GROUP III

PAPER 15

WORK BOOK

STRATEGIC COST MANAGEMENT - DECISION MAKING

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

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Chapter – 1

COST MANAGEMENT

OBJECTIVE TYPE QUESTIONS

1. **B manufacturing Company sells its product at ₹ 1,000 per unit. Due to competition, its competitors are likely to reduce price by 15%. B wants to respond aggressively by cutting 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 product is**

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

3. **Company B uses a 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 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 item 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 Only

(i) Cradle to grave cost **(ii) Future Cost** **(iii) Present cost** **(iv) None of above**

9. Target costing is the answer to

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

Answer :

1. (iii)

Target selling price : Rs 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 + (900000 × 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. All the costs mentioned in the question are parts of the total life cycle costs.

5. (ii) ₹60.

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

Target Cost = Target Price – Target Profit = ₹ 80 – (₹ 80 × 25%) = ₹ 60

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) Importance of Product Life Cycle Costing.

(b) Advantages of Target Costing?

(c) Kaizen Costing

(d) Characteristics and Principles of Re-engineering Process.

(e) The Variants of Backflush Accounting

(f) Lean Accounting.

(g) Socio Economic Costing

(h) Cost Control Vs. Cost Reduction

Answer: 10. (a)

Product Life Cycle Costing is considered important due to the following reasons —

(i) Time Based Analysis: Life cycle costing involves tracing of costs and revenues of each product over several calendar periods throughout their life cycle. Costs and revenues can be analysed by time periods. The total magnitude of costs for each individual product can be reported and compared with product revenues generated in various time periods.

(ii) Overall Cost Analysis: 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.

(iii) Pre-production Costs Analysis: The development period of R&D and design is long and costly. A high percentage of total product costs may be incurred before commercial production begin.

Hence the company needs accurate information on such costs for deciding whether to continue with the R&D or not.

(iv) **Effective Pricing Decisions**: Pricing decisions; in order to be effective; should include market considerations on one hand and cost considerations on the other. Product Life cycle costing and target costing help analyze both these considerations and arrive at optimal price decisions.

(v) **Better Decision Making**: Based on a more accurate and realistic assessment of revenues and costs, at least within a particular life cycle stage, better decisions can be taken.

(vi) **Long Run Holistic View:** Product Life cycle costing 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.

(vii) **Life Cycle Budgeting:** 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.

(viii) **Review**: Life Cycle Costing provides scope for analysis of long term picture of product line profitability, feedback on the effectiveness of life cycle planning and cost data to clarify the economic impact of alternatives chosen in the design and engineering phase etc.

Answer: 10. (b)

Advantages of Target Costing

(i) **Innovation:** it reinforces top-to-bottom commitment to process and product innovation. It is aimed at identifying issues to be resolved.

(ii) **Competitive Advantage**: it enables a Firm to achieve competitive advantage over other Firms in the industry. The firm which achieves cost reduction targets realistically stands to gain in the long run.

(iii) **Market Driven Management**: it helps to create a company's competitive future with market-driven management for designing and manufacturing products that meet the price required for market success.

(iv) **Real Cost Reduction:** it uses management control systems to support and reinforce manufacturing strategies, and to identify market opportunities that can be converted into real savings to achieve the best value rather than simply the lowest cost.

Answer: 10. (c)

The initial VE review may not be complete and perfect in all cost aspects. tThere may be further chances of waste reduction, cost and time reduction and product improvement. Such continuous cost reduction technique is called as **Kaizen Costing**.

The review of product costs under the target costing methodology is not reserved just for the period up to the completion of design work on a new product. There are always opportunities to control costs after the design phase is completed, though these opportunities are fewer than during the design phase.

Meaning: Kaizen Costing refers to the ongoing continuous improvement program that focuses on the reduction of waste in the production process, thereby further lowering costs below the initial targets specified during the design phase. It is a Japanese term for a number of cost reduction steps that can be used subsequent to issuing a new product design to the factory floor.

Process of Kaizen Costing: activities in Kaizen costing include elimination of waste in production, assembly, and distribution processes, as well as the elimination of unnecessary work steps in any of these areas. Thus Kaizen Costing is intended to repeat many of the value engineering steps, continuously and constantly refining the process, thereby eliminating out extra costs at each stage.

Kaizen Costing Vs Value Engineering: cost reductions resulting from Kaizen costing are much smaller than those achieved with value engineering. But these are still significant since competitive pressures are likely to force down the price of a product over time, and any possible cost savings allow a Company to still attain its targeted profit margins.

Multiple Versions of Products - Continuous Kaizen Costing: Multiple improved versions of products can be introduced to meet the challenge of gradually reducing costs and prices. The market price of products continues to drop over time, which forces a company to use both target and kaizen costing to reduce costs and retain its profit margin.

Answer: 10. (d)

Characteristics and Principles of Re-engineering Process

Characteristics of Re-engineering Process:

(i) Several jobs are combined into one

(ii) Often workers make decisions

(iii) The steps in the process are performed in a logical order

(iv) Work is performed, where it makes most sense

(v) Quality is built in

(vi) Manager provides a single point of contact

(vii) Centralized and decentralized operations are combined.

Seven Principles of Business Process Reengineering:

(i) Processes should be designed to achieve a desired outcome rather than focusing on existing tasks.

(ii) Personnel who use the output from a process should perform the process

(iii) Information processing should be included in the work, which produces the information

(iv) Geographically dispersed resources should be treated; as if they are centralized

(v) Parallel activities should be linked rather than integrated

(vi) Doers should be allowed to be self-managing

(vii) Information should be captured once at source.

Answer: 10. (e)

The Variants of Back flush Accounting. There are a number of variants of the Back flush system, each differing as to the 'trigger points' at which costs are recognized within the cost accounts and thus associated with products. All variants, however, have the following common features:

- The focus is on output – costs are first associated with output (measured as either sales or completed production) and then allocated between stocks and costs of goods sold by working back.
- Conversion costs (labour and overheads) are never attached to products until they are complete (or even sold) – thus the traditional WIP account doesn't exist. Materials are recognized at different points according to the variant used, but only to the extent of being either stock of raw materials or part of the cost of stock of finished goods. Again, materials are not attached to WIP.

Two variants of the Back flush system are summarized below. Note that in each as conversion costs (labour and overheads) are incurred they will be recorded in a conversion cost (cc) account. Variant 1 - this has two trigger points (TP):

TP 1 - purchase of raw materials/ components. A 'raw and in process (RIP)' account will be debited with the actual cost of materials purchased, and creditors credited.

TP 2 - completion of good units. The finished goods (FG) account will be debited with the standard cost of unit produced and the RIP and cc account will be credited with the standard cost.

Under this variant, then, there will be two stock accounts:

- raw materials (which may, in fact, be incorporated into WIP)
- finished goods

Variant 2 - This has only one trigger point – the completion of good units. The FG account is debited with the standard cost of units produced, with corresponding credits to the cc account and the creditors account. Thus the cost records exclude:

- Raw materials purchased but not yet used for complete production
- The creditors for these materials (and any price variance) and there is only stock account, carrying the standard cost of finished goods stock.

Other variants include those using the sale of complete goods units as a trigger point for the attachment of conversion cost to unit -- thus there is no finished goods account, just a raw materials stock account, carrying the materials cost of raw materials, WIP and finished goods.

It should be seen that as stock of raw materials, WIP, Finished goods are decreased to minimal levels, as it is in the pure JIT system, these variants will give the same basic results

Ans 10. (f)

Lean Accounting : What we now call lean manufacturing was developed by Toyota and other Japanese companies. Toyota executives claim that the famed Toyota Production System was inspired by what they learned during visits to the Ford Motor Company in the 1920s and developed by Toyota leaders such as Taiichi Ohno and consultant Shigeo Shingo after World War II. As pioneer American

and European companies embraced lean manufacturing methods in the late 1980s, they discovered that lean thinking must be applied to every aspect of the company including the financial and management accounting processes. Lean Accounting is the general term used for the changes required to a company's accounting, control, measurement, and management processes to support lean manufacturing and lean thinking. Most companies embarking on lean manufacturing soon find that their accounting processes and management methods are at odds with the lean changes they are making. The reason for this is that traditional accounting and management methods were designed to support traditional manufacturing; they are based upon mass production thinking. Lean manufacturing breaks the rules of mass production, and so the traditional accounting and management methods are (at best) unsuitable and usually actively hostile to the lean changes the company is making.

Ans 10. (g)

Socio Economics (also known as social economics) is the social science that studies how economic activity affects and is shaped by social processes. In general it analyzes how societies progress, stagnate, or regress because of their local or regional economy, or the global economy.

Socioeconomics is sometimes used as an umbrella term with different usages. The term "social economics" may refer broadly to the —use of economics in the study of society. In many cases, socioeconomics focus on the social impact of some sort of economic change. such changes might include a closing factory, market manipulation, the signing of international trade treaties, new natural gas regulation, etc. such social effects can be wide-ranging in size, anywhere from local effects on a small community to changes to an entire society. Examples of causes of socioeconomic impacts include new technologies such as cars or mobile phones, changes in laws, changes in the physical environment (such as increasing crowding within cities), and ecological changes (such as prolonged drought or declining fish stocks). These may affect patterns of consumption, the distribution of incomes and wealth, the way in which people behave (both in terms of purchase decisions and the way in which they choose to spend their time), and the overall quality of life.

Companies are increasingly interested in measuring socio-economic impact as part of maintaining their license to operate, improving the business enabling environment, strengthening their value chains, and fuelling product and service innovation.

Ans 10. (h)

Both cost reduction and cost control are efficient tools of management but their concepts and procedure are widely different. The differences are summarized below:

Cost Control	**Cost Reduction**
(a) Cost control represents efforts made towards achieving target or goal.	(a) Cost reduction represents the achievement in reduction of cost
(b) The process of cost control is to set up a target, ascertain the actual performance and compare it with the target, investigate the variances, and take remedial measures.	(b) Cost reduction is not concerned with maintenance of performance according to standard

(c) cost control assumes the existence of standards or norms which are not challenged	(c) cost reduction assumes the existence of concealed potential savings in standards or norms which are therefore subjected to a constant challenge with a view to improvement by bringing out savings
(d) Cost control is a preventive function. costs are optimized before they are incurred	(d) Cost reduction is a corrective function. It operates even when an efficient cost control system exists. there is room for reduction in the achieved costs under controlled conditions
(e) cost control lacks dynamic approach	(e) Cost reduction is a continuous process of analysis by various methods of all the factors affecting costs, efforts and functions in an organization. the main stress is upon the why of a thing and the aim is to have continual economy in costs

11. Explain Throughput Accounting and state the problems associated with it.

Answer:

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 focuses importance on generating more throughputs. 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 made by this concept are startling.

Throughput accounting is a system of performance measurement and costing which traces costs to throughput time. It is claimed that it complements JIT principles and forces attention to the true determinants of profitability. Throughput accounting is defined as follows:

Throughput Concepts: a few new terms are used in throughput accounting. They are explained as below:

Throughput: Throughput is the excess of sales value over the totally variable cost. That is nothing but contribution margin left after a product's price is reduced by the amount of its totally variable cost.

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.

Capacity Constraints: it is a resource within 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, but rarely more than one for a specified product or product line.

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.

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'.

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).

Problems associated with Throughput Accounting

1. When throughput accounting is the driving force behind all production scheduling, a customer that has already placed an order for a product, which will result in a sub-optimal profit level for the manufacturing, may find that its order is never filled.
2. The company's ability to create the highest level of profitability is now dependent on the production scheduling staff, who decides, what products are to be manufactured and in what order.
3. Another issue is that all costs are totally variable in the long-run since the management then, has the time to adjust them to long-range production volumes.

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 the Machine 'A', a more expensive machine with a life of 12 years, and the machine 'B' with an estimated life of 6 years. If the 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 averaged over machine life 10% for both machines

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

Answer:

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	(1/6.81)	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 substantially lower rate (by another company-ABC Ltd.) than the price charged by your own mill. The value chain for one of MT of such paper for ABC Ltd is follows,

ABC Ltd sells this particular paper to the merchant at the rate of ₹1,466 per MT. ABC Ltd pays for the freight which amounts to ₹30 per MT

Average returns and allowances amount to 4% of sales and approximately equal ₹60 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 receiving the paper from a huge distribution center maintained by your company at Haryana. Shipment costs from the mill to the Distribution Center amount to ₹11 per MT while the operating costs in the Distribution Center have been estimated to be ₹25 per MT. The return on investments required by the Distribution Center for the investments made amount to an estimated ₹58 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.

Answer:

Computation of Target Cost

		Per MT (in ₹)
ABC Ltd selling price to the merchant		1466
Less: freight paid by ABC Ltd	30	
Less normal sales returns and allowances	60	
M Ltds Capital charge	120	210
Target cost for M Ltd.		1256
Less: Shipment cost Distribution Centre	11	
Operating cost in the Distribution Centre	25	36
		1220
Distribution centre capital charge		58
Target manufacturing cost of the Mill		1162

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?**
3. **If Rate of Return desired is 15%, what will be the maximum investment at full capacity?**

Answer:

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
(b)	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?**

Answer:

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%
Above Sale Price ₹224 = VC + 40% thereon, i.e. 140% on VC. So, Var. Cost = 224 /140%	₹160
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
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 the next year follows:

Quantity	**10,000 units**
Sales price per unit	**30**
Variable costs per unit:	
Direct materials	**8**
Direct labour	**6**
Variable overhead (2 hrs × 0.50)	**1**
Contribution per unit	**15**
Budgeted contribution	**1,50,000**
Budgeted fixed costs	**1,40,000**
Budgeted profit	**10,000**

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 ₹25,000. The company should spend ₹28,500 on advertising, & set the target sales price up to ₹32 per unit. It is expected that the sales volume will also rise, inspite 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 in increased to ₹4. The hourly rate for variable overhead will be unaffected.

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

Answer:

	₹
Target profit	25,000
Add: Fixed cost	1,40,000
Add: Additional Advertisement	28,500
Total contribution	1,93,500
Sales volume	12,000
Contribution per unit (₹1,93,500/12,000)	16.125
Target Selling price per unit	32.000
Less: Contribution per unit	16.125
Target variable cost p.u.	15.875
Less: Material cost p.u.	8.000
Labour + Variable overhead p.u.	7.875
Let the Target time required per unit be x Labour cost per hour = x hour x ₹4 per hour = ₹4x	
Variable overhead per hour = x hour x ₹0.5 per hour = ₹0.5x	
Total Labour cost + Variable overheads = 4x +0.5 x = 4.50 x	
(2) Time required to achieve the target profit = x = (Labour + Variable overheads) /4.5 = 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.

Answer:

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	5	4	3
resource (hours per unit)			
Return per factory hour (₹)	12	10	15
Ranking	2	3	1
Total Available hours			= 3,20,000

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

(-) Hours used for A (30,000 x 5) = 1,50,000 = 2,70,000

Balance hours available for B = 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 40,000units

18. CAT Co. makes a product using three machines – X, Y and Z. The per week capacity of each machine is 800, 600 & 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?

Answer:

Bottleneck resource in order of preference is firstly machine 'Z', secondly machine 'Y' and lastly machine 'X' because the no. of units are in that order in 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 ₹ 720,000 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.

Answer :

(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

Answer:

(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 Rs 3,50,000. It feels quite confident that it can sell the goods produced by the machine as to yield an annual cash surplus of Rs1,00,000. There is however an uncertainty as to the machine 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 life is follows:

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

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

Answer:

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.

Chapter – 2

DECISION MAKING TECHNIQUES

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 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. **4 products viz. A, B, C & D are sold in the ratio of 25:40:30:5 and P/V Ratio is 40%, 32%, 20% & 60%. Budgeted sale is ₹60000/-& fixed cost ₹15000/-.Break even sales will be :**

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

3. **B Ltd. has earned 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 in the division. The Budgeted Capital Investment is ₹10.00 lacs, fixed cost is ₹8.00 lacs and expected sales volume is 4.00 lac units pa. Selling price is ₹12.70/unit and variable cost ₹10/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 was:**

   (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	₹1,20,000	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 for distribution costs. This is, however not incurred in internal sales. There are no capacity constraints. To maximize Company 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 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%

Answer: 2. (iv)

		A	B	C	D	Total
Sales	₹	15000	24000	18000	3000	60000
Variable cost	₹	9000	16320	14400	1200	40920
Contribution	₹	6000	7680	3600	1800	19080
Fixed cost	₹		₹			15000
P/V ratio	%	40%	32%	20%	60%	(19080/60000) x 100 = 31.8%
Break even sales						15000/31.8% = 47170

Answer: 3. (iv)

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

Let sale be S

100000 = S × 25% × 50%

Sale = 800000

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

100000 = (800000 X 25%) – FC

FC = 100000

Answer: 4. (iii)

Variable cost		10.00
Fixed cost per unit	8,00,000 ÷ 4,00,000	2.00
Transfer price		**12.70**
Balance towards cost of capital		0.70
Total amount available towards Required Return =	Return on investment = 0.70 × 400000 = 280000 280000/10,00,000 ×100 = 28%	

Answer: 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

Answer: 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.		

Answer: 7. (ii) 1,11,000 units

At a production of 75,000 units or less the fixed costs amount to ₹ 8 lakh

Contribution is ₹ 10 per unit (₹ 25 – 60% of 25).

Production will however, be more than this level.

Total fixed cost is then ₹ 12 lakh.

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 = 1,11,000 units.

Answer: 8. (ii)

₹ 12.90

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

Answer: 9. (ii)

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

Answer: 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 Cost

(d) Sunk Cost

(e) Make or buy decision

(f) Transfer pricing

(g) Methods of transfer pricing

Answer: 11. (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 cost 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 cost.	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 the cost per unit reduces, as the production increases as it is fixed cost which 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.

Answer: 11. (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. However, accountants generally do not distinguish between differential cost and incremental cost and the two terms are used to mean one and the same thing.

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.

Answer: 11. (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 that differ among alternatives. The two key aspects of relevance are:

i. The costs and revenues must occurs 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 cost - 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.

Answer: 11. (d)

Sunk costs are costs that were incurred in the past. **Committed costs** are costs that will occur in the future, but that cannot be changed. As a practical matter, sunk costs and committed costs are equivalent with respect to their decision-relevance; neither is relevant with respect to any decision, because it cannot be changed. Sometimes, accountants use the term “sunk costs” to encompass committed costs as well.

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 behavior 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.

Answer: 11. (e)

Make or Buy decisions, i.e. whether to produce a component/ product internally, or buy it from outside, Marginal Costing and Opportunity Costing approaches are adopted in 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. Behavior of cost of make and cost of buy in the long run.

Cost Comparison

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

Answer: 11. (f)

Transfer Pricing:

Transfer price is the price of 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 centre, which in turn, are influenced by transfer pricing policies.

Answer: 11. (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:

CVP based Sensitivity Analysis help Managers to cope with uncertainty.

(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.

(f) Therefore, use of CVP-based Sensitivity analysis, helps Managers to cope up with uncertainty.

13. What is Penetrating 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 early. This method is used for pricing a new product and to popularize it initially.

(a) 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.

(b) 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 the 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?

Answer:

(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, 0.40S = ₹ 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	2,880	6	8,000	12.50	39,600	22
Salaries	4,800	10	4,800	7.50	25,200	14
Electricity Charges	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.)

Answer:

(a) 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	6,000 × 55% = 3,300	8,000x55% =4,400	Nil	7,700
(b) Supplies	6,000 × 5% = 300	8,000 x 10% = 800	20,000 X 8% = 1,600	2,700
(c) Electricity Charges	(960- 640) × (10/ 80) =40	(3,200- 1,920)× (10/80) = 160	(13,500- 9,900) x (10/90)= 400	600
(d)Advertisement				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	36,000× 55%=19,800	48,000×55%=26,400	Nil	46,200
(b) Supplies	36,000×5% =1,800	48,000x10%= 4,800	1,60,000x8%=12,800	19,400
(c) Salaries	4,800 × 2 = 9,600	4,800 x 2 = 9,600	(25200-4800)x2= 40,800	60,000
(d)Electricity - Fixed	640 x 2 = 1,280	1,920 × 2 = 3,840	6,900x2 = 13,800	18,920

(e)Electricity - Variable	960-640)x2x (30%/80%)=240	(3,200 -1,920)x 2 x (30%/80%) = 960	(13500- 9900) × 2 × (40%/90%) = 3,200	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.

Answer:

(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	320000	320000
Cost of Manufacturing		
Variable Cost	160000	200000
Depreciation on Machine	30000	20000
Fixed Overheads	54000	28000
Total Cost	244000	248000
Cost Saving on Manufacture	76000	72000

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?

Answer:

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

Answer:

(a) Computation of Relevant Costs of own production

Particulars	Nature and Computation	Rupees
Direct Materials	Variable and Relevant = ₹4 x 10,000	40,000
Direct Manufacturing labour	Variable and Relevant = 2 × 10,000	20,000
Power and Utilities	Variable and Relevant = 1.50 × 10,000	15,000
Inspection, Set up etc.	Batch Related Production Costs= Specific and Relevant (given)	2,000
Machine Rent	Specifically incurred = relevant	3,000
Fixed Costs	Allocated and Irrelevant	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 Power	Variable and Relevant = ₹2 x 6,200 units	12,400
and Utilities	Variable and Relevant = ₹1.50 × 6,200	9,300
Inspection, Set up etc.	units Batch Related Costs = (2,000 + 10 batches)× 8 batches	1,600
Machine Rent	Specifically incurred = relevant	3,000
Fixed Costs	Allocated and Irrelevant	Nil
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?

Answer:

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.

Answer:

Contribution required at budgeted residual income

₹		
Fixed cost		8000000
Profit on 750 lac x 12 %		9000000

Residual income		10000000
Total Contribution required	(A)	27000000
Contribution derived from existing sale	(B)	24000000
Contribution required on additional 3 lac units (A-B)		3000000
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 ₹220i.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 your 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%

Answer:

Present position on transfer of component @ ₹200:

Particulars	**Division Alfa**	**Division Beta**
Units sold	20000	10000
Selling price/unit	₹200	₹1500
Variable cost/unit	₹190	₹1100
Contribution /unit	₹10	₹400
Fixed cost /unit	₹20	₹200
Profit/unit	₹ - 10	₹200
Total Profit/ Loss	₹-200000	₹2000000

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		₹1500
Variable cost/unit		₹1120
Contribution /unit		₹380
Total Contribution		₹3800000
Fixed Cost		₹2000000
Rental Income	₹300000	
Total Profit	₹300000	₹1800000

Overall Profit for the Company is ₹2100000

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

Particulars	Division Alfa (Sale)	Division Beta
Units sold	200000	10000
Selling price/unit	₹220	₹1500
Variable cost/unit	₹190	₹1120
Contribution /unit	₹30	₹380
Total Contribution	₹600000	₹3800000
Fixed Cost	₹400000	₹2000000
Total Profit	₹200000	₹1800000

Overall Profit for the Company is ₹2000000

(c) Capacity enhancement at the cost of capital @12%

Particulars	Division Alfa (Sale)	Division Alfa (transfer)	Division Beta
Units sold	200000	200000	10000
Selling price/unit	₹220	₹210	₹1500
Variable cost/unit	₹190	₹190	₹1120
Contribution /unit	₹30	₹20	₹380
Total Contribution	₹600000	₹400000	₹3800000
Fixed Cost	₹400000	₹100000	₹2000000
Cost of Capital		₹180000	
Total Profit	₹200000	₹120000	₹1800000

Overall profit for the company is ₹2120000

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	1.50	5.00	6.00	6.50
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 of Product 'C' 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.

Answer:

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

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	Variable Cost	₹/unit	15.75	28.50	34.50	54.50	
iv	Contribution	₹/unit	6.00	8.25	9.75	9.50	
v	Total Contribution	₹	120000	41250	341250	142500	645000
vi	Fixed Cost	₹	75000	25000	225000	180000	505000
vii	Profit	₹					140000

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

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	Contribution	₹/unit	5.40	6.90	8.70	7.10	
iv	Total Contribution	₹	108000	207000	304500	106500	726000
v	Fixed Cost	₹	75000	60000	225000	180000	540000
vi	Profit	₹					186000

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

Particulars	₹
Profit for the year 2015	140000
Revised fixed cost	540000
Total contribution required	680000
Contribution of A,C & D	519000
Contribution to be recovered from B	161000

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	**₹3000/unit**
Long run market price of sub assembly	**₹2000/unit**
Incremental cost of completing sub assembly	**₹1500/unit**
Incremental cost in Division A	**₹1200/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

Answer:

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	₹2000	₹3000
Incremental cost in Division A	₹1200	₹1200
Incremental cost in Division B		₹ 1500
Total Variable Cost	₹1200	₹ 2700
Contribution	₹800	₹300

(a) If Division B receives the sub assembly at market price of ₹2000/- plus incremental cost of ₹1500 will make the total cost of product ₹3500, 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 = 1200+150 = 1350 per unit.

Chapter – 3

STANDARD COSTING IN PROFIT PLANNING

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. The following statement is true.

i. If the difference in case of 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. 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 statement 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. The standard labour component and engaged in a job are as under:

	Skilled Worker	Semi-skilled Worker	Unskilled Worker
Standard no. of worker 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. Then

(i) Labour Efficiency Variance (ii) Mix Variance (iii) Rate of wages variance (iv) Labour Cost Variance will be :

i. ₹ 424 (A), ₹ 80 (F), ₹ 2000 (A), ₹ 2,424 (A).

ii. ₹ 424 (F), ₹ 80 (F), ₹ 2000 (F), ₹ 2,424 (A).

iii. ₹ 424 (A), ₹ 80 (A), ₹ 2000 (A), ₹ 2,424 (F).

iv. ₹ 424 (F), ₹ 80 (A), ₹ 2000 (F), ₹ 2,424 (F).

8. A factory operates a 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

9. 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)

10. 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)

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. (iv) All of the above.

7. (i) ₹ 424 (A), ₹ 80 (F), ₹ 20000 (A), ₹ 2,424 (A).

	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

	SRSH	**SRRSH**	**SRAH**	**ARAH**
Skilled	3x1152		3x1120	
Semi-skilled	2x432		2x720	
Unskilled	1x216		1x160	
	4536	5040	4960	6960

SH for skilled workers = (1800/2000) x 1280 = 1152

SRSH = Standard cost of standard labour = 4536

SRRSH = Revised standard cost of labour = 5040

SRAH = Standard cost of actual labour = 4960

ARAH = Actual cost labour = 6960

- Labour sub efficiency variance = 504 (A) = 4536-5040 = (504(A)
- Labour mix variance = 80 (F) = 5040-4960 = 80(F)
- Labour efficiency variance = 424 (A)=4960-4536=424 (A)
- Labour rate variance =4960-6960 =2000(A)
- Labour cost variance = 2424 (A) = 4536-6960 = 2424 (A)

8. (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 = 2,000x12

= ₹ 24,000

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

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

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

$$= \frac{₹\ 50,00,00,000}{250,000 \text{ units}} = ₹\ 2,000 \text{ per unit}$$

Fixed Overhead Volume Variance:

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

The variance is favourable because Motors PLC 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 Motors PLC incurred greater expense than provided for in the budget.

10. (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)

DESCRIPTIVE QUESTIONS

11. What are the advantages of Standard Costing?

Answer:

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

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

(b) The standards provide incentive and motivation to work with greater effort and vigilance for achieving the standard. This increase efficiency and productivity all round.

(c) At the very stage of setting the standards, simplification and standardization of products, methods, and operations are effected and 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. There is a reduction in paper work in accounting and less number of forms and records are required.

(e) Cost are available with promptitude for various purposes like fixation of selling prices, pricing of inter-departmental transfers, ascertaining the value of costing stocks of work-in-progress and finished stock and determining idle capacity.

(f) Standard Costing is an exercise in planning - it can be very easily used for budgetary planning.

(g) Standard Costing system facilitates delegation of authority and fixation of responsibility for each department or individual. This also tones up the general organization of the concern.

(h) Variance analysis and reporting is based on the principles of management by exception. The top management may not be interested in details of actual performance but only in the variances form the standards, so that corrective measures may 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 optimizes the use of plant capacities, current assets and working capital.

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

Answer:

Like Budgetary Control, 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 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.

Budgets are usually based on past costs adjusted for anticipated future changes but standard costs are of help in the preparation of production costs budgets. In fact, standards are often indispensable in the establishment of budgets. On the other hand, while setting standard overhead rates for standard costing purposes, the budgets framed for the overhead costs may be used with modifications, if necessary. Thus, standard costs and budgets are interrelated but not inter-dependent.

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.

13. 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 is 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.
- Poor efficiency of machinery.
- Lack of orders.
- Shortage of 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 if the actual working days are less than the budgeted days.

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

14. 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 follow:

(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.

PRACTICAL PROBLEMS

15. 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.**	**2240**
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 "/ 12 = 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	16,666.67	3,000	0.65	1,950
C	4,444.44	0.70	3,111.11	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)

16. 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)**
Sales margin mix variance	**14000(A)**	**8000(F)**	**17000(F)**	**3000(A)**

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

You are required to

(a) Compute the amount of sales target fixed and the actual amount of contribution earned in case of each of the zonal sales officers.

(b) Evaluate the overall performance of these zonal sales officers taking three relevant base factors and then recommend whose performance is the best.

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 Volume 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)

Since Sales Margin Mix Variance= Sales Margin volume variance

Sales Margin Volume Variance	10,000(A) (14000A+4000F)	2,000 (F) (8000F+6000A)	12000 (F) (17000F+5000A)	5000 (A) (3000A+2000A)
Actual Margin	90,000 (100000-10000)	97,000 (95000+2000)	92,000 (80000+12000)	80,000 (85000-5000)
Actual (%)	15.05% (90000/598000)	20.63% (97000/470000)	18.77% (92000/490000)	15.50% (80000/516000)
Budgeted (%)	16.67% (100000/600000)	20.21% (95000/470000)	16.67% (80000/480000)	16.67% (85000/510000)
Rank on the Basis of				
Target Sale	IV	III	I	II
Contribution %	IV	II	I	III
Contribution (Actual Margin-Budgeted Margin)	IV (10000)	II 2000	I 12000	III (5000)

17. 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 a period was 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 working clearly.

(b) Reconcile the actual Profit with standard profit.

Answer:

Statement showing the actual profit and loss statement:

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

Statement showing reconciliation of standard profit with actual profit

Particulars	**Amount** ₹	**Amount** ₹
Standard Profit (14400 x 1.15)		16560
Add: Material usage variance	1050	
Labour efficiency Variance	3200	

Variable Overhead expenditure variance	400	
Fixed Overhead expenditure variance	400	5050
		21610
Less: Material price variance	4250	
Labour Rate Variance	4000	
Fixed Overhead volume variance	1680	
Administration Expenditure Variance	400	
Administration Volume Variance	1680	12010
Actual Profit		**9600**

18. 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 profits.

Answer:

Working notes:

	Budget ₹	**Actual ₹**
Fixed overhead	20000	18810
Share in semi variable OHs	1500	1350
	21500	20160
Variable OHs	10000	9250
Share in semi variable OHs(4/9)	1200	1080
	11200	10330

Variances:

⇒ Sales

(1)	**(2)**	**(3)**
AQAP	AQSP	SQSP
51.25 x 9000	50 x 9000	50 x 10000
₹461250	₹450000	₹500000

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	
₹19350	₹17415	₹21500	₹20160

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		500000
(+) sales price variance	11250	
(-) sales volume variance	(50000)	(38750)

Actual sales		461250
(-) standard cost of sales		
Material {250000 x (9/10)}	225000	
Wages {75000 x (9/10)}	67500	
Fixed OHs {21500 x(9/10)}	19350	
Variable OHs {11200 x (9/10)}	10080	321930
Standard profit		139320
Add favorable variances		
labour efficiency variance	6750	
Variable OH efficiency	1008	
Fixed OH efficiency	1935	
Fixed OH budget	1340	11033
		150353
Less adverse variances	₹	₹
material usage variance	9000	
Material price variance	23400	
Labour rate variance	10125	
Variable OH budget	1258	
Fixed OH capacity variance	4085	47868
Actual profit		102485

19. 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)	

20. 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:

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 = ₹ 16.66667%

3) Sales Value variance = 770 – 600 = ₹ 170(F)

4) Material cost variance = 350 – 324 = ₹ 26 (F)

5) Material volume variance = 300 x (1/6) = ₹ 50(A)

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

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

6) Material usage variance = 5000 x 250 = ₹ 12.5 (F)

7) Material price variance = (250-240) x 135000 = ₹ 13.5 (F)

8) Labour cost variance = 140-137=₹ 3 (F)

9) Labour volume variance = 120/6 = ₹ 20(A)

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

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

11) Labour efficiency variance = 2 x 5 = ₹ 10 (F)

12) Labour rate variance = 20 – 17 -10 = ₹ 7 (A)

13) VOH cost variance = 70 -69 = ₹ 1(F)

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

15) VOH efficiency variance = 200000 x 2.5 = 5 ₹ (F)

16) VOH expenditure variance = 10 – 9 – 5 = ₹ 4(A)

17) 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

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

Efficiency Ratio = $\frac{\text{Standard hours of production}}{\text{Actual Hours Worked.}} \times 100 = \frac{19,200 \times 100}{17,600} = 109.09\%$

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

Relationship of Ratios

Activity Ratio = Efficiency Ratio x Capacity Ratio

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

22. 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:

a. Calculate all variances.

b. Prepare an operating statement showing standard gross profit, variances and actual gross profit.

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

Answer:

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

(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

(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)

23.

	(₹ 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) = ₹ 12 (A)

3. Sales Volume 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 Variance	8.00	
Variable Overhead Variance	2.00	31.60
		36.60
Less: Sales Volume Variance	12.00	
Price Cost Price Variance	11.88	
Price 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**

Chapter – 4

ACTIVITY BASED COST MANAGEMENT – JIT AND ERP

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 the 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) ₹ 422000 (iii) ₹ 157000 (iv) ₹ 1084

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 a company**

iii. **Engineering drawing software**

iv. **Software used to track the weighbridge record**

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 Hour Rate = 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

DESCRIPTIVE QUESTIONS

8. 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, less working capital is required to finance procurement. Here, a minimum re-order level is set, and only once that mark is reached fresh stocks are ordered, making this a boon to inventory management too.

(d) Due to the afore-mentioned low level of stocks held, the organization's return on investment (referred to as ROI, in management parlance) would 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 makes it especially appealing today, where the market demand is volatile and somewhat unpredictable.

(f) Just-in-time manufacturing 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 from following a just-in-time production system.

(h) Close relationships are fostered along the production chain under a just-in-time manufacturing system.

(i) Constant communication with the customer results in high customer satisfaction.

(j) Over production is eliminated, when just-in-time manufacturing is adopted.

Q.9. 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 application have shifted 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. This provides the company with essential financial information for monitoring 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.

Enterprise and managing the basis data required to effectively run one's business is an important start for effective warehouse management. The basis data includes warehouse, locations, items containers, lot and serial number, units of measures (including conversion), alias numbers, replacement and substitute items and more.

Inventory reporting supports all reporting of specific and general types of stock transactions such as various types of stock transfers, re-classification, ID changes and physical inventory results. Additionally, functions are available for managing different stock and purchase requisitions as well as supporting the selection of appropriate locations for receipts. 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 logistics 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. It doesn't matter how well a product is made if arrives late. Processing distribution or acquisition orders involve several closely related activities.
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.

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

Answer:

Benching Marking: Traditionally control involves comparison of the actual results with an established standard or target. The practice of setting targets using external information is known as 'Bench marking'. Benching marking is the establishment - through data gathering of targets and comparatives, with which performance is sought to be assessed. 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.

(b) Every organization buys its rival's products and tears down to find out how the features and performances etc., compare with its products. This could be the starting point for improvement.

(c) **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.,

(d) **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.

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

(f) **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.

(g) **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.

11. 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: The next step is seeking the "best". To arrive at the best is both expensive and time consuming, so it is better to identify a Company which has recorded performance success in a similar area.

(c) Establishment of the benchmarking or process improvement team: This should include persons who are most knowledgeable about the internal operations and will be directly affected by changes due to benchmarking

(d) Defining the relevant benchmarking measures: Relevant measures will not be restricted to include the measures used by the Firm today, but they will be refined into measures that comprehend the true performance differences. Developing good measurement is key or critical to successful benchmarking.

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 tax 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 out 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. The negative performance gap indicates an undesirable competitive position and provides a basis for performance improvement. If there is no gap it may indicate a neutral position relative to the performance being benchmarked. The zero position should be analysed for identifying means to transform its performance to a level of superiority or positive gap.

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.

PRACTICAL PROBLEMS

12. 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 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; c) to comment on the reasons for any differences in the costs in your answers to (a) and (b)

Answer:

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

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

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

		Setup Cost	Machine Cost	Machine 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	4.5	1542.75	212.69	
		(252450/660)	(210375/46750)	(185130/120)	(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	
Machine Handling Cost	6.61		17.83		20.31	
Inspection Cost	9.16	38.62	17.96	63.49	20.21	93.94
Total Cost		**75.62**		**82.49**		**139.94**

13. 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

1) Overheads relating to Machinery oriented activity

Cost Driver : Machine Hour Rate

(4500 x 1.5) + (13640 x 0.75) + (2340 x 2.5) + (18350 x 4)

1, 65,900/96,230 = ₹ 1.72 per hour

2) Overheads relating to ordering materials

Cost driver : No. of Material orders

8760/30 = ₹ 292 per order

3) Set up costs

Cost driver : No. of set ups

21400/50 = ₹428 per set up

13) Administrative Overheads for spare parts

Cost driver : No. of spare parts 44690/36 = ₹ 1241 per spare part.

14) 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**

14. 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 ₹ 1, 70,000 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**

15. AML Ltd is engaged in the production of three types of ice-cream products. 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	15.240	10.167

16. Activities 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 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	2.50 (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**

17. **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 realisation	₹			**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 by 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.

18. 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	27.025	43 .24	21.62
Factory cost	**93.000**	**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**

Chapter – 5

COST OF QUALITY AND TOTAL QUALITY MANAGEMENT

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. DMAIDV 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. (iii)
2. (ii)
3. (ii)
4. (i)
5. (ii)
6. (i)
7. (iii)
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:

11. (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.

Answer:

11. (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.

Answer:

11. (c) Six Sigma is a set of practices developed by Motorola to systematically improve process be 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.

Answer:

11. (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

Answer:

11. (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 emerged 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 firm, approximately 20% of products may account for about 80% of total sales revenue. Pareto Analysis is used for analysing the firm 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 accounts 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 useful tool for evaluation of the portfolio of customer profile and decision making such as whether to continue serving a same customer group, what is the extent of promotion expenses to be incurred.

(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 monetary investment in stocks.

(d) Application in Activity Based Costing: in activity Based costing it is often said that 20% of an organisation 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	(₹19,968/9,700units) ×100=Rs205.86	(₹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. (Rs 205.86 – Rs 191.13) = Rs 14.73 in case of A Ltd, and (Rs 201.09- Rs 192.31) = Rs 8.78 in case of B Ltd.
- Purchase from A Ltd. is cheaper, as there is cost saving of Rs 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 at a cost of ₹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 shirts)	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		

Chapter – 6

APPLICATION OF OPERATION RESEARCH AND STATISTICAL TOOLS IN STRATEGIC DECISIONS MAKING

OBJECTIVE TYPE QUESTIONS

1. **Learning curve theory is based on 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. **Learning curve theory believes in 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 (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 × x =.

So 2x2 = 5.12 ÷ 4 = Or, x = = 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

Answer:

(a) Uses of Learning curve

Learning curve is now being widely issued in business. Some of the uses are as follows:

(i) Where applicable the learning curve suggests great opportunities for cost reduction to be achieved by improving learning.

(ii) The learning curve concept 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. What level of cumulative cost reduction do they accomplish?

(iii) 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. If production is not interrupted, additional units beyond this quantity should cost at the incremental costs incurred, and not at the previous cumulative average. If the contract agreement so provides, a contract may be cancelled and production stopped before the expected efficiency is reached. This would mean that the company having quoted on the basis of cumulative average unit cost is at a disadvantage because it can not reap the benefit of learning. The contractor must provide for these contingencies so that it will be reimbursed for such loss.

(v) The use of learning curve, where applicable, is important in the working capital required. If the requirement is based on average cumulative unit cost, the revenues from the first few units may not cover the actual expenditures. For instance, if the price was based on the average cumulative unit cost of 328 hours the first unit when produced and sold will cause a deficit of 4.72 hours (8.00 – 3.28). Provision should therefore, be made to cover the deficit of working capital in the initial stages of production.

(vi) 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.

(vii) 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. Specific or average incremental unit cost should be used for this purpose.

(viii) The learning curve may be used for make-or- buy decisions especially if the outside manufacturer has reached the maximum on the learning curve. Help to calculate the sensitive rates in wage bargaining.

(b) Transportation: Transportation models deal with the transportation of a product manufactured at different plants or factories (supply origins) to a number of different warehouses (demand destinations). The objective is to satisfy the destination requirements within the plants' capacity constraints at the minimum transportation cost. Transportation models thus typically arise in situations involving physical movement of goods from plants to warehouses, warehouses to wholesalers, wholesalers to retailers and retailers to customers. Solution of the transportation models requires the determination of how many units should be transported from each supply origin to each demands destination in order to satisfy all the destination demands while minimizing the total associated cost of transportation.

The basic transportation problem was originally developed by F.L. Hitchcock (1941) in his study entitled "the distribution of a product from several sources to numerous locations". In 1947, T.C. Koopmans independently published a study on "optimum utilization of the transportation system".

There are three methods to transportation problems

- North West method
- Lowest cost entry method
- Vogel's approximation method

(c) Vogel's Approximation Method (VAM):

This method is preferred over the other two 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: Re-compute 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 Applications of Simulation

(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, and

(vii) Design of parking lots, harbor, and communication systems etc.

Advantages of Simulation

(i) Enables to experiment and study complex interactions of a system (e.g. company operations, economic policies).

(ii) Possible to study the effects of organizational environment information changes in the operations of a system (e.g. number of stocking points, industrial policies).

(iii) Better insight and understanding of a complex system to indication for improvement.

(iv) Assists in teaching and training (management games).

(v) New situations and policies can be protested.

(vi) Probabilistic features can be easily incorporated.

(vii) A process can be studied in extended or compressed time.

(viii) Risks involved in experimenting with real problems can be eliminated.

(e) Network Analysis

Network analysis is the general name given to certain specific techniques which can be used for planning, management and control of project. It often acts as a network 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.

It offers insight into what is occurring at each critical point of the network. 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.

Network is a graphical representation of all the Activities and Events arranged in a logical and sequential order. Network analysis plays an important role in project management. A project is a combination of interrelated activities all of which must be executed in a certain order for its completion. Activity is the actual performance of the job. This consumes resources (Time, human resources, money, and material). An event refers to start or completion of a job. This does not consume any resources.

13. Mention the major areas where linear programming can be applied as decision making technique

Answer:

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.

(iii) Production Smoothing Problem

(iv) Blending Problems.

(v) Transportation Problems.

(vi) Production distribution problems.

(vii) Trim Loss.

(viii) Linear programming is also used by oil refineries to determine the optimal mix of products to be produced by the refinery during a given period.

(ix) Communication Industry. LP methods are used in solving problems involving facilities for transmission, switching, relaying etc.

(x) Rail Road Industry: An LP model for optimal programming of railway freight, and train movements has been formulated to handle scheduling problems as found at large terminal switching rail points.

(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. The diet problem, one of the earliest applications of linear programming was originally used 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 product.

(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 0.544 = 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

$\log y = \log 10 + \log 20^{-0.322}$

$\log y = \log 10 - (0.322)\log 20$

$= 1 - (0.322)\log 20$

$= 1 - (0.322) \times (1.3010)$

$= 1 - 0.41892 = 0.5811$

$\log y = 0.5811$

Y= Anti log (0.5811) =3.812 hrs (average time)

Total time = 3.812 × 20 = 76.24 hrs

(ii) $\log y = \log + \log 30^{(-0.322)}$

$= 1 - (0.322) \times (1.4771)$

$= 1 - (0.4756) = 0.5244$

Y = anti log (0.5244) = 3.345 hrs (average time)

Total time = 3.345 × 30 = 100.35 hrs

(iii) $\log y = \log 10 + \log 40^{(-0.322)}$

$= 1 - (0.322) \times (1.6021)$

$\log y = 0.4841$

Y = anti log (0.4841) = 3.049hrs

Total Time 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 increase 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 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 necessary to 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 a five-day week, eight hour 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 hour like 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

$Y = ab^x$

$Y = 40\ (14)^{0.322}$

$= 17.14$

Total time = 17.14 × 14 = 239.96

= 240 hour

It is true that learning Ratio 80% is effective.

(ii) 30 Units

$Y = 40(30)^{-0.322}$ =13.380 hours (Average time)

50 Units

$Y = 40(50)^{-0.322}$ =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 subject to 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 = 36.90 hours

Labour cost for 24 units = 63.90 hours × ₹ 12/hr = ₹ 766.80

18. M & N Ltd. has received an order for at least 100 kilograms of a food mix. The food mix is made up from 4 ingredient. 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 ₹ 4, ₹ 7 ,₹ 5 and ₹ 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, but there are no immediate uses to which the ingredient can be put.

Required : **Formulate a linear programming model.**

Answer:

(i) The decision variable are the ingredients in food mix, 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.

(ii) 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:

Objective function. 4K+7L+5M+8N (costs), subject to the following constraints :

$K+L+M+N \geq 100$	(Total supply quantity)
$0.15\,K + 0.5\,L + 0.1\,M \geq 30$	(Carbohydrates)
$0.3\,K + 0.05L + 0.1\,M + 0.7\,N \geq 40$	(Fats)
$0.1\,K + 0.06L + 0.3\,M + 0.05N \geq 10$	(Sugar)
$N \leq 35$	(Maximum Availability)
$K,L,M,N \geq 0$	(Non-negativity restrictions)

19. 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 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 requires for each unit of the respective product is 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 in milling machine)

$4x_1 + 3x_2 \leq 150$ (Capacity in hours in 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)

20. A Dealer Manufactures only two items. Ceiling fans and table fans. He has ₹ 9,000 to invest and a space to store at most 75 pieces. A ceiling fan costs him ₹ 300 and a table fan ₹ 150. He expects to gain ₹ 50 on a ceiling fan and ₹ 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)

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 limits of gasoline 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) $\leqq 0$.

Formulation of LP Model

The objective function is to minimise 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 reader 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 a LP model for the problem.

Answer:

Step 1. The key decision to be made is to determine how many advertisements to place 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 has no outside market for these 3 materials. 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	2
B2	2	2	3
Processing capacity			
(Unit/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 amount of B1 and B2 respectively let

x_1, x_2, x_3 be the amount of A1, A2, A3 produced.

The capacity constraints:

X1 4000 X2 3000 X3 4,800

The demand for each of the 3 of the division *A* product in term of the amounts of the 2 of the Division *B* products to be produced is given by

$$2Y_1 + 2Y_2 - X_1 \geq 0$$

$$0.5Y_1 + 2Y_2 - X_2 \geq 0$$

$$Y_1 + 3Y_2 - X_3 \geq 0$$

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

$$2Y_1 + 2Y_2 - X_1 \geq 0$$

$$0.5Y_1 + 2Y_2 - X_2 \geq 0$$

$$Y_1 + 3Y_2 - X_3 \geq 0$$

$$X_1 \geq 4{,}000$$

$$X_2 \geq 3{,}000$$

$$X_3 \geq 4{,}800$$

Where $Y_1, Y_2, X_1, X_2, X_3 \geq 0$

The optional solution for this problem is

$Y_1 = 666.67$ $Y_2 = 1333.33$ $X_1 = 4,000$

$X_2 = 3,000$ $X_3 = 4661.67$ yielding a profit of ₹ 11.333.

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

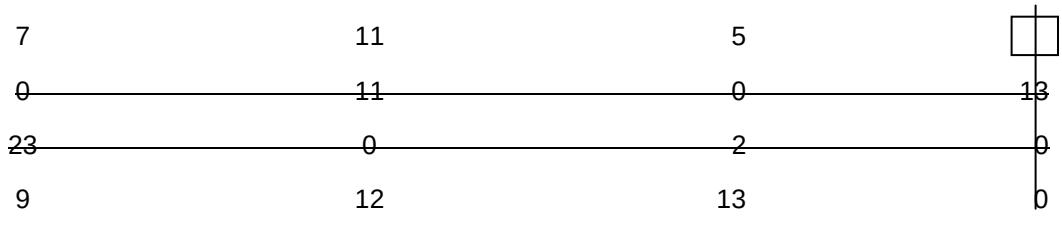
How should the tasks be allocated one to a man, so as to minimize the total man- hours?

Answer:

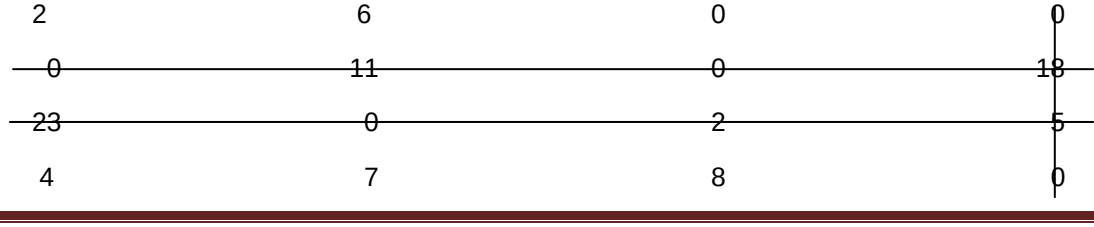
Subtracting the smallest elements of each row from every element of the corresponding row, we get the reduced matrix:

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.



Three lines are required to cover all zero , whereas the order of the matrix is 4. Therefore, optimum assignment cannot be made at this stage also. The minimum uncovered element in 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:



Four lines are required to cover all zero 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

	A	B	C
1	**120**	**100**	**80**
2	**80**	**90**	**110**
3	**110**	**140**	**120**

Assign the 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

Programmers	Programme	Time-minutes
1	C	80
2	B	90
3	A	110
	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.

According, we subtract the minimum element of each raw 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	20

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	0
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. XYZ Airline operating 7 days a week has given the following time table. Crew must have a minimum layover of 5 hours between flights. Obtain the pairing nights that minimizes layover time away from home. For any given pairing the crew will be based at the city results in the smaller layover:

Chennai Mumbai			Mumbai Chennai		
Flight Number	**Depart**	**Arrive**	**Fight Number**	**Depart**	**Arrive**
A_1	**6 AM**	**8 AM**	**B_1**	**8AM**	**10AM**
A_2	**8 AM**	**10AM**	**B_2**	**9AM**	**11AM**
A_3	**2 PM**	**4 PM**	**B_3**	**2 PM**	**4 PM**
A_4	**8 PM**	**10 PM**	**B_4**	**7 PM**	**9 PM**

Answer:

It is first assumed that crew is based at Chennai. The flight A_1 starts from Chennai at 6 am and reaches Mumbai at 8 AM. The schedule time for flight at Mumbai is 8 AM . Since the minimum lay-over time of the crew is 5 hours. This flight can depart only on next day at 8 AM i.e. layover time will be 24 hours in this case. Similarly layover times for other flights are also calculated and given in the following table:

Flight No.	Crew based at Chennai			
	B_1	B_2	B_3	B_4
A_1	24	25	6	11
A_2	22	23	28	9
A_3	16	17	22	27
A_4	10	11	16	21

The layover times for various flight connections when crew is assumed to be based at Mumbai are similarly calculated in the table given below:

Flight No.	Crew based at Mumbai			
	B_1	B_2	B_3	B_4
A_1	20	19	14	9
A_2	22	21	16	11
A_3	28	27	22	17
A_4	10	9	28	23

The crew can be based at either of places, minimum layover times can be obtained for different flight numbers by selecting the corresponding lower value out of the above two tables.

Flight No.	Flight No.			
	B_1	B_2	B_3	B_4
A_1	20*	19	6	9*
A_2	22	21	16*	9
A_3	16	17	22	17*
A_4	10	9*	16	21

A with an entry in the above table indicates that it corresponds to layover time when the crew is based at Mumbai. We will now apply the assignment algorithm to find the optimal solution. Substracting the minimum element of each row from all the elements of that row.

We get the following matrix:

Flight No.	Flight No.			
	B_1	B_2	B_3	B_4
A_1	~~14~~	~~13~~	~~0~~	~~3~~
A_2	13	12	7	0
A_3	~~0~~	~~1~~	~~6~~	~~1~~
A_4	~~1~~	~~0~~	~~7~~	~~12~~

Since there is zero in each column. There is no need to perform column reduction. The minimum number of lines to cover all zero is four , which is equal to the order of the matrix.

Hence the above table will give the optimal solution. The assignment is made below:

Flight No.	Flight No.			
	B_1	B_2	B_3	B_4
A_1	14	13	0	3
A_2	13	12	7	0
A_3	0	1	6	1
A_4	1	0	7	12

The optimal assignment is as follows:

From Flight No.	To Flight No.	Layover Time
A_1	B_3	6
A_2	B_4	9
A_3	B_1*	16
A_4	B_2	9
	(₹)	40 hours.

29. 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 no 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 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 the 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 = 6. Therefore this condition is satisfied. Now the solution is tested for optimality. Let us now 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 $\mu = 0$. Remaining values (refer to notes for detailed calculations) are give below.

Table 4

Factory	Destination (1)	Destination (2)	Destination (3)	Supply	Vis
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. Therefore 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 $\mu_4 = -5$	

30. 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**

and 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

		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	[65] 5	[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 m + n - = 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 calculated below:

Customers	Warehouse			Requirements	U_i's
	W_1	W_2	W_3		
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, therefore 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 $\mu_3 = 7$	

31. 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. The profit obtained will be calculated as follow (for above table) :

Profit = ₹ 34 – ₹ 22- ₹ 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 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 is 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 calculations below:

Table 5

Plants	Sales office A	B	C	D	E	Dummy	Capacity	V_j's
1	50 5	100 3	8 5	9 10	9 0	0 -10	150	-10
2	25 -0 15	11 -2	13 10	5 -4 +0	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		

(**Note:** For values of occupied and unoccupied cells refer to Note 1.)

Table 6

Plant	Sales office* A	B	C	D	E	Dummy	Cap. 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 values of occupied and unoccupied cells.

Since the values 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 $\mu_4 = 9$	$C_{32} = 5 - (-9 + 13) = 1$
	$C_{35} = 10 - (-9 + 13) = 6$
	$C_{36} = 0 - (-9) = 9$

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 $\mu_4 = -5$	$C_{32} = 5 - (-5 + 9) = 1$
	$C_{35} = 10 - (-5 + 13) = 2$
	$C_{36} = 0 - (-5 + 0) = 5$

32. State the major two reasons for using simulation to solve a problem.

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

33. The manager of a book store has to decide the number of copies of a particular tax law book to order. A book costs ₹ 60 and is sold for ₹ 80 since some of the tax laws charge year after year. Any copies unsold while the edition is current must be sold for ₹ 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**
Proportion	**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.

34. 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**

According to the given information, the random number interval is assigned to both the receipts and the payments.

Answer:

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

35. Patients arriving at a village dispensary are treated by a doctor on a first-come-first-served basis. The inter-arrival time of the patents 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.

36. A Book store wishes to carry 'Ramayana' in stock. Demand is probabilistic and replenishment of stock takes 2 days (i.e. if an order is placed on March 1, it will be delivered at the end of the day on March 3).

The probabilities of demand are given below

Demand (daily)	**0**	**1**	**2**	**3**	**4**
Probability	**0.05**	**0.10**	**0.30**	**0.45**	**0.10**

Each time an order is placed, the store incurs an ordering cost of ₹ 10 per order. The store also incurs a carrying cost of ₹ 0.50 per book per day. The inventory carrying cost is calculated on the basis of stock at the end of each day.

The manager of the bookstore wishes to compare two options for his inventory decision.

A. Order 5 books when the inventory at the beginning of the day plus order outstanding is less than 8.

B. Order 8 books when the inventory at the beginning of the day plus order outstanding is less than 8.

Currently (beginning 1st day) the store has a stock of 8 books plus 6 books ordered two days ago and expected to arrive next day.

Using Monte- Carlo Simulation for 10 cycles, recommend–, which option the manager, should choose.

The two digit random numbers are given below:

89 34 70 63 61 81 39 16 13 73

Answer:

Demand	Probability	Cumulative Probability	Range
0	0.05	0.05	0-4
1	0.10	0.15	5-14
2	0.30	0.45	15-44
3	0.45	0.90	45-89
4	0.10	1.00	90-99

Option – A

Day	R No.	Demand	Option	Stock order	Closing Stock	Order Placed
1	89	3	8	-	5	-
2	34	2	5	6	9	-
3	70	3	9	-	6	0
4	63	3	6	-	3	5
5	61	3	3	0	0	-
6	81	3	0	5	2	5
7	39	2	2	-	0	5
8	16	2	0	5	3	-
9	13	1	3	5	7	-
10	73	3	7	-	4	5
					39+5=44	
Ordering cost 4 × 10			₹ 40			
Ordering cost 0.5 × 44			₹ 22			
Total cost			₹ 62			

Option B

Day	R No.	Demand	Option	Stock order	Closing Stock	Order Placed
1	89	3	8	-	5	-
2	34	2	5	6	9	-
3	70	3	9	-	6	-
4	63	3	6	-	3	8
5	61	3	3	-	0	-
6	81	3	0	8	5	-
7	39	2	5	-	3	8
8	16	2	3	-	1	-
9	13	1	1	8	8	-
10	73	3	8	-	5	-
					45	
Ordering cost 2 × 10			₹ 20.00			
Ordering cost 0.5 × 45			₹ 22.5			
Total cost			₹ 42.5			

Option 'B' is better because it has low Inventory costs.

37. 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	35-85
40	0.12	0.98	89-97
50	0.02	1.00	97-99

Stimulated demand for next 10 days

Day	Random no.	Demand
1	25	20
2	39	30
3	65	30
4	76	30
5	10	10
6	05	10
7	73	30
8	89	40
9	19	10
10	49	30

Average Demand per day = 240 / 10 = 24 Units

38. A small maintenance project consists of the following twelve jobs whose preecedence 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.

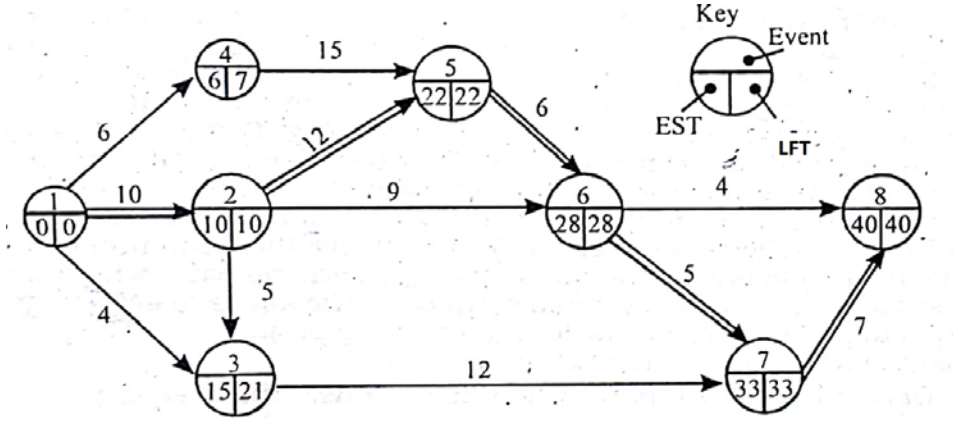
(ii) Calculate earliest start earliest finish , latest finish time for all the jobs.

(iii) Find the critical path and project duration.

(iv) Tabulate total float, free float and independent float.

Answer:

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 (EST)	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

39. 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 the activities of this project is given in the following table:

Activity	T_0	Time estimates (in weeks)	t_p	Normal cost for expected duration	Crash cost (₹)	Immediate Predecessors

		T_m		(₹)		
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.

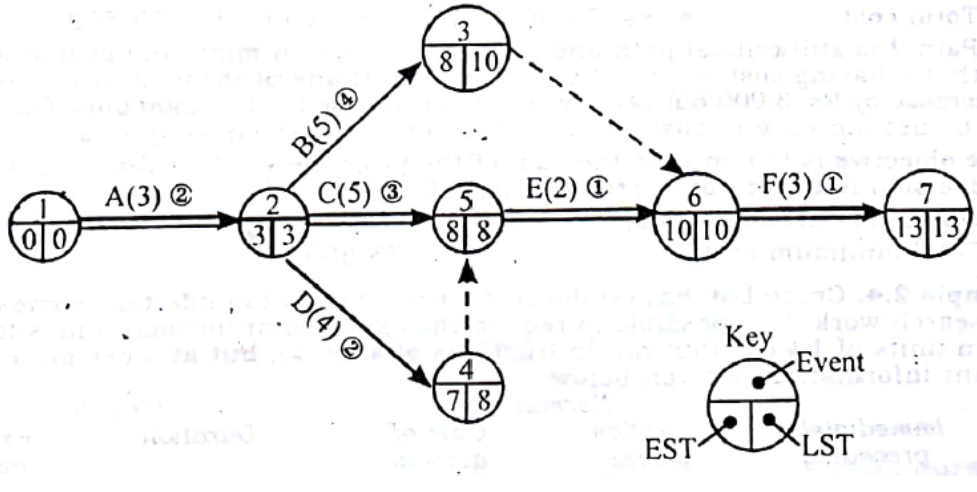
Answer:

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 at the rate of ₹ 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 ΔT (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 activities on critical path; @ 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: 12--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 day.

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 day, the project duration by 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 day , 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 day 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 cost will increase by ₹ 3,000 but penalty cost will decrease by ₹ 2,500 only. Consequently there will be net increase in cost by ₹ 500 by crashing these activities.

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

40. 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

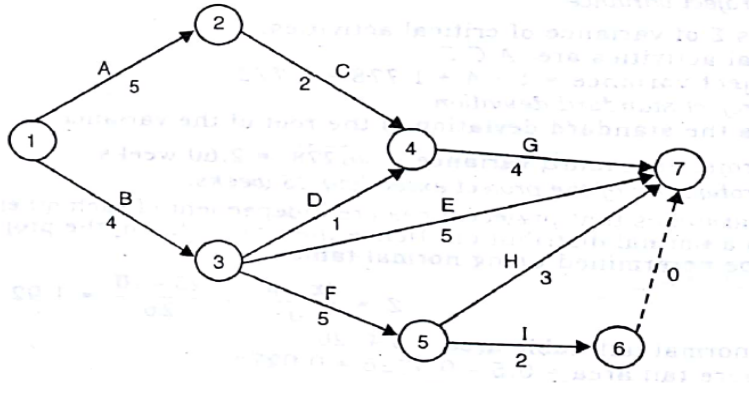
Required:

(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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