINTHS fixed expenses and FOUR - NINTHS variable.**
- **The Standard wages per unit are 5 hours at `1.50, per Unit actual wages were 4.5 hours at `1.75.**
- **There were no opening stocks and the whole production for the period was sold.**
- **The four week period was normal period.**

You are required:

(a) To compute the variances in Sales, Materials, Labour and Over heads 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.

Answer:

Working notes:

	Budget (₹)	Actual (₹)
Fixed overhead	20,000	18,810
Share in semi variable overheads (5/9)	1,500	1,350
	21,500	20,160
Variable overheads	10,000	9,250
Share in semi variable overheads(4/9)	1,200	1,080
	11,200	10,330

Variances:

⇒ Sales

(1)	(2)	(3)
AQAP	AQSP	SQSP
51.25 x 9000	50 x 9000	50 x 10000
₹ 4,61,250	₹ 4,50,000	₹ 5,00,000

AQAP = actual value of sales = ₹461250

AQSP = actual sales at standard prices = ₹ 450000

SQSP = standard value of sales = ₹ 500000

(a) Sales volume variance = (2) – (3) = 50000(A)

(b) Sales price variance = (1) – (2) = 11250(F)

(c) Sales value variance = (1) – (3) = 38750(A)

⇒ Material

(1)	(2)	(3)
SQSP	AQSP	AQAP
1 x 225000	1 x 234000	1.1 x 234000
225000	234000	257400

AQ = 9000 x 26 = 234000

SQ = 9000 x 25 = 225000

1. Standard cost of standard material = ₹ 225000
2. Standard cost of actual material = ₹ 234000
3. Actual cost of material = ₹ 257400
   (a) Material usage variance = (1) – (2) = ₹ 9000(A)
   (b) Material price variance = (2) – (3) = ₹ 23400(A)
   (c) Material cost variance = (1) – (3) = ₹ 32400(A)

⇒ Labour

(1)	(2)	(3)
SRSH	SRAH	ARAH
1.5 x 45000	1.5 x 40500	1.75 x 40500
₹67500	₹60750	₹70875

SH = 9000 x 5 = 45000

1. SRSH = standard cost of standard labour = ₹ 67500
2. SRAH = standard cost of actual labour = ₹ 60750
3. ARAH = actual cost of labour = ₹ 70875
   (a) Labour efficiency variance = (1) – (2) = ₹ 6750(F)
   (b) Labour rate variance = (2) – (3) = ₹ 10125(A)
   (c) Labour cost variance = (1) – (3) = ₹ 3375(A)

⇒ Variable OHs

(1)	(2)	(3)
SRSH	SRAH	ARAH
0.224 x 45000	0.224 x 40500	10330
₹10080	₹9072	₹10330

SR = 11200/50000 = ₹ 0.224

1. SRSH = standard cost of standard variable OHs = ₹ 10080
2. SRAH = standard cost of actual variable OHs = ₹ 9072
3. ARAH = actual cost of variable OHs = ₹ 10330
   (a) Variable OHs efficiency variance = (1) – (2) = ₹ 1008(F)

(b) Variable OHs budget variance =(2) – (3) = ₹ 1258(A)

(c) Variable OH cost variance = (1) - (3) = ₹ 250(A)

⇒ Fixed OHs

(1)	(2)	(3)	(4)
SRSH	SRAH	SRBH	ARAH
0.43 x 45000	0.43 x 40500	0.43 x 50000	
₹ 19,350	₹ 17,415	₹ 21,500	₹ 20,160

SR = 21500/50000 = 0.43

1. SRSH = Standard cost of standard fixed OHs = ₹ 19350
2. SRAH = standard cost of actual fixed OHs = ₹ 17415
3. SRBH = budgeted fixed OHs = ₹ 21500
4. ARAH = actual fixed OHs = ₹ 20160

(a) Fixed OHs efficiency variance = (1) – (2) = ₹ 1935(F)

(b) Fixed OHs capacity variance = (2) –(3) = ₹ 4085(A)

(c) Fixed OHs volume variance = (1) – (3) = ₹ 2150(A)

(d) Fixed OHs budget variance = (3) – (4) = ₹ 1340(F)

(e) Fixed OH cost variance = (1) – (4) = ₹ 810(A)

Statement showing reconciliation of actual & standard profits:

		₹
Budgeted sales		5,00,000
(+) sales price variance	11,250	
(-) sales volume variance	(50,000)	(38,750)
Actual sales		4,61,250
(-) standard cost of sales		
Material {250000 x (9/10)}	2,25,000	
Wages {75000 x (9/10)}	67,500	
Fixed OHs {21500 x(9/10)}	19,350	
Variable OHs {11200 x (9/10)}	10,080	3,21,930
Standard profit		1,39,320

Add favorable variances		
Labour efficiency variance	6,750	
Variable OH efficiency variance	1,008	
Fixed OH efficiency variance	1,935	
Fixed OH budget variance	1,340	11,033
		1,50,353
Less adverse variances	₹	₹
Material usage variance	9,000	
Material price variance	23,400	
Labour rate variance	10,125	
Variable OH budget variance	1,258	
Fixed OH capacity variance	4,085	47,868
Actual profit		**1,02,485**

23. X uses traditional standard costing system. The inspection and setup costs are actually ₹ 1,760 against a budget of ₹ 2,000.

ABC system is being implemented and accordingly, the number of batches is identified as the cost driver for inspection and setup costs. The budgeted production is 10,000 units in batches of 1,000 units, whereas actually, 8,800 units were produced in 11 batches.

(a) Find the volume and total fixed overhead variance under the traditional standard costing system.

(b) Find total fixed overhead cost variance under the ABC system.

Answer:

(a) Calculation of volume and total fixed overhead under Traditional Standard Costing System

Budgeted overhead cost per unit	=	₹2,000/10,000 units	= ₹ 0.20
Actual overhead cost per unit	=	₹1,760/8,800 units	= ₹ 0.20
Total fixed overhead variance	=	Absorbed budgeted overhead - Actual overhead	
	=	(₹ 0.20 x 8,800 units) - ₹1,760	= Nil
Fixed overhead expenditure variance	=	Budgeted overhead - Actual overhead	
	=	2,000 - 1,760	= ₹ 240 (F)
Standard absorption rate	=	₹ 2,000/10,000 units	= ₹ 0.20 per unit
Fixed overhead volume variance	=	Standard absorption rate x (Budgeted units - Actual units)	
	=	₹0.20 (10,000 units - 8,800 units)	= ₹ 240 (A)
Verification:			
Total fixed overhead variance	=	Expenditure variance + Volume variance	
	=	240 (F) + 240 (A)	= Nil

(b) Calculation of fixed overhead cost variance under ABC System

Particulars	Budget	Actual	ABC standard
Total cost (₹)	2,000	1,760	1,800
Production (units)	10,000	8,800	8,800
No. of batches	10	11	9
Batch size (units/batch)	1,000	800	1,000
Cost per batch	200	160	200

Under ABC 8,800 units should have been produced in standard batch size of 1,000 units/batch.

No. of batches	= 8,800/1,000	= 9 approx.
Standard cost under ABC	= Budgeted cost per batch × ABC standard number of batches	
	= ₹ 200 x 9	= 1,800

Under ABC, variability is with respect to batches and not units

Absorbed overheads	= 9 batches × Standard rate per batch	
	= 9 × ₹ 200	= ₹ 1,800
Actual overheads	= ₹ 1,760	
Total overheads cost variance	= ₹ 40 (F)	

24. The summarized results of a company for the two years ended 31st December 2014 and 2015 are given below:

	2015	2014
	₹ lacs	₹ lacs
Sales	**770**	**600**
Direct Materials	**324**	**300**
Direct Wages	**137**	**120**
Variable Overheads	**69**	**60**
Fixed Overheads	**150**	**80**
Profit	**90**	**40**

As a result of re-organization of production methods and extensive advertisement campaign use, the company was able to secure an increase in the selling prices by 10% during the year 2015 as compared to the previous year.

In the year 2014, the company consumed 1,20,000 Kgs. of raw materials and used 24,00,000 hours of direct labour.

In the year 2015, the corresponding figures were 1,35,000 kgs of raw materials and 26,00,000 hours of direct labour.

You are required to:

Use information given for the year 2014 as the base year information to analyze the results of the year 2015 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 2015.

Answer:

A. Sales Variance

1) Sales price variance = 770 – {770 x (100/110)} = ₹ 70(F)
2) Sales volume variance = {770 x (100/110)} - 600 = ₹ 100(F)

   % increase in volume = (100/600) x 100 = ₹ 16.67%
3) Sales value variance = 770 – 600 = ₹ 170(F)

B. Material Vaiance

Material price = (30000000)/120000 = ₹ 250/-

Material expected to be used = (120000/600) x 700 = 140000 Kgs

Standard Material Cost = 140000 X ₹ 250 = ₹ 350 Lacs

4) Material cost variance = 350 – 324 = ₹ 26 (F)
5) Material volume variance = 300 x (1/6) = ₹ 50(A)
6) Material usage variance = 5000 x 250 = ₹ 12.5 (F)
7) Material price variance = (250-240) x 135000 = ₹ 13.5 (F)

C. Labour Variance

Labour hours expected to be used = (2400000/600) x 700 = 2800000

Labour rate = (12000000)/(2400000) = ₹ 5/-

Standard labour cost = 2800000 x 5 = ₹ 140 lacs

8) Labour cost variance = ₹ 140 -137 = ₹ 3 (F)
9) Labour volume variance = 120/6 = ₹ 20(A)
10) Labour efficiency variance = 2 x 5 = ₹ 10 (F)
11) Labour rate variance = 20 – 3 -10 = ₹ 7 (A)

D. Overhead Variance

Standard variable overheads = ₹ 60 + (₹ 60 x 16.67%) = ₹ 70

Standard variable overheads rate per hour = ₹ 60 /24 = ₹ 2.5

12) VOH cost variance = 70 – 69 = ₹ 1(F)

13) VOH volume variance = 60/6 = ₹ 10(A)

14) VOH efficiency variance = (2800000 -2600000) x 2.5 = ₹ 5 (F)

15) VOH expenditure variance = 10 – 1 – 5 = ₹ 4(A)

16) FOH cost variance = ₹ 70(A)

Profit reconciliation statement:

		₹ in lakhs
Profit for 2014		40
(+) sales variance:		
Price	70	
Volume	100	
Material variance:		
Usage	12.50	
Price	13.50	
Labour variance-efficiency	10	
VOH efficiency variance	5	211
		251
(-) material volume variance	50	
Labour variance:		
Volume	20	
Rate	7	
VOH variances:		
Volume	10	
Expenditure	4	
FOH cost variance	70	161
Profit for 2015		90

25. A Company manufactures two products X and Y. Product X requires 8 hours to produce while Y requires 12 hours. In April, 2013, 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.

Calculate Capacity, Activity and Efficiency ratios and establish their relationship.

Answer:

		(Hours)
Standard hours of production		
Product X	(1,200 units x 8 hrs.)	9,600
Product Y	(800 units x 12 hrs.)	9,600
Total standard hours		19,200
Actual hours worked	(100 workers x 8 hrs. x 22 days)	17,600
Budgeted hours per month	(1,86,000 hrs./12 months)	15,500

Capacity Ratio $= \frac{\text{Actual Hours Worked}}{\text{Budgeted hours p.m.}} \times 100 = \frac{17,600}{15,500} \times 100 = 113.55\%$

Efficiency Ratio $= \frac{\text{Standard hours of production}}{\text{Actual Hours Worked}} \times 100 = \frac{19,200}{15,500} \times 100 = 109.09\%$

Activity Ratio $= \frac{\text{Standard hours of production}}{\text{Budgeted hours p.m.}} \times 100 = \frac{19,200}{15,500} \times 100 = 123.87\%$

Relationship of Ratios

Activity Ratio = Efficiency Ratio x Capacity Ratio

$123.87 = \frac{109.09 \times 113.55}{100}$

26. X Ltd. produces and sells a single product. Standard cost card per unit of the product is as follows:

(₹)

Direct materials:	**A**	**(10 kg.@ 5 per kg.)**	**50**
	B	**(5 kg. @ 6 per kg.)**	**30**
Direct wages		**(5 hours @ 5 per hour)**	**25**
Variable production overheads		**(5 hours @ 12 per hour)**	**60**
Fixed production overheads			**25**
Total standard cost			**190**
Standard gross profit			**35**
Standard selling price			**225**

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**
Total			**3,82,500**
Gross profit			**67,500**

The material price variance is extracted at the time of receipt of materials. Material purchase were Material A 20,000 kg. @ ₹ 5.25 per kg & B 11,500 kg. @ ₹ 5.70 per kg.

Required:

(i) Calculate all variances.

(ii) Prepare an operating statement showing standard gross profit, variances and actual gross profit.

(iii) Explain the reason for the difference in actual gross profit given in the question and calculated in (ii) above.

Answer:

(i) Calculation of variances

	Material Variances			
	Standard quantity for actual output	A = 2,000 x 10		= 20,000 kg.
		B = 2,000 × 5		= 10,000 kg.
	Revised standard quantity:	A = 20,000/30,000 x 29,650		= 19,766.67 kg.
		B = 10,000/30,000 × 29,650		= 9,883.33 kg.
	Standard yield	= (2,100/31,500) x 29,650		= 1,976.67
(a)	Material price variance	= (SP - AP) AQ		
		A = (5 - 5.25) × 20,000	= 5,000 (A)	
		B = (6- 5.7) × 11,500	= 3,450 (F)	= ₹ 1,550 (A)
(b)	Material usage variance	=(SQ- AQ) SP		
		A = (20,000 - 18,900) × 5	= 5,500 (F)	
		B = (10,000 - 10,750) × 6	= 4,500 (A)	= ₹ 1,000 (F)
(c)	Material mix variance	= SP (RSQ - AQ)		
		A = (19,766.67- 18,900)×5	= 4,333.33 (F)	
		B = (9,883.33 -10,750)×6	= 5,200.00 (A)	= ₹ 866.67 (A)

(d)	Material yield variance	= SR (AY - SY)		
		= (2,000- 1,976.67) × 80		= ₹ 1,866.67 (F)
Labour Variances				
(a)	Labour rate variance	= (SR- AR)AH		
		= (5 - 4.8) × 10,500		= ₹ 2,100 (F)
(b)	Labour efficiency variance	= SR (SH-AH) = (10,000 - 10,300) × 5		= 1,500(A)
(c)	Labour idle time variance	= Idle hours x SR = 200 × 5		= 1,000 (A)
	Variable Overhead Variances			
	Recovered variable Overheads Standard variable overheads	= 2000 x 60 = 120000 = 10300 x 12 = 123600		
(a)	V. OH. cost variance	= Recovered overhead - Actual overhead = (2,000 X 60 - 1,15,000)		= ₹ 5,000 (F)
(b)	V. OH. exp. Variance	= Standard variable overhead - Actual variable overhead = (10,300 × 12) - 1,15,000		= 8,600 (F)
(c)	V. OH. Efficiency variance	= Recovered variable overhead - Standard variable overhead = 1,20,000 - 1,23,600		= ₹ 3,600 (A)
	Fixed overhead variances			
	Recovered fixed overheads Budgeted fixed overheads	= 2000 x 25 = ₹50000 = (25200 x25)/12 = 52500		
(a)	Fixed OH. cost variance	= Recovered overhead - Actual overhead = (2,000 × 25) - 56,600		= ₹ 6,600 (A)
(b)	Fixed OH. exp. Variance	= Budgeted overhead- Actual overhead = ((25,200 × 25) / 12) - 56,600		= ₹ 4,100 (A)
(c)	Fixed OH. Volume variance	= Recovered overhead- Budgeted overhead = (50,000 - 52,500)		= ₹ 2,500 (A)

(ii) Reconciliation Statement(₹)

	Price	Favourable	Adverse	
Standard profit (35 x 2,000)				70,000
Variances				
Material		-	1,550.00	
	Mix	-	866.67	
	Yield	1,866.67	-	

Labour	Rate	2,100.00	-	
	Efficiency	-	1,500.00	
	Idle time	-	1,000.00	
Variable overheads	Expenditure	8,600.00	-	
	Efficiency	-	3,600.00	
Fixed overheads	Expenditure	-	4,100.00	
	Volume	-	2,500.00	
		12,566.67	15,116.67	2,550 (A)
Actual profit				**67,450**

(iii) Actual gross profit given in the question is 67,500 while calculated operating 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

A	=	18,900 × (5 - 5.2S)	=	4,725 (A)	
B	=	10,750 × (6 - 5.70)	=	3,225 (F)	= ₹ 1,500 (A)

Over recovery in the operating statement is 50 (i.e. 1,550 - 1,500), should be added in actual profit ₹ 67,500.(i.e. 67,450 + 50)

27.

	(₹ In lakhs)	
	31-3-2014	**31-3-2015**
	₹	₹
Sales	**120**	**129.6**
Prime cost of sales	**80**	**91.1**
Variable Overheads	**20**	**24.0**
Fixed expenses	**15**	**18.5**
PROFIT	**5**	**(4.0)**

During 2014-15, average prices increased over those of the previous years

(1) 20% in case of sales (2) 15% in case of prime cost (3) 10% in case of Overheads.

Prepare a profit variance statement from the above data.

Answer:

Calculation of variances:

1. Sales Price Variance : 129.60 – (129.60 x 100/120) = ₹ 21.60 (F)
2. Sales Volume Variance : (129.60 x 100/120) - 120 = ₹ 12 (A)

   (Reduction in sales volume = 10%)
3. Sales Value Variance : 129.60 –120 = ₹ 9.60 (F)
4. Prime Cost price Variance : (91.10 x 100/115) – 91.10 = ₹ 11.88 (A)
5. Prime Cost Volume Variance = 80 x 10/100 = ₹ 8 (F)
6. Prime Cost Usage or efficiency Variance = (80 x 90/100) - (91.10 x 100/115) = ₹ 7.22 (A)
7. Prime Cost Variance : 80 – 91.1 = ₹ 11.1 (A)
8. Variable Overhead Price Variance = (24 x 100/110) - 24 = ₹ 2.18 (A)
9. Variable Overhead Volume Variance = 20 x 10/100 = ₹ 2 (F)
10. Variable Overhead Efficiency Variance = (20 x 90/100) - (24 x 100/110) = ₹ 3.82 (A)
11. Variable Overhead Cost Variance = 20 – 24 = ₹ 4 (A)
12. Fixed Overhead Price Variance = (18.50 x 100/110) – 18.50 = ₹ 1.68 (A)
13. Fixed Overhead Efficiency Variance = 15 - (18.50 x 100/110) = ₹ 1.82 (A)
14. Fixed Overhead Cost Variance = 15 – 18.50 = ₹ 3.5 (A)

Profit Variance Statement:

		₹
Budgeted Profit		5.00
Add: Sales price variance	21.60	
Prime cost volume variance	8.00	
Variable overhead variance	2.00	31.60
		36.60
Less: Sales volume variance	12.00	
Prime cost Price Variance	11.88	
Prime cost usage Variance	7.22	
Variable overhead price variance	2.18	
Variable overhead efficiency variance	3.82	
Fixed overhead price variance	1.68	
Fixed overhead efficiency variance	1.82	40.60
Actual Loss		**4.00**

28. The standard labour component and the actual labour engaged in a week for a job are as under:

Particulars	Skilled workers	Semi skilled workers	Unskilled workers
Standard no. of workers in a gang	32	12	6
Standard wage rate per hour (₹)	3	2	1
Actual no. of workers employed in the gang during the week	28	18	4
Actual wage rate per hour (₹)	4	3	2

During the 40 hour working week the gang produced 1800 standard labour hours of work. Calculate Labour efficiency variance, Mix variance, wage rate variance and labour cost variance.

Answer :

	Standard Data			Actual Data		
	Hours	Rate	Value	Hours	Rate	Value
Skilled	32x40 = 1280	3	3840	28x40 =1120	4	4480
Semi-Skilled	12x40 = 480	2	960	18x40 =720	3	2160
Unskilled	6x40 = 240	1	240	6x40 = 160	2	320
	2000		5040	2000		6960

SH for Skilled Workers = X Std. Hrs. of Skilled Worker

= X 1280 = 1152

SH for Semi-Skilled Workers = X 480 = 432

SH for Unskilled Workers = X 240 = 216

	SRSH	SRRSH	SRAH	ARAH
Skilled	3x1152	3x1280	3x1120	4x1120
Semi-Skilled	2x432	2x480	2x720	3x720
Unskilled	1x216	1x240	1x160	2x160
Total Hrs.	4536	5040	4960	6960

Labour Mix Variance = SRRSH – SRAH

= 5040 – 4960 = ₹80 (F)

Labour Efficiency Variance = SRSH – SRAH

= 4536-4960 = ₹424 (A)

Labour Rate Variance = SRAH – ARAH

= 4960 – 6960 = ₹ 2000 (A)

Labour Cost Variance = SRSH – ARAH

= 4536 – 6960 = ₹ 2424 (A)

Study Note – 4

ACTIVITY BASED COST MANAGEMENT – JIT AND ERP

Learning Objective: *To be able to understand* **Activity-based costing** *(***ABC***) system recognizes the relationship between* **costs**, *overhead* **activities**, *and manufactured products, and, through this relationship, it assigns indirect* **costs** *to products less arbitrarily than traditional methods. Some* **costs** *are difficult to assign through this method of* **cost accounting**. *The objective of the ERP Business Transformation Strategy is to modernize and integrate business processes and systems to increase operating efficiency.*

OBJECTIVE TYPE QUESTIONS:

1. Match the following:

1	Telephone Bill	a	Activities
2	Customer Service	b	Cost Driver
3	Telephone	c	Cost Pool
4	Number of Calls	d	Resources

2. A company manufactures 500 units of product AX. Tthe material cost to manufacture is ₹ 150000, Labour cost ₹ 265000. Material reordering cost is ₹ 4500, Material handling cost is ₹2500

Material order – 35, Material movement – 20

Total Material cost under Activity based costing is.

(i) ₹ 554 **(ii) ₹ 4,22,000** **(iii) ₹ 1,57,000** **(iv) ₹ 1,084**

3. Production overheads of XYZ Manufactures Pvt. Ltd. for 500 units of product X are

Machine oriented activity cost: ₹ 135400

Material ordering overheads: ₹ 69570

Machine hours 1.50 hrs. per unit, No. of material orders are 6

Production of X requires raw material cost ₹ 300 per unit and labour cost ₹ 150 per unit. Total cost of X is

(i) ₹ 588 **(ii) ₹ 744.50** **(iii) ₹ 625** **(iv) ₹ 450**

4. Process of Cost allocation under Activity Based Costing is
   i. Cost of Activities—Activities—Cost Driver – Cost allocated to cost objects
   ii. Cost Driver — Cost of Activities— Cost allocated to cost objects -- Activities
   iii. Activities— Cost of Activities—Cost Driver – Cost allocated to cost objects
   iv. Activities—Cost Driver – Cost allocated to cost objects — Cost of Activities

5. Kanban Japanese System under JIT approach ensures that
   i. Continuous supply of inventory or product
   ii. Minimum & maximum level of stock to be maintained
   iii. Inventory valuation
   iv. All of the above

6. Cost Driver is
   i. Grouping of costs on a particular activity which drives them
   ii. Item for which cost measurement is required.
   iii. Elements that would cause a change in the cost activity.
   iv. All of the above

7. Enterprise Resource Planning is
   i. An accounting software
   ii. Software that integrates all the departments and functions across the company
   iii. Engineering drawing software
   iv. Software used to track the weighbridge record

8. ABC Management
   i. Accurately identifies sources of profit and loss
   ii. Assigns costs using measure of service consumed
   iii. Recognizes the casual relationship of cost drivers to activities
   iv. All of the above

9. JIT relates to
   i. Time Management
   ii. Inventory and product handling
   iii. Delivery systems
   iv. None of the above

10. Bench marking is

i. A continuous process

ii. The practice of setting targets using external information

iii. Method to provide performance assessment

iv. All of the above

Answer:

1.

1	Telephone Bill	c	Cost Pool
2	Customer Service	a	Activities
3	Telephone	d	Resources
4	Number of Calls	b	Cost Driver

2. (iii) ₹1, 57,000

Solution:

Material Cost under Activity Based Costing is

Material cost –	₹ 1, 50,000
Material reordering cost-	₹ 4500
Material Handling Cost-	₹ 2500
Total Material Cost-	₹ 1, 57,000

3. (ii) ₹ 744.50

Solution:

Computation of Cost per Unit of Product X

Overheads cost per unit

Machine Hours = 1.5 x 500 = 750

Machine oriented activity cost = ₹ 1, 35,400

Machine Oriented Cost per Hr. = (135400 / 750) = ₹181

Machine Oriented Cost per Unit = (₹181 X1.5) = 271.50

Material Ordering Nos. = 6 x 500 = 3000

Material Ordering Cost = ₹ 69,570

Material Ordering Cost per Unit = (69570 / 3000) = ₹23

Total Cost of Product x is

Raw Material cost	₹ 300
Labour cost	₹ 150
Machine Oriented Cost	₹ 271.50
Material Ordering Cost	₹ 23
Total Cost	₹ 744.50

4. (iii) Activities – Cost of Activities – Cost Drivers – Cost Allocated to cost Objects

5. (i) Continuous Supply of Inventory or Product

6. (ii) Elements that would cause a change in the cost activity

7. (ii) Software that integrates all the departments and functions across a company

8. (iv) All of the above

9. (ii) Inventory and product handling

10. (iv) All of the above

DESCRIPTIVE QUESTIONS:

11. What are the advantages of Just-In-Time System?

Answer:

Just in time (JIT) is a demand pull system of production, wherein actual orders provide a signal for when a product should be manufactured. Demand-pull enables a firm to produce only what is required, in the correct quantity and at the correct time. This means that stock levels of raw materials, components, work in progress and finished goods can be kept to a minimum. This requires a carefully planned scheduling and flow of resources through the production process. Modern manufacturing firms use sophisticated production scheduling software to plan production for each period of time, which includes ordering the correct stock. Information is exchanged with suppliers and customers through **EDI** (**Electronic Data Interchange**) to help ensure that every detail is correct.

Advantages of Just-In-Time System

Following are the advantages of adopting Just-In-Time Manufacturing System:

(a) Just-in-time manufacturing keeps stock holding costs to a bare minimum. The release of storage space results in better utilization of space and thereby bears a favorable impact on the rent paid and on any insurance premiums that would otherwise need to be made.

(b) Just-in-time manufacturing eliminates waste, as out-of-date or expired product; do not enter into this equation at all.

(c) As under this technique, only essential stocks are obtained or manufactured. So less working capital is required.

(d) Due to the afore-mentioned low level of stocks held, the organization's ROIwould generally be high.

(e) As just-in-time production works on a demand-pull basis, all goods made would be sold, and thus it incorporates changes in demand with surprising ease. This is an appealing preposition today, where the market demand is volatile and somewhat unpredictable.

(f) It encourages the right first time concept, so that inspection costs and cost of rework is minimized.

(g) High quality products and greater efficiency can be derived

(h) Close relationships are fostered along the production chain (i) Constant communication with the customer results in high customer satisfaction.

(j) Over production is eliminated.

12. What are the benefits of Enterprise Resource Planning?

Answer:

In an industry this is sensitive to dynamic market forces, cost fluctuations and manufacturing responsiveness, there are many benefits to be gained from investing in ERP. ERP applications have shifted the focus from assisting after—the—fact monitoring to real –time analysis, control and forecasting and from facilitating standardization, economies to scale and cost reduction in product, to enabling fast, flexible and accurate response and customization.

The benefits accruing to any business enterprise by implementing an ERP package are unlimited.

1. **Product Costing:** Determination of cost of products correctly, is quite critical for every industry. ERP supports advance costing methods, including standard costing, actual costing and activity –based costing.

   Additionally, all costing methods and information can be fully integrated with finance and accounts. This provides the company with essential financial information for monitoring and controlling costs.

2. **Inventory Management:** ERP can be used in multi-national, multi-company, and multi-site manufacturing and distribution environments. This system simplifies complicated logistics by allowing one to plan and manage companies in different countries as a single unit and its advanced functionality allows one to process product and financial information flows in several different ways. It can handle multilocational data to manage warehouses effectively.

   Inventory reporting includes specific and general types of stock transactions such as various types of stock transfers, re-classification, ID changes and physical inventoryetc. Inventory valuation involves both warehouse management and cost accounting. ERP supports several valuation methods including standard cost, average cost, FIFO and batch—specific prices.

3. **Distribution & Delivery:** Delivery and distribution in ERP lets one to define logistic processes, flexibly and efficiently to deliver the right product from the right warehouse to the right customer at the right time – every time. To the customer, the most important element of quality is one-time delivery.

4. **E – Commerce:** Internet enabled ERP offers Internet, Intranet and extranet solutions for business, business to consumer, employee self-service and more.

5. **Automatic Control:** It ensures automatic quality control procedure.

6. **After Sales Service:** It ensures better after sales service.

7. **Improvement in Production Planning:** It improves production planning.

8. **Quick response:** It enables quick response to change in business operations & market conditions.

9. **Cumulative Edge's:** It helps to achieve competitive advantages by improving business process.

13. What is Benchmarking? What are the types of Benchmarking?

Answer:

Benching Marking: The practice of setting targets using external information is known as 'Bench marking'. Benchmarking is the continuous process of enlisting the best practices in the world for the process, goals and objectives leading to world-class levels of achievement.

Types of Benchmarking:

(a) **Product Benchmarking (Reverse Engineering):** is an age old practice of product oriented reverse engineering. Every organization buys its rival's products and tears down to find out how the features and performances etc., compare with its own products. This could be the starting point for improvement.

(b) **Competitive Benchmarking:** This has moved beyond product-oriented comparisons to include comparisons of process with those of competitors. In this type, the process studied may include marketing, finance, HR, R&D etc.,

(c) **Process Benchmarking:** is the activity of measuring discrete performance and functionality against organization through performance in excellent analogous business process e.g. for supply chain management – the best practice would be that of Mumbai Dubbawallas.

(d) **Internal Benchmarking:** is an application of process benchmarking, within an organization by comparing the performance of similar business units or business process.

(e) **Strategic Benchmarking:** differs from operational benchmarking in its scope. It helps to develop a vision of the changed organizations. It will develop core competencies that will help sustained competitive advantage.

(f) **Global Benchmarking:** is an extension of Strategic Benchmarking to include benchmarking partners on a global scale. e.g. Ford Co. of USA benchmarked its A/c payable functions with that of Mazada in Japan and found to its astonishment that the entire function was managed by 5 persons as against 500 in Ford.

14. What are the Various Stages in the process of Benchmarking?

Answer:

Stage 1: Planning

(a) Determination of benchmarking goal statement: This requires identification of areas to be benchmarked, which uses the following criteria –

Benchmark for Customer Satisfaction	Benchmark for improving Bottom line (Profit)
• Consistency of product or service	• Waste and reject levels
• Process cycle time	• Inventory levels
• Delivery performance	• Work-in-progress
• Responsiveness to customer requirements	• Cost of Sales
• Adaptability to special needs	• Sales per employee

(b) Identification of best performance:

(c) Establishment of the benchmarking or process improvement team:

(d) Defining the relevant benchmarking measures:

Stage 2: Collection of data and information: This involves the following steps –

(a) Compile information and data on performance. They may include mapping processes.

(b) Select and contact partners.

(c) Develop a mutual understanding about the procedures to be followed and, if necessary, prepare a Benchmarking Protocol with partners.

(d) Prepare questions and agree terminology and performance measures to be used.

(e) Distribute a schedule of questions to each partner.

(f) Undertake information and data collection by chosen method for example, interviews, site-visits, telephone fax and e-mail.

(g) Collect the findings to enable analysis.

Stage 3: Analysis of findings:

(a) Review the findings and produce tables, charts and graphs to support the analysis

(b) Identify gaps in performance between our Firm and better performers.

(c) Seek explanations for the gaps in performance. The performance gaps can be positive, negative or zero.

(d) Ensure that comparisons are meaningful and credible

(e) Communicate the findings to those who are affected.

(f) Identify realistic opportunities for improvements.

Stage 4: Recommendations:

Making recommendations	Implementing recommendations
Deciding the feasibility of making the improvements in the light of conditions that apply within own Firm	Implement the action plans
• Agreement on the improvements that are likely to be feasible	Monitor performance
• Producing a report on the Benchmarking in which the recommendations are included	Reward and communicate success.
• Obtaining the support of owners/ management for making the changes needed.	Keep owners/management informed of progress
• Developing action plan(s) for implementation.	

Stage 5: Monitoring and reviewing: This involves –

(a) Evaluating the benchmarking process undertaken and the results of the improvements against objectives and success criteria plus overall efficiency and effectiveness.

(b) Documenting the lessons learnt and make them available to others.

(c) Periodically re-considering the benchmarks for continuous improvement.

15. What are the problems of Traditional Costing arising out of volume-based cost allocation to products? How can Activity-Based Costing help refining such costing system?

Answer:

Under traditional costing, overheads which occupy an important share of the total cost of the firm, are generally allocated on the basis of volume based allocation of rates. This allocation can be on the basis of labour hour, machine hour, % of labour cost, etc. It does not take into consideration the quantum of services actually consumed. As a result, the product cost gets distorted i.e., some products are over burdened and vice versa. The basic assumption in cost allocation is; the higher the volume, the greater the share of indirect costs to the product or service. This simplistic assumption does not hold good in reality.

The Activity-Based Costing (ABC) is a system that focuses on activities as the fundamental cost objects and uses the cost of these activities for computing the costs of products. The Activity-Based Costing refines the problems of Traditional Costing System by the following means:

(i) In ABC, the focus is on activities rather than products because activities in various departments may be combined and costs of similar activities ascertained, e.g., quality control, handling of materials, repairs to machines etc., If detailed costs are kept by activities, the total company costs for each activity can be obtained, analysed, planned and controlled.

(ii) Under ABC, activities are managed and not products. Changes in activities lead to changes in costs. Therefore, if the activities are managed well, costs will fall and the resulting products will be more competitive.

(iii) Allocating Overhead Cost to production based on a single cost driver can result in an unrealistic product cost because the traditional system fails to capture cause-and-effect relationships. To manage activities better and to make wiser economic decisions, managers need to identify the relationships of causes (activities) and effects (costs) in a more detailed and accurate manner.

(iv) ABC highlights problem areas that deserve management's attention and more detailed analysis. Many actions are possible, on pricing, on process technology, on product design, on operational movements and on product mix. Traditional Costing can lead to under costing or over costing of products or services which distorts cost information. This distorted information leads to inappropriate crucial decisions e.g. pricing, product emphasis, make or buy etc.

ABC differs from the traditional system only in respect of allocations of overheads or indirect costs. Direct Costs are identified with, or assigned to, the cost object, in the same manner as is done in case of traditional costing system. Overhead costs are linked to the cost objects based on activities.

PRACTICAL PROBLEMS:

16. XYZ. Limited makes three main products, using broadly the same production methods and equipment for each. A conventional product costing system is used at present, although and Activity Based Costing (ABC) system is being considered. Details of the three products, for typical period are:

	Labour Hours per Unit	Machine Hours per unit	Material (Rs.Per unit)	Volumes Units
Product X	**1 ½**	**3 ½**	**25**	**3,500**
Product Y	**½**	**2**	**15**	**2,250**
Product Z	**2**	**5**	**30**	**6,000**

Direct labour costs ₹8 per hour and production overheads are absorbed on a machine hour basis. The rate for the period is ₹18 per machine hour.

You are required:

(a) To calculate the cost per unit for each product using conventional methods.

Further analysis shows that the total of production overheads can be divided as follows

	%
Costs relating to set-ups	**30**
Costs relating to machinery	**25**
Costs relating to materials handling	**22**
Costs relating to inspection	**23**
Total production overhead	**100**

The following activity volumes are associated with the product line for the period as a whole. Total activities for the period

	Number of Set-ups	Number of movements of materials	Number of Inspections
Product X	**65**	**15**	**150**
Product Y	**110**	**26**	**190**
Product Z	**485**	**79**	**570**
	660	**120**	**910**

You are required:

(b) To calculate the cost per unit for each product using ABC principles;

Answer:

(a) Computation of cost per unit using Conventional Methods:

Computation of Cost

	X	Y	Z
	₹	₹	₹
Materials	25	15	30
Labour	12	4	16
Overheads	63	36	90
Factory Cost	**100**	**55**	**136**

(b) Under ABC Costing

Total overheads		₹
X	= 3500 x3.5 x 18 =	2,20,500
Y	= 2250 x 2 x 18 =	81,000
Z	= 6000 x 5 x 18 =	5,40,000
		8,41,500

		Setup Cost	Machine Cost	Material Handling Cost	Inspection Expenses	Total
Costs	₹	2,52,450	2,10,375	1,85,130	1,93,545	8,41,500
Cost Driver		No. of setups	Machine hours	No. of Moment of Materials	No. of Inspections	
Cost driver rates	₹	382.50 (252450/660)	4.5 (210375/46750)	1542.75 (185130/120)	212.69 (193545/910)	

Cost per unit under ABC costing

	X		Y			Z
	₹	₹	₹	₹	₹	₹
Materials		25.00		15.00		30.00
Labour		12.00		4.00		16.00
Overheads						
Setup Cost	7.10		18.70		30.92	
Machine cost	15.75		9.00		22.50	
Material Handling Cost	6.61		17.83		20.31	
Inspection Cost	9.11	38.57	17.96	63.49	20.21	93.94
Total Cost		**75.57**		**82.49**		**139.94**

17. A company produces four products, viz. P, Q, R and S. The data relating to production activity are as under

Product	Quantity of production	Material cost/ unit ₹	Direct labour hours/unit	Machine hours/ unit	Direct Labour cost/ unit ₹
P	4,500	12	2	1.50	8
Q	13,640	15	2	0.75	9
R	2,340	25	5	2.50	27
S	18,350	21	4	4.00	25

Production overheads are as under:		₹
(i)	Overheads applicable to machine oriented activity:	1,65,900
(ii)	Overheads relating to ordering materials	8,760
(iii)	Set up costs	21,400
(iv)	Administration overheads for spare parts	44,690
(v)	Material handling costs	25,545

The following further information have been compiled:

Product	No. of set up	No. of materials orders	No. of times materials handled	No. of spare parts
P	3	3	6	6
Q	18	12	30	15
R	5	3	9	3
S	24	12	36	12

Required:

(i) Select a suitable cost driver for each item of overhead expense and calculate the cost per unit of cost driver.

(ii) Using the concept of activity based costing, compute the factory cost per unit of each product.

Answer:

Computation of Cost Driver Rates

(i) Overheads relating to Machinery oriented activity

Cost Driver : Machine Hour Rate

Total Machine hours = (4500 x 1.5) + (13640 x 0.75) + (2340 x 2.5) + (18350 x 4)= 96230

1, 65,900/96,230 = ₹ 1.72 per hour

(ii) Overheads relating to ordering materials

Cost driver : No. of Material orders

8760/30 = ₹ 292 per order

(iii) Set up costs

Cost driver : No. of set ups

21400/50 = ₹428 per set up

(iv) Administrative Overheads for spare parts

Cost driver : No. of spare parts

44690/36 = ₹ 1241 per spare part.

(v) Material Handling costs

Cost driver : No. of times materials handled

25545/81 = ₹ 315 per material handling

Computation of factory cost for each product

		P		Q		R		S
Materials		12.00		15.00		25.00		21.00
Labour		8.00		9.00		27.00		25.00
Overheads								
Machine oriented activity	2.580		1.290		4.300		6.880	
Ordering of Materials	0.195		0.257		0.374		0.191	
Set up costs	0.285		0.565		0.915		0.560	
Administrative Spare Parts	1.655		1.365		1.592		0.812	
Material handling	0.420	5.14	0.694	4.17	1.213	8.39	0.619	9.06
Factory Cost (₹)		**25.14**		**28.17**		**60.39**		**55.06**

18. The budgeted overheads and cost driver volumes of XYZ are as follows.

Cost Pool	Budgeted Overheads (₹)	Cost Driver	Budgeted Volume
Material procurement	**6,75,000**	**No. of orders**	**950**
Material handling	**1,80,000**	**No. of movements**	**540**
Set-up	**4,25,000**	**No. of set ups**	**550**
Maintenance	**8,95,000**	**Maintenance hours**	**7,500**
Quality control	**2,76,000**	**No. of inspection**	**990**
Machinery	**7,20,000**	**No. of machine hours**	**24,000**

The company has produced a batch of 3,200 components of SK-15, its material cost was ₹170,000 and labor cost ₹2,70,000. The usage activities of the said batch are as follows.

Material orders – 29, maintenance hours – 685, material movements – 21, inspection – 32, set ups – 26, machine hours – 1,770

Calculate – cost driver rates that are used for tracing appropriate amount of overheads to the said batch and ascertain the cost of batch of components using activity Based Costing.

Answer:

Computation of Cost Driver Rates

	Particulars		**Amount (₹)**
1.	Material procurement	675000/950	711
2.	Material handing	180000/540	333
3.	Set-up	425000/550	773
4.	Maintenance	895000/7500	119
5.	Quality control	276000/990	279
6.	Machinery	720000/24000	30

Computation of Batch Cost of 3200 units of SK-15

		₹
Material cost		1,70,000
Labour Cost		2,70,000
Prime Cost		4,40,000
Add: Overheads		
Material orders 29 x 711	20,619	
Material handling 21 x 333	6,993	
Set-up 26 x 773	20,098	
Maintenance 685x 119	81,515	
Quality Control 32 x 279	8,928	
Machinery 1770 x 30	53,100	1,91,253
Total Cost		**6,31,253**

19. AML Ltd is engaged in the production of three types of ice-cream products viz. Coco, Strawberry & Vanilla. The Company presently sells 50,000 units of Coco @ ₹ 25 per unit, Strawberry 20,000 units @ ₹ 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, 72600 units of Vanilla. The company marks up 25% of the cost of product.

The company management decides to apply ABC analysis. For this purpose, it identifies four activities and 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 per unit sold

The other relevant information for the products are as follows

	Coco	Strawberry	Vanilla
Direct Material p.u. (₹)	8	6	5
Direct Wages p.u. (₹)	5	4	3
No. of purchase order	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 to:

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

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

Answer:

(i) Cost under Traditional Costing

	Coco	Strawberry	Vanilla
Direct Material	8	6	5
Direct Labour	5	4	3
	13	10	8
Support Cost @ 30%	3.90	3.00	2.40
	16.90	13.00	10.40
Units	60,500	24,200	72,600
Total	10,22,450	3,14,600	7,55,040

(ii) Cost under Activity Based Costing

	Coco	Strawberry	Vanilla
Direct Material	4,84,000 (8 x 60500)	1,45,200 (6 x 24200)	3,63,000 (5 x 72600)
Direct Labour	3,02,500 (5 x 60500)	96,800 (4 x 24200)	2,17,800 (3 x 72600)
Order Cost	28,000 (35 x 800)	24,000 (30 x 800)	12,000 (15 x 800)
Delivery Cost	78,400 (112 x 700)	46,200 (66 x 700)	33,600 (48 x 700)
Shelf Stocking	25,870 (199 x 130)	29,850 (199 x 150)	31,840 (199 x 160)
Customer Support & Assistance	66,550 (1.10 x 60500)	26,620 (1.10 x 24200)	79,860 (1.10 x 72600)
	9,85,320	**3,68,670**	**7,38,100**
Units	60,500	24,200	72,600
Cost per Unit	16.286	15.234	10.167

20. Activities that have been identified and the budget quantified for the three months ended 31st March 2018 are as follows.

Activities	Cost Driver Unit Basis	Unit of Cost Driver	Cost (₹000)
Product Design	Design Hours	8000	2000 (see Note 1)
Purchasing	Purchase Order	4000	200
Production	Machine Hours	12000	1500 (see Note 2)
Packing	Volume (Cu.m.)	20000	400
Distribution	Weight (Kg)	120000	600

Note 1: This includes all design costs for new products released during this period.

Note 2: This includes depreciation provision of ₹ 3, 00,000 of which ₹ 8000 applies to 3 months depreciation on straight-line basis for a new product (NPD). The remainder applies to other products.

New product NPD is included in the above budget. The following additional information applies to NPD.

1. **Estimated total output over the product life cycle, 5000 units (4 years life cycle)**
2. **Product design requirement 400 design hours**
3. **Output in quarter ended 31st March 2018 250 units**
4. **Equivalent batch size per purchase orders 50 units.**
5. **Other product unit data production time 0.75 machine hours, volume 0.4 Cu.m. Weight 3 Kg.**

Required:

Prepare a unit overhead cost for product NPD using an activity based approach which includes an appropriate share of life cycle costs using the information provided.

Answer:

Cost of product NPD under Activity Based Approach

	Total Cost (₹ 000)	Cost per Unit
Product Design	1,00,000 = (20,00,000 x 400) 8000	20.00 (1,00,000/5000)
Purchasing Cost	250, = (2,00,000 x 250) (4000 x 50)	1.00 (250/250)
Production	18,750 = (15,00,000-3,00,000)x0.75x250 12000	75.00 (18,750/250)
Depreciation	8,000	32.00 (8000/250)
Packing	2,000 = (4,00,000x0.4x250) 20,000	8.00 (2000/250)
Distribution	3,750 = (6,00,000x3x250) 120000	15.00 (3750/250)
Total Cost		**151.00**

21. Precision Auto comp Ltd. Manufactures and sells two automobile components A and B. Both are identical with slight variation in design. Although the market for both the products is the same, the market share of the company for product A is very high and that of product B very low. The company'.s accountant has prepared the following profitability statement for the two products (Cost of production: same for both the products)

Direct Material	₹	**125**
Direct Labour	₹	**24**
Direct Expenses (sub-contract charges)	₹	**36**
Overheads (400% of direct labour)	₹	**96**
Total Cost	₹	**281**

		Product A	Product B	Total
Quantity sold	**No.**	**1,24,000**	**23,150**	**1,47,150**
Unit sale price	₹	**300**	**290**	
Total sales realization	₹			**4,39,13,500**
Cost of sales as above	₹			**4,13,49,150**
Margin	₹			**25,64,350**

The company's marketing manager, after attending a workshop on activity-based costing challenges the accountant's figures. The nearest competitor's prices for the two products are ₹ 330 and ₹ 275 per unit respectively and, if the company can match the competitor's prices, it can sell 75,000 nos. each of the two products. The Production Manager confirms that he can produce this product mix with the existing facilities. The management engages you as consultant, and the following facts have been identified by you:

(a) product A undergoes 5 operations and product B undergoes two operations by sub-contractors, although the total subcontract- charges are the same for both the products, and

(b) 75% of the overheads is accounted for under three major heads relating to sub-contracting operations, *viz.,* ordering, inspection and movement of components, to and from the sub-contractor's works.

Prepare a revised profitability statement to find out if the marketing manager's proposal is viable.

Answer:

Total overheads = 1,47,150 x 96 = ₹1,41,26,400

Operations overhead = 1,41,26,400 x 75/100 = ₹ 1,05,94,800

Balance 25% assumed to be fixed i.e. ₹ 35,31,600

Allocation of Variable Overheads under ABC

A = 1,05,94,800 x 5/7 = ₹ 75,67,714

B = 1,05,94,800 x 2/7 = ₹ 30,27,086

Statement showing computation profit under Activity Based Costing as per Manager's suggestion:

			A		B	Total
No. of units		**Units**	**75000**	**Units**	**75000**	
Materials	₹	125	93,75,000	125	93,75,000	1,87,50,000
Labour	₹	24	18,00,000	24	18,00,000	36,00,000
Direct expenses	₹	36	27,00,000	36	27,00,000	54,00,000
Prime Cost	₹	**185**	**1,38,75,000**	**185**	**1,38,75,000**	**2,77,50,000**
Variable Overheads	₹	101	75,67,714	40	30,27,086	1,05,94,800
Fixed Overheads	₹	24	17,65,800	24	17,65,800	35,31,600
Total Cost	₹	**310**	**2,32,08,514**	**249**	**1,86,67,886**	**4,18,76,400**
Profit	₹	20	15,41,486	26	19,57,114	34,98,600
Sales	₹	**330**	**2,47,50,000**	**275**	**2,06,25,000**	**4,53,75,000**

As the profit is more at the Marketing Manager's proposal by ₹ 9,34,250 and hence this proposal may be accepted.

22. Relevant data relating to a company are:

			Products		
		P	**Q**	**R**	**Total**
Production and sales (units)		**60,000**	**40,000**	**16,000**	
Raw material usage in units		**10**	**10**	**22**	
Raw material costs	₹	**50**	**40**	**22**	**24,76,000**
Direct labour hours		**2.5**	**4**	**2**	**3,42,000**
Machine hours		**2.5**	**2**	**4**	**2,94,000**
Direct labour costs	₹	**16**	**24**	**12**	
No. of production runs		**6**	**14**	**40**	**60**
No. of deliveries		**18**	**6**	**40**	**64**
No. of receipts		**60**	**140**	**880**	**1,080**
No. of production orders		**30**	**20**	**50**	**100**

Overheads: ₹

Setup	**60,000**
Machines	**15,20,000**
Receiving	**8,70,000**
Packing	**5,00,000**
Engineering	**7,46,000**

The company operates a JIT inventory policy and receives each component once per production run.

Required:

(i) Compute the product cost based on direct labour-hour recovery rate of overheads.

(ii) Compute the product cost using activity based costing.

Answer:

(i) Traditional Method of absorption of overhead i.e. on the basis of Direct Labour Hours

Total overheads 36,96,000 / Hours (60000 × 2.5)+ (40000 × 4)+ (16000 × 2)

= 36,96,000 / 3,42,000 = ₹ 10.81 per labour hour

Calculation of Factory cost of the products

	P	Q	R
	₹	₹	₹
Raw Material	50. 000	40 .00	22 . 00
Direct Labour	16. 000	24 . 00	12 . 00
Overheads (2.5 x 10.81)	27 .025	43 .24	21 . 62
Factory cost	**93 . 025**	**107 . 24**	**55. 62**

(iii) Under Activity Based Costing System

Computation of Cost Drivers Rates.

(1) Set up cost = Cost driver : No. of Production run 60000/60 = ₹ 1000/per run

(2) Machines = Cost driver : Machine hour rate

15,20,000/2,94,000 = ₹ 5.17 per Machine hour rate

(3) Receiving cost = Cost driver : No. of Receipts 8,70,000/1080 = ₹ 805.56

(4) Packing = Cost driver : No. of deliveries 5,00,000/64 = ₹ 7812.5 per delivery

(5) Engineering= Cost driver : No. of Production order 7,46,000/100 = ₹ 7,460 per order

Calculation of Factory Cost per unit of Production **(in ₹)**

	P		Q		R	
Materials		50.00		40.00		22.00
Direct Labour		16.00		24.00		12.00
Overheads						
Setup cost	0.10		0.35		2.50	
Machines	12.93		10.34		20.68	
Receiving cost	0.81		2.82		44.31	
Packing	2.34		1.17		19.53	
Engineering	3.73	19.91	3.73	18.41	23.31	110.33
Factory Cost		**85.91**		**82.41**		**144.33**

23. AXE Ltd wants to implement a JIT Program, with the impact on the three types of Stocks as given below. Find out the Cost Savings to the Company, due to implementation of JIT with the following Information-

Particulars	Present Situation, i.e. before JIT	After JIT
Sales Value	**₹ 12,00,00,000**	**Same as present**
Percentage of Costs to Sales Value	**Materials 40%, Conversion 30%**	**Materials 44%, Conversion 32%**
Stockholding	**Raw Materials:1 month WIP: 0.5 month Finished Goods: 0.5 month**	**Raw Materials: 25% less than present WIP: 50% less than present Finished Goods: 40% less than present**
Percentage of Completion of WIP	**Materials 90%, Conversion 75%**	**Materials 90%, Conversion 75%**
Stock-related Costs are as under -		
Raw Materials Fixed Variable	**₹ 2,00,000 ₹ 0.09 per Rupee of Stock held**	**15% less than present ₹ 0.05 per Rupee of Stock held**
WIP Fixed Variable	**₹ 3,00,000 ₹ 0.04 per Rupee of Stock held**	**20% less than present ₹ 0.02 per Rupee of Stock held**
Finished Goods Fixed Variable	**₹ 2,50,000 ₹ 0.02 per Rupee of Stock held**	**40% less than present ₹ 0.01 per Rupee of Stock held**

Financial Charges due to Impact of stockholding on working capital requirement =18% per annum on the value of stocks held.

Answer :

Particulars	Before JIT Programme		After JIT Programme	
	Computation	₹	Computation	₹
1. Sales Value		12,00,00,000	Given	12,00,00,000
2. Raw Material Stock	12,00,00,000 x 40% RM Cost x 1/12 Stockholding	40,00,000	(12,00,00,000× 44% RM Cost x1/12 Stockholding) less 25%	33,00,000
3. RM Stock Related Costs				
Fixed	Given	2,00,000	₹ 2,00,000 less 15%	1,70,000
Variable	₹ 40,00,000 × ₹ 0.09	3,60,000	₹ 33,00,000 × 0.05	1,65,000
Interest	₹ 40,00,000 ×18%	7,20,000	₹ 33,00,000 x 18%	5,94,000
Sub-Total		12,80,000		9,29,000
		Cost Saved = ₹ 3,51,000		
4. WIP Stock (Note)	12,00,00,000× 58.5% WIP Cost x 0.5/12 Stockholding	29,25,000	12,00,00,000x63.6% WIP Cost × 0.5/12 Stockholding × 50%	15,90,000
5. WIP Related Costs				
Fixed	Given	3,00,000	₹ 3,00,000 less 20%	2,40,000
Variable	₹ 29,25,000 × 0.04	1,17,000	₹ 15,90,000 × 0.02	31,800
Interest	₹ 29,25,000 ×18%	5,26,500	₹ 15,90,000 × 18%	2,86,200
Sub-Total		9,43,500		5,58,000
		Cost Saved = ₹ 3,85,500		
6. Finished Goods Stock	12,00,00,000x70% FG Cost × 0.5/12 Stockholding	35,00,000	12,00,00,000 × 76% FG Cost × 0.5/12 Stock holding ×60%	22,80,000
7. FG Related Costs				
Fixed	Given	2,50,000	₹ 2,50,000 less 40%	1,50,000
Variable	₹ 35,00,000 x 0.02	70,000	₹ 22,80,000 x 0.01	22,800
Interest	₹ 35,00,000 x18%	6,30,000	₹ 22,80,000 x 18%	4,10,400
		9,50,000		5,83,200
		Cost Saved = 3,66,800		

Total Cost Savings = ₹ 3,51,000 + ₹ 3,85,500 + ₹ 3,66,800 = ₹ 11,03,300

Note: WIP Cost is computed as under –

Before: (Materials 90% Complete × 40%) + (Conversion 75% Complete x 30%)

= 36% + 22.5% = 58.5% on Sales.

After: (Materials 90% Complete × 44%) + (Conversion 75% Complete x 32%)

= 39.6% + 24% = 63.6% on Sales.

Study Note – 5

COST OF QUALITY AND TOTAL QUALITY MANAGEMENT

Learning Objective: *To be able to understand that improvement of quality is a continuous process. To understand that good quality management is required to maintain sustainable production and organisational growth.*

OBJECTIVE TYPE QUESTIONS:

1. TQM stands for
   i. Technical Quantitative Management
   ii. Total Quality Management
   iii. Theory of Queuing Management
   iv. None of the Above

2. Four Ps of Total Quality Management
   i. Principles, Project, Problem, & Process
   ii. People, Process, Problem & Preparation
   iii. Product identification, Product quality, Product utility & Product expectation
   iv. None of the above

3. PRAISE stands for
   i. Appreciating someone
   ii. Product, Recognition, Adoption, Invention, Solution & Evaporation
   iii. Problem Identification, Ranking, Analysis, Innovation, Solution & Evaluation
   iv. None of the above

4. Six Sigma is about
   i. Quality systems
   ii. Quality control process
   iii. Statistical technique
   iv. None of the above

5. DMIADV is a methodology associated with
   i. Pareto Analysis
   ii. PRAISE
   iii. Six Sigma
   iv. None of the above

6. Pareto analysis recognizes
   i. 80:20 Rule
   ii. 50:50 Rule
   iii. 20:80 Rule
   iv. None of the above

7. Cost of Rework is a cost related to
   i. Internal failure
   ii. Appraisal
   iii. Prevention
   iv. None of the above

8. The cost incurred to ensure that failures do not happen
   i. External failure cost
   ii. Internal failure cost
   iii. Prevention cost
   iv. None of the above

9. Which of the following is not the quality parameter for service organizations?
   i. Consistency
   ii. Friendliness
   iii. Durability
   iv. Promptness

10. Match the following:

(a) Staff training	**i. Six Sigma**
(b) ISO 9000:2000	**ii. Internal Failure cost**
(c) Package Inspection	**iii. Quality control costs**
(d) DMAIC	**iv. Quality Systems**
(e) Six C	**v. Appraisal Cost**
(f) Six Sigma	**Vi. External Failure Cost**
(g) Down time due to quality defects	**vii. Prevention Cost**
(h) Cost for achieving high quality	**viii. Total Quality Management**
(i) Lost sales	**ix. 3.4 DPMO**

Answer:

1. (ii)
2. (ii)
3. (iii)
4. (i)
5. (iii)
6. (i)
7. (i)
8. (iii)
9. (iii)
10. (a) – vii, (b) – iv, (c) – v, (d) – i, (e) – viii, (f) – ix, (g) – ii, (h) – iii, (i) - vi

DESCRIPTIVE QUESTIONS:

11. Write Notes on:

(a) Total Quality Management

(b) PRAISE Analysis

(c) Six Sigma

(d) Pareto Analysis

(e) Cost of Quality

Answer:

(a) **Total Quality Management** is a philosophy of continuously improving the quality of all the products and processes in response to continuous feedback for meeting the customers' requirements. It aims to do things at first instance rather than trouble shooting after occurrence. Its basic objective is customer satisfaction.

The elements of TQM are:

Total	Quality involves everyone and all activities in the Company as whole
Quality	Understanding and meeting the customer requirements
Management	Quality can and must be managed

TQM is a vision based, customer focused, prevention oriented, continuously improvement strategy based on scientific approach adopted by cost conscious people committed to satisfy the customers first time every time. It aims at managing an organisation so that it excels in areas important to the customer.

(b) **PRAISE Analysis** is a six step process of the Total Quality Management where identification of improvement opportunities and implementation of quality improvement process takes place. Six Steps are : Problem identification, Ranking, Analysis, Innovation, Solution and evaluation. These steps are represented by acronym PRAISE.

Process involves

(i) Problem identification of customer dissatisfaction

(ii) Ranking of the problems and opportunities as per priorities

(iii) Analysis of possible causes of problem, potential implications and quantification of cause and effect

(iv) Innovation by creative thinking to generate potential solutions

(v) Solution implementation by making required changes in the systems and reinforcing the same with training and documentation backup

(vi) Evaluation by monitoring the effectiveness of the actions and identify the potential for further improvements and return to step 1.

(c) **Six Sigma** is a set of practices developed by Motorola to systematically improve process by eliminating defects. A defect is defined as non conformity of a product or service to its specifications.

The term six Sigma refers to the ability of highly capable processes to produce output with specifications. In particular, processes that operate with six sigma quality produce at defect levels below 3.4 defects per million opportunities (DPMO). Six Sigma's implicit goal is to improve all process to that level of quality or better.

Six Sigma has two key methodologies viz. DMAIC and DMADV inspired by W. Edward Deming's Plan-Do-Check-Act Cycle. DMAIC is used to improve on existing business process and DMADV is used to create new product or process designs for predictable, defect free performance.

(d) **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 an Italian Economist. He noticed that 80% of wealth is owned by 20% of the people. This phenomenon can be observed in many different business situations. The management can use it in a number of circumstances to direct management attention to the key control mechanism. It helps to clearly establish top priorities and to identify profitable and unprofitable targets.

Pareto Analysis is useful in routine business situations:

(i) Pricing of a product

(ii) Customer profitability analysis

(iii) Stock controls – ABC analysis

(iv) Activity based costing

(v) Quality control

(e) **Cost of Quality** has a great implication in overall cost of product or services. Off late, organizations have started appreciating the high cost of poor quality. The most obvious consequence occurs when poor quality creates dissatisfied customers and eventually leads to loss of business. However quality has many other costs, which can be divided into two categories. The first category consists of quality control costs which are incurred to achieve high quality. These are basically categorized into two parts Prevention costs & Appraisal Costs. The second category consists of costs that emerge due to poor quality. These are known as quality failure costs. These include costs incurred on account of internal failures and external failures. The first two costs are incurred in the hope of preventing the second two. We can tabulate as follows:

(i) Prevention Costs – Ensuring the failures do not happen

(ii) Appraisal costs – Checking for failures

(iii) Internal Failure costs – Keeping defective products from falling into the hand of customers

(iv) External Failure Costs – Cost of defects discovered by the customers

12. Explain the 6 Cs of Total Quality Management

Answer:

The essential requirements for successful implementation are described as the 6 Cs of Total Quality Management.

They are:

(a) Commitment : It is not sufficient to delegate quality issues to a single person. Quality expectations must be made by the top management, together with the support and training required for its achievement. If a TQM culture is to be developed, total commitment must come from top management.

(b) Culture: Training lies at the center of effecting of change in culture and attitudes. Negative perceptions must be changed to encourage individual contributions and to make quality a culture

(c) Continuous Improvement: TQM should be recognised as a 'continuous process'. It's not a one time program, there should always be a room for improvement, however small it may be.

(d) Co-operation: TQM visualizes total employee involvement. Employee involvement and cooperation should be sought in the development of improvement strategies and associated performance measures

(e) Customer Focus: The needs of external customer (recipient of final product or services) and also the internal customers (colleagues who receive the supply of goods, services and information), should be the prime focus.

(f) Control: Documentation, procedures and awareness of current best practices are essential for the effective functioning of TQM. Unless control procedures are in place, improvements cannot be monitored and measured.

13. Explain the principles of Total Quality Management

Answer:

Following are the four principles of TQM, commonly known as 4 Ps -

(a) People – TQM teams should consist of team spirited individuals who have a flair for accepting and meeting challenges. Individuals otherwise should not get involved in it.

(b) Process – It is essential to approach problem solving practically through a system designed formal process to prevent participants from jumping to conclusions.

(c) Problem – Problems need to be approached in a systematic manner, with teams tackling solvable problems with a direct economic impact, allowing for an immediate feedback together with the recognition of the contribution made by individual participants

(d) Preparation – Additional training of creative thinking and statistical processes are needed in order to give participants a greater appreciation of the diversity of the process. The training must quickly be extended beyond the immediate accounting circle to include employees at supervisory and data entry levels.

14. Explain steps involved in DMAIC and DMIADV with respect to Six Sigma

Answer:

DMAIC - There are 5 steps involved in DMAIC to improve an existing business process:

(a) Define the process improvement goals that are consistent with customer demands and enterprise strategy

(b) Measure the current process and collect relevant data for future comparison

(c) Analyse to verify relationship and casualty of factors. Determine what relationship is, and attempt to ensure that all factors have been considered

(d) Optimise the process based upon the analysis using techniques like Design of Experiments

(e) Control to ensure that variances are corrected before they result in defects. Set up pilot runs to establish process capability, transition to production and thereafter continuously measure the process and institute control mechanisms.

DMIADV – There are 5 steps involved to create new product or process designs for defect free performance:

(a) Define the goals of the design activity that are consistent with customer demands and enterprise strategy

(b) Measure and identify CTQs (Critical to Qualities), product capabilities, production process capability and risk assessment

(c) Analyse to develop and design alternatives, create high level design and evaluate design capability to select the best design

(d) Design details, optimize the design and plan for design verification.

(e) Verify the design, set up pilot runs, implement production process and handover to production process owners

15. Narrate 5 routine business situations, where Pareto Analysis is useful

Answer:

Pareto Analysis may be applicable in the presentation of performance indicators data through selection of representative process characteristics that truly determine or directly or indirectly influence or confirm the desired quality or performance result or outcome. The Pareto Analysis is generally applicable to the following business situations:

(a) Pricing of a product:

- In the case of a firm dealing with multi products, it would not be possible for it to analyse cost-profit-price-volume relationships for all of them. In practice, in case of such a firm, approximately 20% of products may account for about 80% of total sales revenue. Pareto Analysis is used for analysing the firm's estimated sales revenues 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 levels of management, thus freeing them to concentrate on the pricing decisions for products approximately 20% which are essential for the company's survival.

- Thus, a firm can adopt more sophisticated pricing methods for small proportion of products that jointly account for approximately 80% of total sales revenue. For the remaining 80% of the products which account for 20% of total sales revenue the firm may use cost based pricing method.

(b) Customer Profitability analysis:

- Instead of analysing products, customers can be analysed for their relative profitability to the organisation.
- Again it is often found that approximately 20% of customers generate 80% of the profit. There will always be some customers who are less profitable than others, just as some products are less profitable than others.
- Such an analysis is a useful tool for evaluation of the portfolio of customer profile and decision making such as whether to continue serving the same customer group, what is the extent of promotion expenses to be incurred, etc.

(c) ABC analysis- Stock Control: Another application of Pareto Analysis is in stock control where it may be found that only a few of the goods in stock make up most of the value. In practice approximately 20% of the total quantity of stock may account for about 80% of its value. The outcome of such analysis is that by concentrating on small proportion of stock items that jointly accounts for 80% of the total value, a firm may well be able to control most of the monetary investment in stocks.

(d) Application in Activity Based Costing: in activity Based costing it is often said that 20% of an organisation's cost drivers are responsible for 80% of the total cost. By analysing, monitoring and controlling those cost drivers that cause most cost, a better control and understanding of overheads will be obtained.

(e) Quality Control:

- Pareto Analysis seeks to discover from an analysis of defect report or customer complaints which "vital few" causes are responsible for most of the reported problems.
- Often, 80% of reported problems can usually be traced to 20% of the various underlying causes. By concentrating once efforts on rectifying the vital 20%, one can have the greatest immediate impact on product quality.
- The Pareto Analysis indicates how frequently each type of failure (defect) occurs. The purpose of the analysis is to direct management attention to the area where the best returns can be achieved by solving most of quality problems, perhaps just with a single action.

16. Narrate costs directly related to quality and give minimum 2 examples of each

Answer:

Costs directly related to quality are divided into two parts i.e. Quality Control Costs and Quality Failure Costs. These are further divided into two categories of each i.e. Prevention costs, Appraisal costs, Internal failure costs and External failure costs. The examples of each are given below :

(a) Prevention costs – Quality training, system development for prevention & quality improvement

(b) Appraisal costs – Testing and inspection charges, package inspection, final product testing

(c) Internal failure costs – Cost of spoilage, retesting, down time due to defects in quality

(d) External Failure costs – Cost of field servicing, warranty repairs & replacements, Lost sales

PRACTICAL PROBLEMS:

17. Zebra Limited introduced a quality improvement program and following results are observed.

₹ In Lacs

Particulars	2015-16	2016-17
Sales	10000	10000
Scrap	100	50
Rework	650	550
Production inspection	250	325
Product Warranty	500	250
Quality Training	125	250
Materials inspection	120	90

Required :

(a) Classify the quality costs and express each class as a percentage of sales

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

Answer:

(a) Classification of Quality Costs

Cost classification	Expenditure	2015-16 ₹ in Lacs	2016-17 ₹ in Lacs	2015-16 Cost as % of Sales	2016-17 Cost as % of Sales
Prevention Cost	Quality Training	125	250		
	Material Inspections	120	90		
	Sub Total	245	340	2.45%	3.40%
Appraisal Cost	Production Inspection	250	325	2.50%	3.25%
Cost of Internal Failures	Scrap	100	50		
	Rework	650	550		
	Sub Total	750	600	7.50%	6.00%
Cost of External Failures	Product Warranty	500	250	5.00%	2.50%

(b) Increase in profits due to quality improvement

Quality cost incurred in 2015-16 – ₹ 1745 lacs

in 2016-17 – ₹ 1515 lacs

Total cost saving during 2016-17 - ₹ 230 lacs

So increase in profits due to quality improvement is ₹ 230 lacs during 2016-17

18. A Company manufactures a single product, which requires two components. The Company purchases one of the components from two suppliers: x Ltd and Y Ltd. The price quoted by X Ltd is ₹180 per 100 units of the component and it is found that on an average 3% of the total receipt from this supplier is defective. The corresponding quotation from Y Ltd is ₹174 per 100 units, with defect rate of 5%. If the defectives are not detected, they are utilized in production causing a damage of ₹180 per 100 units of the component.

The Company Intends to introduce a system of inspection for the components on receipt. The Inspection cost is estimated at ₹24 per 100 units of the component. Such an inspection will be able to detect only 90% of the defective components received. No payment will be made for components found to be defective in Inspection.

Required:

(a) Please justify the Inspection at the point of receipt, give your working for the same.

(b) Assuming a total requirement of 10,000 units, ascertain the lowest supplier

Answer:

(a) Computation of cost per 100 units of good components without Inspection

Particulars	**A Ltd**	**B Ltd**
(a) Purchase Price (b) Production Damage	₹180 ×10,000/100= 18,000 (18,000 × 3%) =540	₹174 x 10,000/100=17,400 (17,400 × 5%) = 870
(c) Total Costs (a + b)	₹18,540	₹ 18,270
(d) Number of good components	(10,000- 300) = 9,700 units	(10,000 – 500) = 9,500 units
(e) Cost per 100 good components (c ÷ d)	₹18,540/9,700 units × 100 =191.13	₹18,270/9,500 units × 100 =192.31

(b) Computation of Cost per 100 units of good components with Inspection

Particulars	A Ltd	B Ltd
(a) Total Units Required	10,000 units	10,000 units
(b) Defective Units	3% of 10,000 = 300 units	5% of 10,000 = 500 units
(c) Defectives not detected (10%)	30 units	50 units
(d) Defectives detected	270 units	450 units
(e) Components paid for (a-d)	9,730 units	9,550 units
(f) Purchase Price	(9,730 × 180) ÷100 =₹17,514	(9,550 × 174) ÷ 100 = ₹16,617
(g) Inspection Cost	(10,000 × 24) ÷100 = ₹2,400	(10,000 × 24) ÷ 100 = ₹2,400
(h) Production Damage	(30 x 180) ÷100 = ₹54	(50 × 174) ÷ 100 = ₹ 87
(i) Total Costs (f + g + h)	₹19,968	₹19,104
(j) Cost per 100 good components	(₹19,968/9,700 units) ×100 = ₹ 205.86	(₹19,104/9,500 units) ×100 = ₹201.09

Conclusion:

- Inspection at the point of receipt is not advantageous, due to additional cost per 100 good components, i.e. (₹ 205.86 – ₹ 191.13) = ₹ 14.73 in case of A Ltd, and (₹ 201.09 - ₹ 192.31) = ₹ 8.78 in case of B Ltd.
- Purchase from A Ltd. is cheaper, as there is cost saving of ₹ 1.18 per 100 good components

19. Rags Ltd. manufactures and sells premium quality of sports shoes in India. Noted sports clubs and its members are the main customers. Finished products show some rectifiable defects. These problems can be detected and rectified during internal inspection. Inspection cost is Rs.30 per unit. Rectification cost is Rs.18 per unit.

During 2017, 60000 pairs of shoes were manufactured and sold. After inspection defect was detected in respect of 5% of output. Inspection cost is ₹30 per pair. After sales, customers reported defects in respect of 6% of output. These shoes were received back from customers at a transportation cost of ₹10 per pair. Due to negative publicity arising out of sale of defective materials, loss in sales is expected in next year to the extent of 5% of external failures.

Required:

(a) Analyze the cost of quality showing its elements separately with working

(b) If the selling price per pair of shoes is ₹600 and variable cost is 60% of sales, fixed cost is ₹5,50,000 p.a., prepare the profitability statement for the product during 2017.

Answer:

(a) Statement of Costs of Quality

		₹
(a)	Inspection or Appraisal Cost (30 × 60,000 shoes)	18,00,000
(b)	Internal failure (re-work) cost (5% × 60,000 × ₹ 18)	54,000
(c)	External failure cost (i.e., transportation + re-work cost) [6% × 60,000 × (₹10 + 18)]	1,00,800
(d)	Opportunity cost (i.e., loss of contribution) [5% × (6% × 60,000) × (₹600 × 40%)]	43,200
	Total Quality Cost	19,98,000

(b) Profitability statement

	₹
Sales (60,000 ×₹600)	3,60,00,000
Less: Variable Cost (60%)	2,16,00,000
Contribution	1,44,00,000
Less: Quality Cost (as above)	19,98,000
Contribution, net of quality costs	1,24,02,000
Less: Fixed Cost	5,50,000
Net Profit	1,18,52,000

20. The following information is obtained from the records of ABC Ltd. for the period ending on 31.3.2017:

Product	Contribution (₹)
A	**500**
B	**200**
C	**1500**
D	**75**
E	**100**
F	**125**
Total	**2500**

Required :

(i) Prepare a Pareto Product contribution chart and comment on the result

Answer:

Statement of Pareto Analysis

Product	Contribution ₹	Accumulated contribution	%
C	1500	1500	60
A	500	2000	80
B	200	2200	88
f	125	2325	93
E	100	2425	97
D	75	2500	100
Total	2500		

Study Note – 6

APPLICATION OF OPERATION RESEARCH AND STATISTICAL TOOLS IN STRATEGIC DECISIONS MAKING

Learning Objective: *Operations research is a quantitative approach that solves problems, using a number of mathematical techniques. It is helpful to use operations research when you're trying to make decisions but the conditions are uncertain, and when differing objectives are in conflict with each other. The contributions of Operations Research (OR) in the healthcare field have been extensively, covering decision support tools with operational, tactical, and strategic approaches.*

OBJECTIVE TYPE QUESTIONS:

1. Learning curve theory is based on the idea that
   (i) Maximum efficiency can be achieved in the beginning
   (ii) Maximum efficiency cannot be achieved in the beginning
   (iii) Maximum efficiency cannot be achieved
   (iv) None of the above

2. In Learning Curve theory relationship between labour cost per unit and cumulative production are
   (i) Directly proportional
   (ii) Inversely proportional
   (iii) No relationship at all
   (iv) None of the above

3. The time taken to produce the first unit of a product is 4000 hrs. What will be the total time taken to produce the 5th to 8th unit of the product, when a 90% learning curve applies?
   (i) 10,500 hours (ii) 12,968 hours (iii) 9,560 hours (iv) 10,368 hours

4. ASHLIN Ltd., has developed a new product and just completed the manufacture of first four units of the product. The first unit took 2 hours to manufacture and the first four units together took 5.12 hours to produce. The Learning Curve rate is
   (i) 83.50% (ii) 80.00% (iii) 75.50% (iv) None of above

5. If the direct labour cost is reduced by 20% with every doubling of output, what will be the cost of labour for the sixteenth unit produced as an approximate percentage of the cost of the first unit produced?
   (i) 51.20% (ii) 40.96% (iii) 62.00% (iv) None of these

6. Linear Programming is a technique for
   (i) Optimization (ii) Minimization (iii) Maximization (iv) None of These

7. Hungarian method is a way to solve problem related to
(i) Transportation (ii) Assignment (iii) Learning Curve (iv) None of These

8. Which of the following is not a method to solve Transportation problems
(i) Least Cost Method (ii) NWC Method (iii) Hungarian Method (iv) VA Method

9. Least Cost Method is a way to solve problem related to
(i) Linear Programming (ii) Assignment (iii) Transportation (iv) All of these

10. Simulation is
(i) An analysis & modeling tool (ii) Manufacturing System
(iii) Quality control Mechanism (iv) None of these

11. Which of the following is not a type of simulation
(i) Behavioral simulation (ii) Functional simulation
(iii) Pareto Analysis (iv) Static timing analysis

Answer:

1. (ii)
2. (ii)
3. (iv)

Units	Average Time per Unit (hours)	Total Time (hours)
1	4000	4000
2	3600	7200
4	3240	12960
8	2916	23328

Total time for 5th to 8 units = 23328 - 12960 = 10368 hrs.

4. (ii) 80%

Let the learning rate be x.

Since the first unit took 2 hours, average time for the first two units = 2x and

The average time for the first 4 units = $2x \times x =. 2\ x^2$

So $2x^2 = 5.12 \div 4 = 1.28$ or, $x = \sqrt{1.28} \div 2$

0.80 i.e. 80%.

5. (ii) 40.96%

1st	100%
2nd	80% x 100%
4th	80% of 2nd
8th	80% of 4th
16th	80% of 8th = 0.80 x 0.80 x 0.80 x 0.80 = 40.96%

6. (i) Optimization
7. (ii) Assignment
8. (iii) Hungarian Method
9. (iii) Transportation
10. (i) An analysis & modeling tool
11. (iii) Pareto Analysis

DESCRIPTIVE QUESTIONS:

12 Write Notes on:

(a) Uses of Learning curve

(b) Transportation

(c) Vogel's Approximation Method (VAM)

(d) Application & Advantages of Simulation

(e) Network Analysis

(f) Assignment

Answer:

(a) Uses of Learning curve

Learning curve is now being widely usedin business. Some of the applications are as follows:

(i) Suggests great opportunities for cost reduction to be achieved by improving learning.

(ii) It Suggests a basis for correct staffing in continuously expanding production. The curve shows that the work force need not be increased at the same rate as the prospective output. This also helps in proper production planning through proper scheduling of work; providing manpower at the right moment permitting more accurate forecast of delivery dates. Learning curve concept provides a means of evaluating the effectiveness of training programs.

(iii) It seeks answers to questions like, how does the learning curve for this group or shop compare with others? Any of the employees, who lack the aptitude to meet normal learning-curve, should be eliminated.

(iv) Learning curve is frequently used in conjunction with establishing bid price for contracts. Usually, the bid price is based on the cumulative average unit cost for all the units to be produced for a given contract.

(v) It helps in working capital requirement estimation. As employees become more efficient, the rate of production increases and so more materials are needed, the work-in-progress inventory turns over faster, and finished goods inventory grows at an accelerated rate. A knowledge of the learning curve assists in planning the inventories of materials, work-in-progress, and finished goods.

(vi) Learning curve techniques are useful in exercising control. Variable norms can be established for each situation, and a comparison between these norms and actual expenses can be made.

(vii) The learning curve may be used for make-or- buy decisions especially if the outside manufacturer has reached the maximum on the learning curve. It helps to calculate the sensitive rates in wage bargaining.

(b) Transportation Problem

The transportation problem, a special type of Linear Programming Problem, is used to find the optimal way in which a product produced at various plants or sources can be transported to various destinations (demand points). The objective of the problem is to find the amount of commodity to be transported from each source to each destination so that the destination requirements within the operating production capacity constraints are satisfied at minimum transportation cost. Various methods have been developed to solve the transportation problem and obtain an optimal solution, such as the modified distribution (MODI) method. In order to proceed with these methods, it is necessary to obtain the initial feasible solution. One can use a similar techniques used in solving the assignment problem to find the initial feasible solution for the transportation problem.

Mathematical Formulation of the Transportation Problem

A homogenous product available at a finite number of origins m is to be transported to a finite number of destinations n. The total amount available at each of these origins is known and the total quantity required at each of the destinations is known. The unit transportation cost from each origin to each destination is given. The question here is to determine the amount of the products to be transported from these origins to destinations so as to minimize the total transportation cost. Thus, the underlying assumptions are:

(i) The total supply of the product from origin i is ai, where i = 1, 2...m

(ii) The total quantity demanded for the product at destination j is bj, where j = 1, 2...n

(iii) The transportation cost of sending one unit of the product from origin i to destination j is cij, where i = 1, 2...m and j = 1, 2...n.

(iv) The amount of product transported from origin i to destination j is xij, where i = 1, 2...m and j = 1, 2...n.

The decision variable of the problem is the amount of goods needed to be transported from each origin to each destination, which is xij.

Terminology

Feasible Solution: A set of non-negative values xij, i=1, 2, ..., m; j = 1, 2, ..., n that satisfies no. of rows to no. of columns is called a feasible solution to the transportation problem.

Basic Feasible Solution: An initial feasible solution with an allocation of (m + n – 1) number of variables, xij, i=1, 2, ..., m; j = 1, 2, ..., n, is called a basic feasible solution.

Optimum Solution: A feasible solution (not necessarily basic) is said to be optimum if it minimizes the total transportation cost.

Balanced or Unbalanced Transportation Problems: A transportation problem can be balanced or unbalanced. It is said to be balanced if the total demand of all the warehouses equals the amount produced in all the factories. If in reality, capacity is greater than requirement, then a dummy warehouse may be used to create desired equality. If capacity is less than requirement, then a dummy factory may be introduced. The transportation cost in both the dummy cases is assumed to be zero. Where the number of rows and columns are not equal, it is called unbalanced transportation problem.

Loops in Transportation Table: In a transportation table, an ordered set of four or more cells is said to form a loop if any two adjacent cells in the ordered set lie either in the same row or in the same column. Moreover, every loop has an even number of cells.It may be noted that a feasible solution to a transportation problem is basic if and only if the corresponding cells in the transportation table do not contain a loop.

Degeneracy of a Transportation Problem: When the quantities are allocated to cost cells within the matrix and if such allocations are less than m + n -1allocations (where 'm' stands for no. of rows and 'n' stands for no. of columns), such a situation is said to be Degeneracy of a Transportation Problem.

Methods of Solving Transportation Problem

The following are the methods of solving transportation problem:

1. The north-west corner rule

2. Lowest cost entry method

3. Vogel's approximation method

Assimilation

Transportation is a method of quantitative analysis adopted to solve business problems relating to physical distribution of products whereby companies minimise costs and as a consequence maximise profits.

(c) Vogel's Approximation Method (VAM):

This method is preferred over the other methods because the initial basic feasible solution obtained is either optimum or very close to the optimum solution. Therefore, the amount of time required to arrive at the optimum solution is greatly reduced. Various steps of this method are summarized as under:

Step 1: Compute a penalty for each row and column in the transportation table. The penalty for a given row and column is merely the difference between the smallest cost and the next smallest cost in that particular row or column.

Step 2: Identify the row or column with the largest penalty. In this identified row or column, choose the cell which has the smallest cost and allocate the maximum possible quantity to the lowest cost cell in that row or column so as to exhaust either the supply at a particular source or satisfy demand at a warehouse. If a tie occurs in the penalties, select that row/column which has minimum cost. If there is a tie in the minimum cost also, select that row/column which will have maximum possible assignments. It will considerably reduce computational work.

Step 3: Reduce the row supply or the column demand by the amount assigned to the cell.

Step 4: If the row supply is now zero, eliminate the row, if the column demand is now zero, eliminate the column, if both the row supply and the column demand are zero, eliminate both the row and column.

Step 5: Recompute the row and column difference for the reduced transportation table, omitting rows or columns crossed out in the preceding step.

Step 6: Repeat the above procedure until the entire supply at factories are exhausted to satisfy demand at different warehouses.

(d) Applications & Advantages of Simulation

Application

Avenues of application of Simulation include:

(i) Scheduling aircraft

(ii) Job-ship scheduling and personnel scheduling

(iii) Manpower-hiring decisions

(iv) Traffic light-timing

(v) Transport-scheduling

(vi) Evaluating alternative investment opportunities

(vii) Design of parking lots, harbour, and communication systems etc.

Advantages

Advantages of Simulation may be listed as:

(a) Enables to experiment and study complex interactions of a system (e.g. company operations, economic policies)

(b) Possible to study the effects of organizational environment informational changes in the operations of a system (e.g. number of stocking points, industrial policies)

(c) Better insight and understanding of a complex system to indication for improvement

(d) Assists in teaching and training (management games)

(e) New situations policies can be protested

(f) Probabilistic features can be easily incorporated

(g) A process can be studies in extended or compressed time

(h) Risks involved in experimenting with real problems can be eliminated

(e) Network Analysis

Concept

Network analysis is the general name given to PERT and CPM techniques which can be used for planning, management and control of a project.

Network is a graphical representation of all the activities and events of a project arranged in a logical and sequential order. In this context, activity is the actual performance of the job which consumes resources like time, human resources, money, material, etc. An event refers to the starting point or completion point of a job.

Net work Analysis acts as a management tool for breaking down projects into components or individual activities and recording the result on a flow chart or network diagram. These results generally reveal information that is used to determine duration, resource limitations and cost estimates associated with the project.

A project is a combination of interrelated activities all of which must be executed in a certain order for its completion. Project management and efficient resource allocation are two critical aspects of the production and operations managers' responsibilities. Since a project is non-repetitive and temporal in nature, the mode of management differs from the usual job shop or other related types of scheduling.

Network analysis enables us to take a systematic quantitative structural approach to the problem of managing a project through to successful completion. Also, since it has a graphical representation, it can be easily understood and used by those with a less technical background.

PERT & CPM

PERT: Project Evaluation and Review Techniques (PERT) is a method of analysing the tasks involved in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project. It incorporates uncertainty by making it possible to schedule a project while not knowing precisely the details and durations of all the activities. It is more of an event-oriented technique rather than start- and completion-oriented, and is used more in projects where time is the major factor rather than cost. It is applied to very large-scale, one-time, complex, non-routine infrastructure and Research and Development projects.

CPM: Critical Path Method (CPM) or Critical Path Analysis (CPA) is a project management tool that helps determination of the minimum time needed to complete a project. The CPM:

(i) Sets out all the individual activities that make up a larger project.

(ii) Shows the order in which activities have to be undertaken.

(iii) Shows which of the activities can be taken up only when the other activities have been completed.

(iv) Shows which of the activities can be undertaken simultaneously, thereby reducing the overall time taken to complete the whole project.

(v) Pinpoints the time schedules needed for the specified resources, for example, a crane to be hired for a building site.

PERT and CPM are complementary tools. CPM employs one time estimate and one cost estimate for each activity. PERT may utilize three time estimates (optimistic, expected, and pessimistic) and no costs for each activity. Although these are distinct differences, the term PERT is applied increasingly to all critical path scheduling.

Avenues of Application

(i) Construction of Buildings and Complexes

(ii) Ship building

(iii) Satellite mission development

(iv) Installation of a pipe line project

(v) Research & Development

(vi) Inventory Planning & Control

(vii) Traffic flow Control

(viii) Long Range Planning

(ix) And so on ...

Assimilation

PERT has the ability to cope with uncertainty in activity completion times while CPM emphasizes on the trade-off between cost of the project and its overall completion time.

(f) Assignment

Assignment

An assignment is a particular case of transportation problem where the objective is to assign a number of resources to an equal number of activities so as to minimize total cost or maximize total profit by means of allocation. The assignment problem is one of the fundamental combinatorial optimization problems in the branch of optimization or operations research in Mathematics. In a way, assignment is a special linear programming problem.

A typical assignment problem consists of a number of agents and a number of tasks. Any agent can be assigned to perform any task, incurring some cost that may vary depending on the agent-task assignment. In such a situation, the objective is to perform all the tasks by assigning a cost effective agent to each task in such a way that the total cost of the assignment is minimized.

Assuming that a taxi firm has three taxis (the agents) available, and three customers (the tasks) wishing to be picked up as soon as possible. The firm prides itself on speedy pickups and that for each taxi the "cost" of picking up a particular customer will depend on the time taken for the taxi to reach the pickup point. The solution to the assignment problem will be the combination of taxis and customers that will result in the least cost.

Methods

There are four methods of solving an assignment problem, viz. Enumeration Method, Simplex Method, Transportation Method and Hungarian Method.

(i) **Enumeration method:** In this method, a list of all possible assignments among the given resources (like men, machines, etc.) and activities (like jobs, sales areas, etc.) is prepared. Then, by the process of comparison, an assignment involving the minimum cost (or maximum profit), time or distance is selected.

(ii) **Simplex Method:** An assignment problem, being in the nature of a linear programming problem can be solved by the simplex method also.

(iii) **Transportation Method:** Since an assignment problem is a special case of the transportation problem, it can also be solved by transportation methods. However, the problem of degeneracy at each solution makes the transportation method computationally inefficient for solving an assignment problem.

(iv) **Hungarian Method:** Of the four methods, Hungarian method is considered as one of the best available for solving an assignment problem. The method works on the principle of reducing the given cost matrix to a matrix of opportunity costs.

Application

Some of the situations where the assignment technique may be useful are assignment of workers to machines, salesmen to different sales areas, clerks to various checkout counters, classes to rooms, etc.

13. Mention the major areas where linear programming can be applied as decision making technique.

Answer:

Linear Programming is a technique for the optimization of a linear objective function, subject to linear equality and linear inequality constraints. In practice linear programming has proved to be one of the most widely used technique of managerial decision making in business, industry and numerous other fields.

(a) Industrial Applications: Linear programming is extensively used to solve a variety of industrial problems. In each of these applications, the general objective is to determine a plan for production and procurement in the time period under consideration. It is necessary to satisfy all demand requirements without violating any of the constraints. Few examples of industrial applications are as follows:

(i) Product Mix-Problem.

(ii) Production Scheduling& smoothing Problem

(iii) Blending Problems.

(iv) Transportation Problems.

(v) Trim Loss.

(vii) In Communication Industry for solving problems involving facilities for transmission, switching, relaying etc.

(viii) In Rail Road Industry for optimal programming of railway freight, and train movements

(b) Management Applications:

(i) Portfolio Selection.

(ii) Financial Mix Strategy.

(iii) Profit Planning.

(iv) Media Selection.

(v) Travelling Salesmen Problem.

(vi) Determination of equitable salaries.

(vii) Staffing problem.

(c) Miscellaneous Applications:

The additional applications of Linear Programming are as follows:

(i) Farm planning.

- The particular crops to be grown or cattle to keep during a period
- The acreage to be devoted to each, and
- The particular production methods to be used.

(ii) Airline routine.

(iii) Administration, Education and Politics have also employed linear programming to solve their problems.

(iv) Diet Problems. One of the earliest applications of linear programming was by hospitals to determine the most economical diet for patients.

(d) Administrative applications of Linear Programming: Linear programming can be used for administrative applications. Administrative applications of Linear Programming are concerned with optimal usage of resources like men, machine and material.

(e) Non-Industrial applications of linear programming: Linear programming techniques/tools can be applied in the case of non-industrial applications as well. Examples of the use of L.P techniques for non-industrial applications are given below:

(i) Agriculture.

(ii) Environmental Protection.

(iii) Urban Department.

(iv) Facilities Location.

(f) Further applications of Linear Programming are:

(i) In structural design for maximum productivity.

(ii) In balancing assembly lines.

(iii) In scheduling of a military tanker fleet.

(iv) In determining which parts to make and which to buy to obtain maximum profit margin.

(v) In selecting equipment and evaluating methods improvements that maximize profit margin.

(vi) In planning most profitable match of sales requirements to plant capacity that obtains a fair share of the market.

(vii) In design of optimal purchasing policies.

PRACTICAL PROBLEMS AND SOLUTIONS:

14. The Usual Learning Curve Model is $Y = ax^b$ where

Y is the average time per unit for x units.

a is the time for first Unit

X is the cumulative number of units

b is learning coefficient and is

equal to $= \frac{\log 0.8}{\log 2}$ **=-0.322 for a learning rate of 80%**

Given that a =10 hours and learning rate 80% , you are required to calculate:

(1) The average time for 20 units.

(2) The total time for 30 units.

(3) The time for 31 to 40 units.

Given that log 2 = 0.301, Antilog of 0.5811 = 3.812

log 3 = 0.4771, Antilog of 0.5244 = 3.345

log 4 = 0.6021,Antilog of 0.4841 = 3.049.

Answer:

(i) $Y = AX^b$

$Y = 10(20)^{-0.322}$

Taking log on both sides

$\log y = \log 10 + \log 20^{-0.322}$

$\log y = \log 10 - (0.322) \log 20$

$=1-(0.322) \log 20$

$=1-(0.322)X(1.3010)$

$=1-0.41892=0.5811$

Log y = 0.5811

Y= Anti log (0.5811) =3.812 hrs (average time)

Total time = 3.812 × 20 = 76.24 hrs

(ii) $Y = AX^b$

$Y = 10(30)^{-0.322}$

Taking log on both sides

Log y = log 10 + $\log 30^{(-0.322)}$

= 1 – (0.322) × (1.4771)

= 1 – (0.4756) = 0.5244

Y = anti log (0.5244) = 3.345 hrs (average time)

Total time = 3.345 × 30 = 100.35 hrs

(iii) $Y = 10(40)^{-0.322}$

Taking log on both sides

Log y = log 10 + $\log 40^{(-0.322)}$

= 1 – (0.322) × (1.6021)

Log y = 0.4841

Y = anti log (0.4841) = 3.049hrs

Total Time = 3.049 x 40 =121.96 hrs.

Total Time for 31 to 40 units = 121.96 – (100.35) = 21.61hrs

15. The Learning curve as a management accounting has now become or going to become an accepted tool in industry, for its applications are almost unlimited. When it is used correctly , it can lead to increased business and higher profits; When used without proper knowledge, it can lead to lost business and bankruptcy. Illustrate the use of learning curve for calculating the expected average units cost of making (a) 4 machines and (b) 8 machines by using the data below:

Direct labour need to make first machine	**= 1000 hrs.**
Learning curve	**= 90%**
Direct labour cost	**= ₹ 15/- per hour.**
Direct material cost	**= ₹ 1,50,000**
Fixed cost for either size orders	**= ₹ 60,000.**

Answer:

Statement showing computation of cost of making 4 machines & 8 machines:

No. of machines	Average Time	Lobour Cost	Material	Fixed Cost	Total
	Hours	₹	₹	₹	₹
1	1000	15000	150000	60000	225000
2	900	13500	150000	30000	193500
4	810	12150	150000	15000	177150
8	729	10935	150000	7500	168435

Average cost of making 4 machines ₹ 177150

Average cost of making 8 machines ₹ 168435

16. Z.P.L.C experience difficulty in its budgeting process because it finds necessaryto qualify the learning effect as new products are introduced.

Substantial product changes occur and results in the need for retraining.

An order for 30 units of a new product has been received by Z.P.L.C. so far, 14 have been completed; the first unit required 40 direct labour hours and a total of 240 direct labour has been recorded for the 14 units. The production manager expects an 80% learning effects for this type of work.

The company use standard absorption costing. The direct costs attributed to the centre in which the unit is manufactured and its direct material costs are as follow:

	₹
Direct Material	**30.00 per Unit**
Direct Labour	**6.00 per Unit**
Variable Overhead	**0.50 per direct labour hour.**
Fixed Overhead	**6,000 per four week operating period.**

There are 10 direct employees working five-days per week, eight hours per day. Personal and other downtime allowances account for 25% of total available time.

The company usually quoted a four-week delivery period for orders.

You are required to:

(i) Determine whether the assumption of an 80% learning effect is a reasonable one in this case , by using standard formula $y = ax^b$

Where Y = the cumulative average direct labour time per unit (productivity).

a = the average labour time per unit for the first batch.

x = the cumulative number of batches produced.

b = the index of learning.

(ii) Calculate the number of direct labour hours likely to be required for an expected second order of 20 units.

(iii) Use the cost data given to produce an estimated product cost for the initial order, examine the problems which may be created for budgeting by the presence of the learning effect.

Answer:

(i) Total time taken to 14 units

$Y = ab^x$

$Y = 40\ (14)^{-0.322}$

Log y = log 40 + log $14^{-0.322}$

Log y = log 40 – (0.322)log 14

= 1.6021-(0.322)x1.1461

=1.6021 -0.3690 =1.233

Y = Antilog ((1.2333) = 17.14

Total time = 17.14 × 14 = 239.96

= 240 hour

It is true that learning Ratio 80% is effective.

(ii) For **30 Units –** $Y= 40(30)^{-0.322}$

log y= Log 40+log $30^{-0.322}$

log y = 1.6021-.322x1.4771 =1.1265

Y =13.380 hours (Average time)

For 50 Units - $Y= 40(50)^{-0.322}$

log y= Log 40+log $50^{-0.322}$

log y = 1.6021-.322x1.6990 =1.055

Y=11.35 hours (Average time)

Total time for 30 units = 13.38X30 = 401.4 hours

Total time for 50 units = 11.35X50 = 567.5 hours

Time taken for 20 units from 31 to 50 units (567.5-401.4)= 166.1hours

(iii)

Man hours = 10X8X5X4 = 1600

(-) down time = 400

1200

Fixed cost per hour = 6000/1200 = ₹ 5

Computation of Total cost for the initial order

₹

Material (30X30)	=	900.00
Labour (401.4X6)	=	2408.40
Variable overheads (0.5X401.4)	=	200.70
Fixed overheads(5X401.4)	=	2007.00
	=	5516.10

17. A Firm Received an order to make and supply eight units of standard product which involve intricate labour operations. The first unit was made in 10 hours. It is understood that this type of production is subjectto 80% learning rate. The workers are getting a wages rate of ₹ 12 per hour.

(i) What is the total time and labour cost required to execute the above order?

(ii) If a repeated order of 24 units is also received from the same customer, what is the labour cost necessary for the second order?

Answer:

80% Learning Curve results are given below:

Production (Units)	Cumulative Average Time (hours)	Total Time (hours)
1	10	10
2	8	16
4	6.4	25.6
8	5.12	40.96
16	4.096	65.54
32	3.2768	104.86

Labour time required for first eight units = 40.96 hours

Labour cost required for 8 unit = 40.96 hour X₹ 12/hr ₹ 491.52

Labour time for 32 units = 104.86 hours

Labour time for first eight units = 40.96 hours

Labour time required for 2nd order for 24 units = 63.90 hours

Labour cost for 24 units = 63.90 hours × ₹ 12/hr = ₹ 766.80

18. A Manufacturing firm has discontinued production of a certain unprofitable product line and this has created considerable excess production capacity. Management is considering to devote this excess capacity to produce one or more of the three products 1,2 and 3. The available excess capacity on the machines , which might limit output is summarized in the following table:

Machine Type	Available excess Capacity (In machine hour per week)
Milling machine	250
Lathe	150
Grinder	50

The number of machine-hours required for each unit of the respective products are given below.

Machine Type	Capacity Requirement In machine hour per unit		
	Product 1	Product 2	Product 3
Milling machine	8	2	3
Lathe	4	3	0
Grinder	2	0	1

The per unit contribution would be ₹ 20 ₹ 6 and ₹ 8 respectively for products 1,2 and 3. Formulate the problem mathematically.

Answer:

Step 1. Key decision to be made is to determine the number of products to be manufactured by the firm to maximise profit.

Step 2. Decision Variables

x_1 be the number of products to be manufacture of product 1

x_2 be the number of products to be manufacture of product 2

x_3 be the number of products to be manufacture of product 3

Step 3. Feasible alternatives are set of values of $x_1, x_2,$ and x_3 where x_1, x_2, and x_3(each) ≥0

Formulation of LP Model

The objective function is to maximise the profit which is given by the linear function:

Maximise $Z = 20x_1 + 6x_2 + 8x_3$

Subject to constraints

$8x_1 + 2x_2 + 3x_3 \leq 250$ (Capacity in hours on milling machine)

$4x_1 + 3x_2 \leq 150$ (Capacity in hours on lathe)

$2x_1 + x_3 \leq 50$ (Capacity in hours in grinder) $x_1 \geq 0$, $x_2 \geq 0$, $x_3 \geq 0$ (Non-negativity restrictions)

19. A Dealer Manufactures only two items. Ceiling fans and table fans. He has Rs.9,000 to invest and a space to store at most 75 pieces. A ceiling fan costs him Rs.300 and a table fan Rs.150. He expects to gain Rs.50 on a ceiling fan and Rs.20 on a table fan. Assuming that he can sell all the fans that he manufactures, Prepare a mathematical model of the problem stated above.

Answer:

Step 1. The key decision is to determine the number of ceiling fans and table fans to be manufactured and sold to maximise profit.

Step 2. Decision Variables

Let x_1 be the number of ceiling fans to be manufactured

x_2 be the number of table fans to be manufactured

Step 3. Feasible alternatives are set by value of x_1 and x_2

Where $x_1 \geq 0$, $x_2 \geq 0$.

Formulation of LP Model

The objective is to maximise profit and, therefore, objective function is:

(Maximise) $Z = 50 x_1 + 20 x_2$

Subject to constraints :

$300x_1 + 150x_2 \leq 9,000$ (Amount to be invested)

Or $2x_1 + x_2 \leq 60$

$X_1 + x_2 \leq 75$

$x_1 \geq 0$, $x_2 \geq 0$ (Non-negativity restrictions

20. M & N Ltd. has received an order for at least 100 kilograms of a food mix. The food mix is made up from 4 ingredients, K, L, M and N. But the proportions of each ingredient in the mix may be varied. The costs per kilogram of K, L, M and N are Rs.4, Rs.7, Rs.5 and Rs.8 respectively. The order when delivered, must contain at least 30 kilograms of carbohydrates, 40 kilograms of fats and 10 kilograms of sugar. One Kilogram of each ingredient contains the following (by weight):

	Carbohydrates	Fats	Sugar	Others
K	15%	30%	10%	45%
L	50%	5%	6%	39%
M	10%	10%	30%	50%
N	0%	70%	5%	25%

M & N Ltd. has only 35 kg. of ingredient N in stock. More of the ingredient cannot be purchased from any supplier in time to meet this order.
Required: **Formulate a linear programming model.**

Answer:

(i) **Step 1.** Key decision to be made is to determine the cost of the food mix containing all the four ingredients of K, L,M, N in order to minimize cost

(ii) **Step 2.** Decision variables:

The decision variable are the ingredients in food mix,i.e. K, L, M and N.

Let K be the number of kilogram of K used.

Let L be the number of kilogram of L used.

Let M be the number of kilogram M used.

Let N be the number of kilogram of N used.

Step 3. Feasible alternatives are set of values of K, L, M, N each ≥ 0

There are five constraints i.e.,

(a) total supply quantity

(b) the minimum weight of carbohydrates required

(c) the minimum weight of fats required

(d) the minimum weight of sugar required

(e) the maximum supply of N.

This can be expressed as follows:

The Objective function is

To Minimize Z = 4K+7L+5M+8N (costs),

Subject to the following constraints :

$K+L+M+N \geq 100$ (Total supply quantity)

$0.15K + 0.5L + 0.1M \geq 30$ (Carbohydrates

$0.3K + 0.05L + 0.1M + 0.7N \geq 40$ (Fats)

$0.1K + 0.06L + 0.3M + 0.05N \geq 10$ (Sugar)

$N \leq 35$ (Maximum Availability)

$K,L,M,N \geq 0$ (Non-negativity restrictions)

21. The manager of an oil refinery must decide on the optimum mix of 2 possible blending processes of which the input and output production runs are as follows:

	Input		Output	
Process	**Crude A**	**Crude B**	**Gasoline X**	**Gasoline Y**
1	**6**	**4**	**6**	**9**
2	**5**	**6**	**5**	**5**

The maximum amount available of crude A and B are 250 units and 200 units respectively. Market demand shows that at least 150 units of gasoline X and 130 units of gasoline Y must be produced. The profits per production run from process 1 and process 2 are ₹ 4 and ₹ 5 respectively.

Formulate the problem for maximising the profit.

Answer:

Step 1. The key decision to be made is to determine the number of unitsof gasoline to be produced from processes 1 and 2 respectively to maximise profit.

Step 2. Let x_1 represent the number of units of gasoline produced from process 1;

$x_2$represent the number of units of gasoline produced from process 2**.**

Step 3. Feasible alternatives are set of x_1, $x_2$where x_1 , $x_2 \geq 0$.

Formulation of LP Model

The objective function is to

Maximise $Z = 4x_1 + 5x_2$

Subject to constraints:

(i) $6x_1 + 5x_2 \leq 250$ (Available Crude A)

(ii) $4x_1 + 6x_2 \leq 200$ (Available Crude B)

(iii) $6x_1 + 5x_2 \geq 150$ (Demand of gasoline X)

(iv) $9x_1 + 5x_2 \geq 130$ (Demand of gasoline Y)

(v) $x_1, x_2 \geq 0$ (Non-negativity restrictions)

22. A Diet conscious housewife wishes to ensure certain minimum intake of vitamins A, B, and C for the family. The minimum daily (quantity) need of the vitamins A,B and C for the family are respectively 30, 20 and 16 units. For the supply of these minimum vitamin requirements, the housewife relies on two fresh foods. The first one provides 7,5,2 units of the three vitamins per gram respectively and the second one provides 2,4,8 units of the same three vitamins per gram of the foodstuff respectively. The first foodstuff costs ₹ 3 per gram and the second ₹ 2 per gram. The problem is how many grams of each foodstuff should the housewife buy everyday to keep her food bill as low as possible?

Formulate the underlying LP problem.

Answer:

Step 1. The key decision is to determine the number of units of food x and food y to minimise the cost.

Step 2. Decision Variables.

Let x_1 = Number of units of food x (First one)

x_2 = Number of units of food y (second one)

Step 3. The Feasible alternatives are set of values of x_1 and x_2 where x_1, x_2 (each) > 0.

Formulation of LP Model

The objective function is to minimize the cost which is given by the linear function:

Minimise $Z = 3x_1 + 2x_2$

Subject to constraints

$7x_1 + 2x_2 \geq 30$ (Minimum amount require for Vitamin A)

$5x_1 + 4x_2 \geq 20$ (Minimum amount require for Vitamin B)

$2x_1 + 8x_2 \geq 16$ (Minimum amount require for Vitamin C)

x_1, x_2 each ≥ 0 (Non-negativity restrictions)

23. The owner of metro Sports wishes to determine how many advertisements to place in the selected three monthly magazines A, B and C. His objective is to advertise in such a way that total exposure to principal buyer of expensive sports goods is maximised. Percentages of readers for each magazine are known. Exposure in any particular magazine is the number of advertisements placed multiplied by the number of principal buyers. The following data may be used:

	Magazine		
	A	**B**	**C**
Readers	**1 lakh**	**0.6 lakh**	**0.4 lakh**
Principal Buyer	**20%**	**15%**	**8%**
Cost per Advertisement (₹)	**8,000**	**6,000**	**5,000**

The budgeted amount is at most ₹ 1 lakh for the advertisements. The owner has already decided that magazine A should have not more than 15 advertisements and that of B and C each should have at least 8 advertisements. Formulate aLP model for the problem.

Answer:

Step 1. The key decision to be made is to determine how many advertisements to be placed in the selected three monthly magazines A, B and C so that total exposure to principal buyers of expensive sports goods is maximised

Step 2. Decision Variables

Let x_1 = number of insertions in magazine *A*,

x_2 = number of insertions in magazine *B*

x_3 = number of insertions in magazine *C*.

Step 3. Feasible alternatives are sets of values of x_1, x_2, x_3.

Where x_1, x_2, x_3 each ≥ 0

Formulation of LP model

The objective is to maximise (total exposure)

Maximise $Z = (20\% \text{ of } 100000)x_1 + (15\% \text{ of } 60,000)x_2 + (8\% \text{ of } 40,000)x_3$
$= 20,000x_1 + 9,000x_2 + 3,200x_3$

Subject to constraints

$8,000x_1 + 6,000x_2 + 5,000x_3 \leq 1,00,000$ (Budgeted amount)

$x_1 \leq 15$, $x_2 \geq 8$ and $x_3 \geq 8$ (Advertisement)

$x_1 \geq 0$, $x_2 \geq 0$ and $x_3 \geq 0$ (Non-negativity restrictions)

24. A company has two divisions A and B. Division A produces 3 products for Division B andthere is no outside market for these 3 materials. Division B produces 2 products B1 & B2. The following details are relevant:

	A1	A2	A3
Variable cost per unit ₹	1.00	0.50	0.75
Quantity used			
(units) per unit of B1	2	0.5	1
B2	2	2	3
Processing capacity			
(Units/week in Division *A*)	4,000	3,000	4,800

The Price and variable processing cost for products B1 and B2 are:

	B1	B2
Price	₹ 8	₹ 14
Processing cost in division *B*	2	1.75

The overall profitability of the company has to be maximized and with this end in view, formulate the optimisation as a linear programming model and calculate the optimum units of products in both the divisions as well as the overall profit.

Answer:

Let y_1 and y_2 be the quantity of B1 and B2 respectively, and let

x_1, x_2, x_3 be the quantity of A1, A2, A3 produced.

The capacity constraints in Division A:

$x_1 \leq 4000 \quad x_2 \leq 3000 \quad x_3 \leq 4{,}800$

The demand for each of the 3 products of division *A* in terms of the products to be produced by Division B is given by

$$2Y_1 + 2Y_2 - X_1 \geq 0$$

$$0.5Y_1 + 2Y_2 - X_2 \geq 0$$

$$2Y_1 + 3Y_2 - X_3 \geq 0$$

The Model to be formulated

Maximize $(8-2)\ Y_1 + (14 - 1.75)\ Y_2 - 1X_1 - 0.5X_2 - 0.75\ X_3$

Subject to

$2Y_1 + 2Y_2 - X_1 \geq 0$

$0.5Y_1 + 2Y_2 - X_2 \geq 0$

$2Y_1 + 3Y_2 - X_3 \geq 0$

$X_1 \leq 4{,}000$

$X_2 \leq 3{,}000$

$X_3 \leq 4{,}800$

Where $Y_1, Y_2, X_1, X_2, X_3 \geq 0$

The optional solution for this problem is

$Y_1 = 666.67$ $Y_2 = 1333.33$ $X_1 = 4{,}000$

$X_2 = 3{,}000$ $X_3 = 4666.67$ yielding a profit of ₹ 11.333.

Working note – by solving equations

$2Y_1 + 2Y_2 = 4000$

$.5Y_1 + 2Y_2 = 3000$

So $Y_1 = 666.67$

25. A Departmental head has four subordinates and four tasks to be performed. The subordinates differ in efficiency, and the tasks differ in their intrinsic difficulty. His estimate, of the time each man would take to perform each task, is given in the matrix below:

Tasks	Men			
	E	F	G	H
A	18	26	17	11
B	13	28	14	26
C	38	19	18	15
D	19	26	24	10

How should the tasks be allocated one to a man, so as to minimize the total man- hours?

Answer:

Subtracting the smallest elements of each row from every element of the corresponding row, we get the reduced matrix:

Tasks	Men			
	E	F	G	H
A	7	15	6	0
B	0	15	1	13
C	23	4	3	0
D	9	16	14	0

Subtracting the smallest element of each column of the reduced matrix from every element of the corresponding column, we get the following reduce matrix.

7	11	5	0
~~0~~	~~11~~	~~0~~	~~13~~
~~23~~	~~0~~	~~2~~	~~0~~
9	12	13	0

Three lines are required to cover all zeros, whereas the order of the matrix is 4. Therefore, optimum assignment cannot be made at this stage also. The minimum uncovered element is 5. Therefore, subtracting this element from all the uncovered elements and adding the same to all the elements lying at the intersections of the lines. We obtain the following reduced matrix:

2	6	0	0
~~0~~	~~11~~	~~0~~	~~18~~
~~23~~	~~0~~	~~2~~	~~5~~
4	7	8	0

Four lines are required to cover all zeros and order of the matrix is also 4. Therefore, Optimum assignment can be made at this stage as follows.

2	6	[0]	0
[0]	11	0	18
23	[0]	2	5
4	7	8	[0]

Now, each row and each column has one and only one assignment. Therefore, optimal solution is reached. Optimum assignment is as follows:

A → G , B → E ,C → F and D → H

The minimum total time for the assignment schedule is as follows

Tasks	Men	Man-hours
A	G	17
B	E	13
C	F	19
D	H	10
	Total man – hours.	59

26. A computer centre has got three expert programmers. The centre needs three application programmes to be developed. The Head of the computer centre, after studying carefully the programmes to be developed, estimates the computer time in minutes required by the experts to the application programmes as follows:

	Programmes		
Programmers	**A**	**B**	**C**
1	**120**	**100**	**80**
2	**80**	**90**	**110**
3	**110**	**140**	**120**

Assignthe programmers to the programmes in such a way that the total computer time is least.

Answer:

Using the Hungarian Assignment Method, we subtract the smallest element of each row to get the following table:

Programmers	Programmes		
	A	B	C
1	40	20	0
2	0	10	30
3	0	30	10

Now from all the elements of a column, subtract the minimum element of that column.

Repeat this operation with all the columns to get the following table:

Programmes	Programmes		
	A	B	C
~~1~~	~~40~~	~~10~~	~~0~~
~~2~~	~~0~~	~~0~~	~~30~~
~~3~~	~~0~~	~~20~~	~~10~~

The minimum number of lines to cover all the zeros is 3, which is equal to the order of the matrix (3). Hence the above table will give the optimum assignment. The assignments are as follows:

Programmers	Programmes		
	A	B	C
1	40	10	[0]
2	~~0~~	[0]	30
3	[0]	20	10

The assignment of programmes to programmer are

1 → C , 2 → B and 3 → A

The minimum computer time required is

ProgrammersProgramme	Time-minutes
1	C80
2	B90
3	A110
Total time– minutes.	280

27. A firm produces four products. There are four operators who are capable of producing any of these four products. The processing time varies from operator to operator. The firm records 8 hours a day and allows 30 minutes for lunch. The processing time in minutes and the profit for each of the product are given below:

Operator	Products			
	A	B	C	D
1	15	9	10	6
2	10	6	9	6
3	25	15	15	9
4	15	9	10	10
Profit (₹ Per unit)	8	6	5	4

Find the optimum assignment of product to operators.

Answer:

The firm records 8 hours a day and allows 30 minutes for lunch. Hence net working time available per day is 7 hours and 30 minutes. i.e. 450 minutes. The number of units of each product, which could be produced in 450 minutes by the four operators is calculated in the table given below:

Operators	Products			
	A	B	C	D
1	450 ÷ 15 = 30	450 ÷ 9 = 50	450 ÷ 10 = 45	450 ÷ 6 = 75
2	450 ÷ 10 = 45	450 ÷ 6 = 75	450 ÷ 9 = 50	450 ÷ 6 = 75
3	450 ÷ 25 = 18	450 ÷ 15 = 30	450 ÷ 15 = 30	450 ÷ 9 = 50
4	450 ÷ 15 = 30	450 ÷ 9 = 50	450 ÷ 10 = 45	450 ÷ 10 = 45
profit (₹) per unit	8	6	5	4

Since profit per unit is given, the profit matrix is computed as given below:

Operators	Profit of products			
	A	B	C	D
1	240	300	225	300
2	360	450	250	300
3	144	180	150	200
4	240	300	225	180

The above matrix is converted into a loss matrix by subtracting all elements of the profit matrix from its highest pay off i.e.. 450. The loss matrix so obtained is given below:

Operators	Loss matrix – Products			
	A	B	C	D
1	210	150	225	150
2	90	0	200	150
3	306	270	300	250
4	210	150	225	270

Now let us apply the assignment algorithm. i.e. Hungarian Rule to the above loss matrix.

Subtract the minimum element of each row from all its elements in turn. The above matrix thus gets reduce to:

Operators	Loss matrix – Products			
	A	B	C	D
1	60	0	75	0
2	90	0	200	150
3	56	20	50	0
4	60	0	75	120

Subtract the minimum element of each column from all the elements of the column in turn. Draw the minimum number of lines in the resultant matrix so as to cover all zeros.

Operators	Loss Matrix – Products			
	A	B	C	D
1	4	0	25	0
2	34	0	150	150
3	0	20	0	0
4	4	0	25	120

The number of lines to cover all zeros is three, which is one less than the order of the matrix. We subtract 4 (minimum element of all uncovered elements) from all uncovered elements and add it to the element lying at the intersection of the two lines.

Operators	Loss matrix – Products			
	A	B	C	D
1	0	0	21	0
2	30	0	146	150
3	0	24	0	4
4	0	0	21	120

Since the number of lines to cover all zeros is 4, which is equal to the order of the matrix, the above matrix will give optimal solution. The optimal assignments are given below.

Operators	Loss matrix – Products			
	A	B	C	D
1	~~0~~	~~0~~	121	[0]
2	30	[0]	146	150
3	~~0~~	24	[0]	4
4	[0]	0	21	120

The optimal assignment is as follows:

Operators	Products	Profit (₹)
1	D	300
2	B	450
3	C	150
4	A	240
		1140

28. Consider the following data for the transportation problem:

Factory	Distribution			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. Find the optimum allocation that minimizes the transportation and penalty costs.

Answer:

The demand is 75 + 20 +50 = 145. The supply is 10 + 80 + 15 = 105. The demand exceeds supply by 40 units. Therefore given problem is an unbalanced problem. We introduce a dummy factor with a supply of 40 units. It is given that for the unsatisfied demands, the penalty cost is Rupees 1, 2, 3 for destinations (1), (2), (3) respectively. Hence the transportation problem can be written in a matrix form as follows:

Table 1

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	145 145

The initial solution is obtained below by Vogel's method:

Table 2

Factory	Destination			Supply units	Difference		
	1	2	3				
A	5	10 1	7	10	4	-	-
B	20 6	10 4	50 6	80	2	2	-
C	15 3	2	5	15	1	1	1
Dummy	40 1	2	3	40	1		
Demand units	75	20	50	145 145			
Difference	2	1	2				
	2	-	2				

The initial solution is given in the table given below.

Table 3

Factory	Destination			Supply units
	1	2	3	
A	5	10 1	7	10
B	20 6	10 4	50 6	80
C	15 3	2	5	15
Dummy	40 1	2	3	40
Demand units	75	20	50	145 / 145

The number of allocations is 6 which is equal to required (m + n – 1) i.e. 6. Therefore the condition of degeneracy is satisfied. Now the solution is to be tested for optimality. Let us introduce μ and V_J, I = (1 , 2 , 3 , 4) and I = 1 , 2 , 3 such that $C_y = \mu_1 + v_1$ for occupied cells and $\Delta_y = c_y - (\mu + v)$ for unoccupied cells. We assume that μ= 0. Remaining values (refer to notes for detailed calculations) are given below.

Table 4

Factory	Destination			Supply	Vis
	(1)	(2)	(3)		
A	5	10 1	7 4	10	-3
B	20 6	10 4	50 6	80	0
C	15 3	2 1	5 2	15	-3
Dummy	40 1	2	3	40	-5
Demand	75	20	50	145 / 145	
V_js	6	4	6		

Since all Δ_y'S for unoccupied cells are positive, the solution obtained is an optimal one. The allocation of factories to different destinations and their cost is given below:

Factory	Destination	Units	Cost per unit	Total Cost	
A	2	10	₹ 1	₹ 10	X
B	1	20	6	120	X
B	2	10	4	40	X
B	3	50	6	300	X
C	1	15	3	45	X
Dummy	1	40	1	40	#
			Total cost	555	

X Transportation Cost

Penalty

Working Notes:

Occupied cells $C_{ij} = \mu_1 + v_j$	Unoccupied cells $\Delta_{ij} = c_{ij} - (\mu_1 + v_j)$
$C_{12} \Rightarrow \mu_1 + v_2 = 1$ or $\mu_1 = -3$	$C_{11} = 5 - (-3 + 6) = 2$
$C_{21} \Rightarrow \mu_2 + v_1 = 6$ or $v_1 = 6$	$C_{13} = 7 - (-3 + 6) = 4$
$C_{22} \Rightarrow \mu_2 + v_2 = 4$ or $v_2 = -4$	$C_{32} = 2 - (-3 + 4) = 1$
$C_{23} \Rightarrow \mu_2 + v_3 = 6$ or $v_3 = 6$	$C_{33} = 5 - (-3 + 6) = 2$
$C_{31} \Rightarrow \mu_4 + v_1 = 3$ or $\mu_3 = -3$	
$C_{41} \Rightarrow \mu_4 + v_1 = 1$ or $\mu_4 = -5$	

29. A company has three warehouses w_1, w_2, and w_3 . It is required to deliver a product from these warehouses to three customers A, B and C. The warehouses have the following units in stock:

Warehouse	**W_1**	**W_2**	**W_3**
No. of units	**65**	**42**	**43**
Customer requirements are :			
Customer	**A**	**B**	**C**
No. of units	**70**	**30**	**50**

The table below shows the costs of transporting one unit from warehouse to the customer

		Warehouse		
		W_1	W_2	W_3
Customer	A	5	7	8
	B	4	4	6
	C	6	7	7

Find the optimum transportation route.

Answer:

Let us formulate the given problem into a transportation problem as given below:

Table 1

Customer	Warehouse			Requirement
	W_1	W_2	W_3	
A	5	7	8	70
B	4	4	6	30
C	6	7	7	50
Stock	65	42	43	150 / 150

Since stock is equal to customer requirements (i.e. 150 units), we note that the above transportation problem is a balanced one and it is a minimization problem. We shall now apply Vogel's Approximation Method to find an initial solution.

Table 2

Customer	Warehouse			Requirement	Difference		
	W_1	W_2	W_3				
A	655	5 7	8	70	2	2	-
B	4	30 4	6	30	0	-	-
C	6	7 7	43 7	50	1	1	0
Stock	65	42	43	150 / 150			
Difference	1	3	1				
	1	0	1				
	1	-	1				

The initial solution obtained by **VAM is** given below :

Table 3

Customers	Warehouse			Requirement
	W_1	W_2	W_3	
A	65 5	5 7	8	70
B	4	30 4	6	30
C	6	7 7	43 7	50
Stock	65	42	43	150 / 150

The total number of allocations is 5 which is equal to the required i.e. (m + n – 1) = 5 allocations. Let us now test the optimality of the initial solution obtained above. Introduce μ_v VJ, i = (1 , 2 , 3 ,) and j = (1 , 2 , 3) such that Cy = μ1 + v1 for occupied cells and Δy = cy – (μ + v) for unoccupied cells. We assume that μ= 0. Remaining values are calculated below:

Customers	Warehouse W_1	W_2	W_3	Requirements	U_i's
A	65 5	5 7	8 1	70	0
B	4 2	30 4	6 2	30	-3
C	6 1	7 7	43 7	50	0
Stock	65	42	43	150	
V_j's	5	7	7		

(**Note**. For calculation of values refer to notes.)

Since all A_u's for unoccupied cells are positive, the solution obtained is an optimal one. The allocation of units from warehouse to customers and their costs are given below:

Warehouse	Customer	Units	Cost per unit	Total Cost
W_1	A	65	₹ 5	325
W_2	A	5	7	35
W_2	B	30	4	120
W_2	C	7	7	49
W_3	C	43	7	301
Total Cost				830

Working Notes:

Table 4

Occupied cells ($c_y = _1 + V_j$)	Unoccupied cells $\Delta y = cy - (\mu_i + vj)$
$C_{11} \Rightarrow \mu_1 + v_1 = 5$ or $\mu_1 = 5$	$C_{13} = 8 - (0 + 7) = 1$
$C_{12} \Rightarrow \mu_1 + v_2 = 7$ or $v_1 = 7$	$C_{21} = 4 - (-3 + 5) = 2$
$C_{22} \Rightarrow \mu_2 + v_2 = 4$ or $v_2 = -3$	$C_{23} = 6 - (-3 + 7) = 2$
$C_{32} \Rightarrow \mu_3 + v_2 = 7$ or $v_3 = 0$	$C_{31} = 6 - (-0 + 5) = 1$
$C_{33} \Rightarrow \mu_3 + v_3 = 7$ or $\mu_3 = 7$	

30. ABC Enterprises is having three plants manufacturing dry- cells, located at different locations. Production cost differs from plant to plant. There are five sales offices of the company located in different regions of the country. The sales prices can differ from region to region. The shipping cost from each plant to each sales office and other data are given below:

Product Data

Production cost per unit (₹)	Max. capacity in no. of units	Plant no.
20	150	1
22	200	2
18	125	3

Shipping Cost (in ₹)

	Sales Offices				
	A	B	C	D	E
Plant 1	1	1	5	9	4
Plant 2	9	7	8	3	6
Plant 3	4	5	3	2	7

Demand and sales Prices

Demand (Units)	80	100	75	45	125
Sales Price (₹)	30	32	31	34	29

Find the production and distribution schedule most profitable to the company

Answer:

In order to solve the transportation problem, we use the given information to derive the profit matrix. This is being done as follows:

Profit = sales Price – Production cost – shipping Cost

Thus, If we transport one unit of dry cell from each of the three plants to each of the five sales office , the following matrix is obtained :

Table 1

Plant	A	B	C	D	E	Capacity(units)
1	9	11	6	5	5	150
2	-1	3	1	9	1	200
3	8	9	10	14	4	125
Demand	80	100	75	45	125	475 425

Here, If we transport one unit from plant 2 to sales office D, the profit obtained can be calculated as follows (for the above table) :

Profit = ₹ 34 – ₹ 22- Rs.3 = ₹ 9

The objective of the company is to maximize the profit. For achieving this objective,

Let us convert this maximization problem into minimization problem by subtracting all the elements of the above pay – off matrix from the highest pay – off, i.e. 14 . Thus we have:

Table 2

Plant	Loss Matrix					Capacity (units)
	A	B	C	D	E	
1	5	3	8	9	9	150
2	15	11	13	5	13	200
3	6	5	4	0	10	125
Demands	80	100	75	45	125	475 425

The problem is an unbalanced problem. i.e. capacity is 475 and demand is 425. Hence a dummy sales office is added with cost equal to zero for all plants and demand equal to 50 units. Now, let us apply Vogel's Approximation Method to the resultant balanced matrix for finding the feasible solution.

Table 3

Plant	Sales office A	B	C	D	E	Dummy	Capacity	Difference		
1	50 5	100 3	8	9	9	0	150	3	3	2
2	25 15	11	13	5	125 13	50 0	200	5	11	2
3	5 6	5	75 4	45 0	10	0	125	0	4	1
Demand	80	100	75	45	125	50	475 475			
Difference	1	2	4	5	1	0				
	1	2	4	-	1	-				
	1	2	4	-	1	-				

The initial solution obtained by VAM is given below, which is tested for optimally

Table 4

Plant	Sales office A	B	C	D	E	Dummy	Capacity (units)
1	50 5	100 3	8	9	9	0	150
2	25 15	11	13	5	125 13	50 0	200
3	5 6	5	75 4	45 0	10	0	125
Demand	80	100	75	45	125		

Since there are 8 allocations, the solution is non – degenerate. Let us now introduce μ a- VJ, i = (1 , 2 , 3) ; j = (1 , 2 ..... 6) such that $\Delta y = cy - (\mu + v)$ for unoccupied cells. We assume that μ= 0. Remaining μ_i ,s, v's and Δ_y 's are calculated below:

Table 5

Plants	Sales office A	B	C	D	E	Dummy	Capacity	V_i's
1	50 5	100 3	8 5	9 10	9 0	0 -10	150	-10
2	25 -0 15	11 -2	13 10	+0 5 -4	125 13	50 0	200	0
3	5 +0 6	5 1	75 4	45 -0 0	10 6	0 9	125	-9
Demand	80	100	75	45	125	50	475 475	
V_j's	15	13	13	9	13	0		

(For values of occupied and unoccupied cells refer to Note 1.)

Table 6

	Sales office*						Cap.	
Plant	A	B	C	D	E	Dummy	units	V_i's
1	50 5	100 3	8 5	9 10	9 2	0 6	150	– 6
2	15 4	11 2	13 4	25 5	125 13	50 0	200	0
3	30 6	5 1	75 4	20 0	10 2	0 5	125	-5
	80	100	75	45	125	50	475 475	
V_j's	11	9	9	5	13	0		

(Refer to Note 2 for values of occupied and unoccupied cells)

Since the values of opportunity cost in all the unoccupied cells are positive, the solution obtained above is optimal. The allocation of plants to sales office and their profit amount is given below :

Plant	Sales office	Units	Profit per unit₹	Profit₹
1	A	50	9	450
1	B	100	11	1,100
2	D	25	9	225
2	E	125	1	125
2	Dummy	50	0	0
3	A	30	8	240
3	C	70	10	750
3	D	20	14	280
			Total profit	3,170

Working Notes

1. Values in Table 5 have been calculated as follows :

Occupied cell $c_y = \mu_1 + v_j$	Unoccupied cell $\Delta_y = c_y - (\mu_i + v_j)$
$C_{11} \Rightarrow \mu_1 + v_1 = 5$ or $\mu_1 = 5 - 15 = -10$	$C_{13} = 8 - (10 + 13) = 5$
$C_{12} \Rightarrow \mu_1 + v_2 = 3$ or $v_2 = 3 + 10 = 13$	$C_{14} = 9 - (-10 + 9) = 10$
$C_{21} \Rightarrow \mu_2 + v_1 = 15$ or $v_1 = -15 - 0 = 15$	$C_{15} = 9 - (-10 + 13) = 6$
$C_{25} \Rightarrow \mu_2 + v_5 = 13$ or $v_5 = 13 - 0 = 13$	$C_{16} = 0 - (-10 + 0) = 10$
$C_{26} \Rightarrow \mu_2 + v_6 = 0$ or $\mu_6 = 0$	$C_{22} = 11 - (0 + 13) = -2$
$C_{31} \Rightarrow \mu_3 + v_1 = 6$ or $\mu_3 = 6 - 15 = -9$	$C_{23} = 13 - (-0 + 13) = 0$
$C_{33} \Rightarrow \mu_3 + v_3 = 4$ or $v_3 = 4 + 9 = 13$	$C_{24} = 5 - (-0 + 9) = -4$
$C_{34} \Rightarrow \mu_3 + v_4 = 0$ or $\mu_4 = 9$	$C_{32} = 5 - (-9 + 13) = 1$
	$C_{35} = 10 - (-9 + 13) = 6$
	$C_{36} = 0 - (-9) = 9$

2. Values in Table 6 have been calculated as follows :

Occupied cell $c_y = \mu_1 + v_j$	Unoccupied cell $\Delta_y = c_y - (\mu_i + v_j)$
$C_{11} \Rightarrow \mu_1 + v_1 = 5$ or $\mu_1 = 5 - 11 = -6$	$C_{13} = 8 - (-6 + 9) = 5$
$C_{12} \Rightarrow \mu_1 + v_2 = 3$ or $v_2 = 3 + 6 = 9$	$C_{14} = 9 - (-6 + 5) = 10$
$C_{21} \Rightarrow \mu_2 + v_1 = 5$ or $v_1 = 5$	$C_{15} = 9 - (-6 + 13) = 2$
$C_{25} \Rightarrow \mu_2 + v_5 = 13$ or $v_5 = 13$	$C_{16} = 0 - (-6 + 0) = 6$
$C_{26} \Rightarrow \mu_2 + v_6 = 0$ or $\mu_6 = 0$	$C_{22} = 15 - (0 + 1) = 4$
$C_{31} \Rightarrow \mu_3 + v_1 = 6$ or $\mu_3 = 6 + 15 = -9$	$C_{23} = 11 - (-0 + 9) = 2$
$C_{33} \Rightarrow \mu_3 + v_3 = 4$ or $v_3 = 9$	$C_{24} = 13 - (-0 + 9) = 4$
$C_{34} \Rightarrow \mu_3 + v_4 = 0$ or $\mu_4 = -5$	$C_{32} = 5 - (-5 + 9) = 1$
	$C_{35} = 10 - (-5 + 13) = 2$
	$C_{36} = 0 - (-5 + 0) = 5$

31. A confectioner sells confectionery item. Past data of demand per week in hundred kilograms with frequency is given below:

Demand / week	**0**	**5**	**10**	**15**	**20**	**25**
Frequency	**2**	**11**	**8**	**21**	**5**	**3**

Using the following sequence of random numbers, generate the demand for the next 10 weeks. Also find out the average demand per week

Random Numbers	**35**	**52**	**13**	**90**	**23**	**73**	**34**	**57**
	35	**83**	**94**	**56**	**67**	**66**	**60**	

Answer:

Random No. Range Table for demand				
Demand per week	**Frequency**	**Probability**	**Cumulative Probability**	**Range**
0	2	.04	.04	0-3
5	11	.22	.26	4-25
10	8	.16	.42	26-41
15	21	.42	.84	42-83
20	5	.10	.94	84-93
25	3	.06	1.00	94-99
	$\sum f = 50$	1.00		

Simulated Value for next 10 week		
Weeks	**R. Nos.**	**Demand**
1	35	10
2	52	15
3	13	5
4	90	20
5	23	5
6	73	15
7	34	10
8	57	15
9	35	10
10	83	15
		120

Average weekly demand = $\frac{120}{10}$ = 12

32. The manager of a book store has to decide the number of copies of a particular tax law book to order. A book costs Rs. 60 and is sold for Rs. 80. Since some of the tax laws change year after year, any copies unsold while the edition is current must be sold for Rs.30. From past records, the distribution of demand for this book has been obtained as follows:

Demand (No. of copies)	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Probability	**0.05**	**0.08**	**0.20**	**0.45**	**0.10**	**0.07**	**0.03**	**0.02**

Using the following sequence of random numbers, generate the demand for 20 time periods (years). Calculate the average profit obtainable under each of the course of action open to the manager. What is the optimal policy?

14 02 93 99 18 71 37 30 12 10
88 13 00 57 69 32 18 08 92 73

Answer:

Random No. Range Table			
Demand per week	**Probability**	**Cumulative Probability**	**Range**
15	.05	.05	0-4
16	.08	.13	5-12
17	.20	.33	13-32
18	.45	.78	33-77
19	.10	.88	78-87
20	.07	.95	88-94
21	.03	.98	95-97
22	.02	1.00	98-99
	1.00		

Calculation of demand and profit for next 20 years					
Year	Random Numbers	Expected Demand	No. of books unsold if stock is		
			16	17	18
1	14	17	-	-	1
2	02	15	1	2	3
3	93	20	-	-	-
4	99	22	-	-	-
5	18	17	-	-	1
6	71	18	-	-	-
7	37	18	-	-	-
8	30	17	-	-	1
9	12	16	-	1	2
10	10	16	-	1	2
11	88	20	-	-	-
12	13	17	-	-	1
13	00	15	1	2	3
14	57	18	-	-	-
15	69	18	-	-	-
16	32	17	-	-	1
17	18	17	-	-	1
18	08	16	-	1	2
19	92	20	-	-	-
20	73	18	-	-	-
Total			2	7	18

Statement Showing Computation of profit			
No. of Books order	No. of books sold	Profit	Average Profit
15	15 × 20 = 300	₹ 6000	₹ 300
16	16 × 20 - 2 = 318	₹ 6300 (318 × 20) – 2 × 30	₹ 315
17	(17 × 20) – 7 = 333	₹ 6450 (333 × 20) – 7 × 30	₹ 322.5
18	(18 × 20) - 18	₹ 6300 (342 × 20) – 18 -30	₹ 315

Since profit is more at 17 books order, it is the best quantity and ordering is more optimum.

33. A small retailer has studied the weekly receipts and payments over the past 200 weeks and has developed the following set of information:

Weekly Receipts (₹)	Probability	Weekly Payments (₹)	Probability
3000	.20	4000	.30
5000	.30	6000	.40
7000	.40	8000	.20
12000	.10	10000	.10

Using the following set of random numbers, simulate the weekly pattern of receipts and payments for the 12 weeks of the next quarter.Assuming further that the beginning bank balance is ₹ 8000. What is the estimated balance at the end of the 12 weekly period? What is the highest weekly balance during the quarter? What is the average weekly balance for the quarters? Random Numbers

For Receipts	03	91	38	55	17	46	32	43	69	72	24	22
For payments	61	96	30	32	03	88	48	28	88	18	71	99

Answer:

According to the given information, the random number interval is assigned to both the receipts and the payments.

Range of random numbers							
Receipt (₹)	Probability	Cumulative probability	Range	Payments (₹)	Probability	Cumulative probability	Range
3000	0.20	0.20	0-19	4000	0.30	0.30	0-29
5000	0.30	0.50	20-49	6000	0.40	0.70	30-69
7000	0.40	0.90	50-89	8000	0.20	0.90	70-89
12000	0.10	1.00	90-99	10000	0.10	1.00	90-99

Simulation of Data for a period of 12 weeks					
Week	**Random No. For receipt**	**Expected Receipt (₹)**	**Random No. for Payment**	**Expected Payment (₹)**	**Week end Balance (₹)**
Opening Balance					8000
1	03	3000	61	6000	5000 (8000+3000-6000)
2	91	12000	96	10000	7000
3	38	5000	30	6000	6000
4	55	7000	32	6000	7000
5	17	3000	03	4000	6000
6	46	5000	88	8000	3000
7	32	5000	48	6000	2000
8	43	5000	28	4000	3000
9	69	7000	88	8000	2000
10	72	7000	18	4000	5000
11	24	5000	71	8000	2000
12	22	5000	99	10000	(3000)

Estimated balance at the end of 12th week = ₹(3000)

Highest balance = ₹ 7,000

Average balance during the quarter = 45,000/12 = ₹ 3,750

34. Patients arriving at a village dispensary are treated by a doctor on a first-come-first-served basis. The inter-arrival time of the patients is known to be uniformly distributed between 0 and 80 minutes, while their service time is known to be uniformly distributed between 15 and 40 minutes. It is desired to simulate the system and determine the average time a patient has to be in the queue for getting service and the proportion of time the doctor would be idle. Carry out the simulation using the following sequences of random numbers. The numbers have been selected between 00 and 80 to estimate inter-arrival times and between 15 and 40 to estimate the service time required by the patients.

Series 1	**07**	**21**	**12**	**80**	**08**	**03**	**32**	**65**	**43**	**74**
Series 2	**23**	**37**	**16**	**28**	**30**	**18**	**25**	**34**	**19**	**21**

Answer:

Simulation of data at village dispensary							
No. of patients	**Inter arrival Time Random No. (minutes)**	**Entry time in to queue (hrs)**	**Service Time Random No. (minutes)**	**Service Start time (hrs)**	**End time (hrs)**	**Waiting time of patient (minutes)**	**Idle time of doctor (minutes)**
1	07	8.07	23	8.07	8.30	-	07
2	21	8.28	37	8.30	9.07	2	-
3	12	8.40	16	9.07	9.23	27	-
4	80	10.00	28	10.00	10.28		37
5	08	10.08	30	10.28	10.58	20	-
6	03	10.11	18	10.58	11.16	47	-
7	32	10.43	25	11.16	11.41	33	-
8	65	11.48	34	11.48	12.22	-	07
9	43	12.31	19	12.31	12.50	-	09
10	74	01.45	21	01.45	02.06	-	55
Total (in minutes)						129	115

Average waiting time of patient = 129/10 = 12.9 minutes

Average waiting time of doctor = 115/10 = 11.5 minutes

It has been assumed that starting time be 8.00 A.M.

35. A bakery keeps stock of a popular brand of cakes. Previous experience shows the daily demand pattern for the item with associated probabilities as given:

Demand (daily) (No.s)	**0**	**10**	**20**	**30**	**40**	**50**
Probability	**0.01**	**0.20**	**0.15**	**0.50**	**0.12**	**0.02**

Use the following sequence of random numbers to simulate the demand for next 10 days. Also find out the average demand per day

Random Numbers: 25, 39, 65, 76, 12, 05, 73, 89, 19, 49

Answer:

Daily demand	Probability	Cumulative Probability	Random No.Range
0	0.01	0.01	-
10	0.20	0.21	1-20
20	0.15	0.36	21-35
30	0.50	0.86	36-85
40	0.12	0.98	86-97
50	0.02	1.00	98-99

Stimulated demand for next 10 days

Day	Random no.	Demand
1	25	20
2	39	30
3	65	30
4	76	30
5	12	10
6	05	10
7	73	30
8	89	40
9	19	10
10	49	30

Average Demand per day = 240 / 10 = 24 Units

36. A small maintenance project consists of the following twelve jobs whose precedence relations are identified with their node number:

Job (i,j)	:	**(1,2)**	**(1,3)**	**(1,4)**	**(2,3)**	**(2,5)**	**(2,6)**
Duration (in days)	:	**10**	**4**	**6**	**5**	**12**	**9**
Job (i,j)	:	**(3,7)**	**(4,5)**	**(5,6)**	**(6,7)**	**(6,8)**	**(7,8)**
Duration (in days)	:	**12**	**15**	**6**	**5**	**4**	**7**

(i) Draw an arrow diagram representing the project.

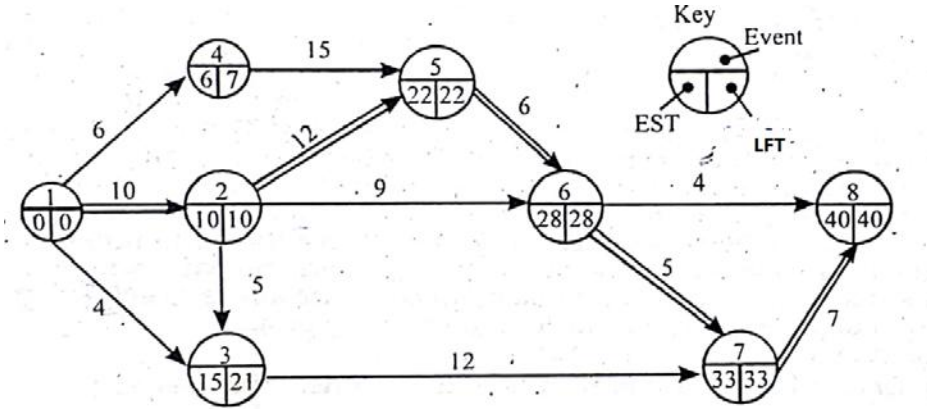
(ii) Calculate earliest start earliest finish , latest finish time for all the jobs.

(iii) Find the critical path and project duration.

(iv) Tabulate total float, free float and independent float.

Answer:

(i)The network diagram of the project corresponding to normal duration is given below:



(ii) Statement showing Earliest Start Time (EST), Earliest Finish Time (EFT), Latest Start Time (LST) and Latest Finish Time (LFT) for all jobs.

Jobs	Duration in days	Earliest Time		Latest Time		Slack of event		Total Float (TF)	Free Float (FF)	Independent Float
		Start (EST)	Finish (EFT)	Start (LST)	Finish (LFT)	at start of activity	at end of activity			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1-2	10	0	10	0	10	0	0	10-10=0	0-0= 0	0-0=0
1-3	4	0	4	17	21	0	6	21-4=17	17-6=11	11-0=11
1-4	6	0	6	1	7	0	1	7-6=1	1-1=0	0-0=0
2-3	5	10	15	16	21	0	6	21-15=6	6-6=0	0-0=0
2-5	12	10	22	10	22	0	0	22-22=0	0-0=0	0-0=0
2-6	9	10	19	19	28	0	0	28-19=9	9-0=9	9-0=9
3-7	12	15	27	21	33	6	0	33-27=6	6-0=6	6-6=0
4-5	15	6	21	7	22	1	0	22-21=1	1-0=1	1-1=0
5-6	6	22	28	22	28	0	0	28-28=0	0-0=0	0-0=0
6-7	5	28	33	28	33	0	0	33-33=0	0-0=0	0-0=0
6-8	4	28	32	36	40	0	0	40-32=8	8-0=8	8-0=8
7-8	7	33	40	33	40	0	0	33-33=0	0-0=0	0-0=0

(iii) Critical Path is 1→ 2 → 5 →6 →7→ 8

And project duration is 10 + 12 + 6 + 5 + 7 = 40 days

(iv) Total Float, Free Float and Independent Float has been shown in the table at (ii).

Note:

(i) EST of the activity of the EST of node at the start of activity.

(ii) EFT of activity is the EST of the activity plus time duration of the activity.

(iii) LFT of the activity is the LFT of the node at the end of the activity.

(iv) LST of the activity is difference between LFT of the activity minus time duration of the activity.

(v) Total Float (TF) is the difference between:

(a) (LFT – EFT) of the activity or

(b) (LST– EST) of the activity

(vi) Free Float = Total Float – Slack of event at end of the activity

(vii) Independent Float = Free Float – Slack of the event at start of the activity

37. As per Project Manager of quick construction company, you are involved in drawing a PERT network for laying the foundation of a new art museum. The relevant information for all theactivities of this project is given in the following table:

Activity	T_0	Time estimates (in weeks) T_m	t_p	Normal cost for expected duration (₹)	Crash cost (₹)	Immediate Predecessors
A	2	3	4	6,000	8,000	-
B	4	5	6	12,000	13,500	A
C	3	5	7	16,000	22,000	A
D	2	4	6	8,000	10,000	A
E	1	2	3	6,000	7,500	C,D
F	1	3	5	14,000	20,000	B,E

(i) Construct the PERT 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 PERT 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 week or part there of 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 optimum duration of the project if your objective is to minimize the sum of the project execution cost and penalty cost.

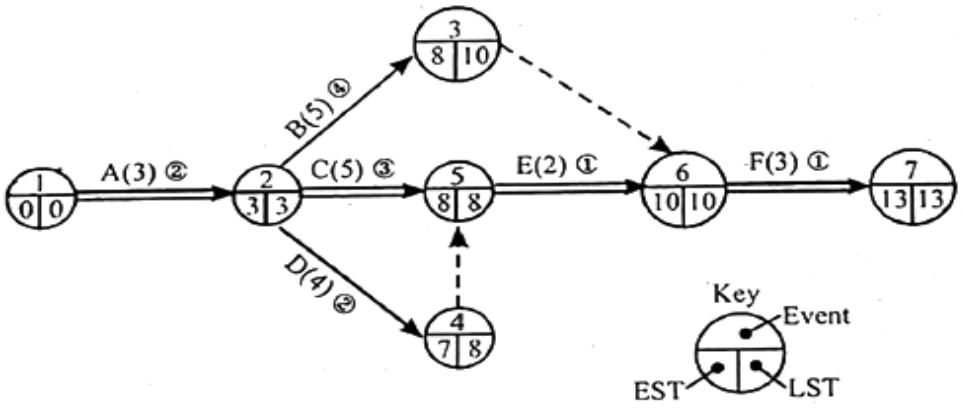
Answer:

We know that $t_e = \frac{a+4m+b}{6}$ or $\frac{t_o + 4t_m + t_p}{6}$

Based on this formula, expected duration of each activity is given below:

Activity	:	A	B	C	D	E	F
Expected duration	:	3	5	5	4	2	3

(i) The PERT network and the expected duration of each activity is given below:



(Normal time of activities is written in brackets and crash time in circle.)

The critical path is 12567 or AC EF with project duration of 13 weeks. Since the project has to be completed by seven weeks, otherwise a penalty @ ₹ 2,500 per weeks has to be paid, the total project execution cost.

= Normal cost + Penalty cost = ₹ 62000 + 6 x₹ 2,500 = ₹ 77,000

(ii) Crashing

Step 1 – The computations of cost slopes are given below:

Activity	Normal Time –Crash Time Δ T (weeks)	Crash cost – Normal cost Δ C (₹)	Cost Slope ₹	Ranking @
A : 1 – 2	3 – 2 = 1	8,000 – 6,000 = 2,000	2,000	II
B : 2 – 3	5 – 4 = 1	13,500 – 12,000 = 1,500	1,500	
C : 2 – 5	5 – 3 = 2	22,000 – 16,000 = 6,000	3,000	III
D : 2 - 4	4 – 2 = 2	10,000 – 8,000 = 2,000	1,000	
E : 5 – 6	2 – 1 = 1	7,500 – 6,000 = 1,500	1,500	I
F : 6 – 7	3 – 1 = 2	20,000 – 14,000 = 6,000	3,000	III

@ shows ranking of activities on critical path.

(a) As it is, there are following three paths:

Path 1: 1-2-3-6-7 = 3 + 5 + 3 = 11 weeks

Path 2: 1-2-5-6-7 = 3 + 5 + 2 + 3 = 13 weeks

Path 3: 1-2-4-5-6-7 = 3 + 4 + 2 + 3 = 12 weeks

Path 2 is critical path and E is the activity on critical path with minimum cost slope. Activity E is crashed by one week.

Project duration = 13 – 1 = 12 weeks

Decrease in cost = (-) 2,500 + 1,500 = (-) ₹ 1,000

Total cost = ₹ 62,000 + 2,500 x 5 + 1,500 = ₹ 76,000

(b) After crashing of E by one week, the project duration for different paths is as follows:

Path 1 : 1-2-3-6-7 = 3 + 5 + 3 = 11 weeks

Path 2 : 1-2-5-6-7 = 3 + 5 + 1 + 3 = 12 weeks

Path 3 : 1-2-4-5-6-7 = 3 + 4 + 1 + 3 = 11 weeks

Still path 2 is critical path and next activity on critical path with the least cost slope is A. If it is crashed by one week, the project duration by different paths will be as follows:

Path 1 : 1-2-3-6-7 = 2 + 5 + 3 = 10 weeks

Path 2 : 1-2-5-6-7 = 2 + 5 + 1 + 3 = 11 weeks

Path 3 : 1-2-4-5-6-7 = 2 + 4 + 1 + 3 = 10 weeks

It means activity *A* can be crashed by one week and path 2 will still remain critical.

Project duration = 12 - 1 = 11 weeks

Decrease in cost = (-) 2,500 + 2,000 = (-) ₹ 500

Total cost = ₹ 76,000 - 2,500 + 2,000 = ₹ 75,500

(c) Path 2 still critical path and next activities with minimum cost slopes are C and F. Both are having cost slope of ₹ 3,000 each. If any of these activities is crashed, there will be net increase in cost by ₹ 500 (Rs.3000–Rs.2500) per week.

Since, objective is to minimise the sum of the project execution cost and the penalty cost , the decision is taken not to crash activity C or F.

Optimum duration of project = 11 weeks

Total minimum cost = ₹ 75,500

38. Following information is given regarding a maintenance project of *X* Ltd.:

Activity	Immediately preceding activity	Duration (weeks)
A	-	5
B	-	4
C	A	2
D	B	1
E	B	5
F	B	5
G	C , D	4
H	F	3
I	F	2

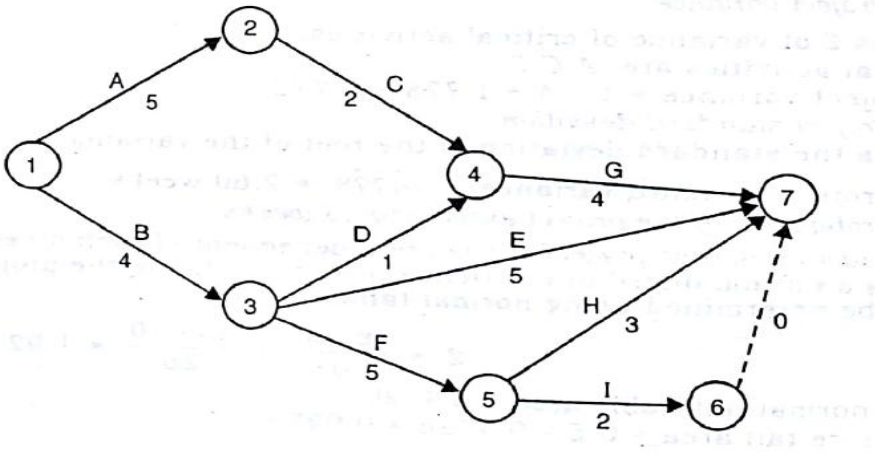
Required:

(a) What are the paths through the network?

(b) What is the critical path and its duration?

Answer:

A network diagram based on the above information relating to activity, precedence and duration can be drawn as follows:



(a) Various paths through the network and their overall completion times can be summarized as follows:

Path	*Duration (weeks)*
A C G	(5 + 2 + 4) = 11
B D G	(4 + 1 + 4) = 9
B E	(4 + 5) = 9
B F H	(4 + 5 + 3) = 12
B F I Dummy	(4 + 5 + 2 + 0) = 11

(b) The critical path is the longest, i.e., BFH with a duration of 12 weeks. This is the minimum time needed to complete the project.



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