SUGGESTED ANSWERS

TO

QUESTIONS

SET AT THE

INSTITUTE'S EXAMINATIONS

MAY, 1996 – NOVEMBER, 2008

A COMPILATION

FINAL EXAMINATION

PAPER – 5 : COST MANAGEMENT

BOARD OF STUDIES
THE INSTITUTE OF CHARTERED ACCOUNTANTS OF INDIA

CONTENTS

1

BASIC COST CONCEPTS IN DECISION MAKING

Question 1

Write short notes on Responsibility Accounting. *(May 1996)*

Answer

It refers to a control system of management accounting and reporting. The basis of responsibility accounting is the creation/recognition of various responsibility/decision centres in an organization. The individual Managers of these centres are made responsible for the incurrence and control of costs relating to their responsibility centres. It aims of control of cost and not its determination. It will examine the responsibility for cost under review. The performance of the Mangers of the various responsibility centres is judged by assessing how far they have been able to monitor these costs. This is done through performance reports. The method can be tailored according to the needs of an organization. Thus responsibility accounting is a primary management tool which provides complete suggestions for corrective action. The preparation of an organization chart, individual interest, probability of resistance and feeling of dissatisfaction are the limitation of responsibility accounting. The names of various responsibility centres are: (i) Cost Centre, (ii) Profit Centre, (iii) Investmetn Centre, (iv) Contribution Centre, (v) Revenue Centre and (vi) Service Cost Centre.

Question 2

Somesh of Agra presently operates its plant at 80% of the normal capacity to manufacture a product only to meet the demand of Government of Tamil Nadu under a rate contract.

He supplies the product for Rs.4,00,000 and earns a profit margin of 20% on sales realisations Direct cost per unit is constant.

The indirect costs as per his budget projections are:

Indirect costs	*20,000 units (80% capacity) Rs.*	*22,500 units (90% capacity) Rs.*	*25,000 units (100% capacity) Rs.*
Variable	*80,000*	*90,000*	*1,00,000*
Semi-variable	*40,000*	*42,500*	*45,000*
Fixed	*80,000*	*80,000*	*80,000*

He has received an export order for the product equal to 20% of its present operations. Additional packing charges on this order will be Rs.1,000.

Arrive at the price to be quoted for the export order to give him a profit margin of 10% on the export price.
(May 1996)

Answer

Working notes:

1. Direct cost per unit

	Rs.
Selling price per unit	20
(Rs.4,00,000/20,000 units)	

Less: Profit margin	4
(20% × Rs.20/-)	
Total cost	16
Less: Indirect costs	10
(Rs.2,00,000 / 20,000)	
Direct cost per unit	6

2. Statement of differential cost for 4,000 units

	Present production 20,000 units Rs.	Proposed production 20,000 units Rs.	(20% of 20,000 units) Differential for 4,000 units
Direct cost @ Rs.6/- p.u.	1,20,000	1,44,000	24,000
Indirect Cost :			
Variable @ Rs.4/- p.u.	80,000	96,000	16,000
Semi-variable	40,000	44,000	4,000
Fixed	80,000	81,000	1,000
Total	3,20,000	3,65,000	45,000

Computation for the price to be quoted for the export order of 4,000 units

	Rs.
Differential cost	45,000
(refer to Working note 2)	
Add: profit	5,000
(10% of export price or 1/9th of cost)	
Price to be quoted	50,000
Export price per unit Rs.12.50	
(Rs.50,000/4,000 units)	

Question 3

ZED Ltd. operates two shops. Product A is manufactured in Shop – 1 and customer's job against specific orders are being carried out in Shop 2. Its annual statement of income is:

	Shop-1 (Product-A) Rs.	*Shop-2 (Job Works) Rs.*	*Total Rs.*
Sales/Income	*1,25,000*	*2,50,000*	*3,75,000*
Material	*40,000*	*50,000*	*90,000*
Wages	*45,000*	*1,00,000*	*1,45,000*
Depreciation	*18,000*	*31,500*	*49,500*
Power	*2,000*	*3,500*	*5,500*
Rent	*5,000*	*30,000*	*35,000*
Heat and Light	*500*	*3,000*	*3,500*
Other Expenses	*4,500*	*2,000*	*6,500*
Total	*1,15,000*	*2,20,000*	*3,35,000*
Net Income	*10,000*	*30,000*	*40,000*

The depreciation charges are for machines used in the shops. The rent and heat and light are apportioned between the shops on the basis of floor area occupied. All other cots are current expenses identified with the output in a particular shop.

A valued customer has given a job to manufacture 5,000 units of X for shop-2. As the company is already working at its full capacity, it will have to reduce the output of product-A by 50%, to accept the said job. The customer is willing to pay Rs.25 per unit of X. The material and labour will cost Rs.10 and Rs.18 respectively per units. Power will be consumed on the job just equal to the power saved on account of reduction of output of A. In addition the company will have to incur additional overheads of Rs.10,000.

You are required to compute the following in respect of this job.

(a) Differential cost;

(b) Full costs;

(c) Opportunity costs; and

(d) Sunk cost.

Advise whether the company should accept the job. *(May 1996)*

Answer

(a) Differential Cost of the job

	Increase Rs.	Decrease Rs.
Material cost	50,000	20,000
Labour cost	90,000	22,500
Additional Overheads	10,000	-
Other expenses	-	2,250
Total	1,50,000	44,750

Net differential cost of the job : Rs.1,05,250

(Rs.1,50,000 – Rs.44,750)

Note: Depreciation, rent, heat and light and power are not going to affect the costs.

(b) Full Cost of the jobs:

	Rs.
Cost as above at (a)	1,50,000
(i.e. increased costs)	
Depreciation	9,000
Power	1,000
Rent	2,500
Heat & Light	250
Total	1,62,750

(c) Opportunity cost of taking the order:

	Rs.	Rs.
Sale of Product A		62,500
Less:		
Material	20,000	

Labour	20,500	
Power	1,000	
Other expenses	2,250	45,750
Total		16,750

(d) Sunk cost of the jobs:

	Rs.
Depreciation	9,000
Power*	1,000
Rent	2,500
Heat & Light	250
Total	12,750

*If a student treats power as a relevant cost, in that case it would not appear here. Advice regarding the jobs :

ZED Ltd. should not accept the job as there will be a chase disadvantage of Rs.42,750/- as computed below:

	Rs.	Rs.
Incremental revenue		
5,000 units @ Rs.25	1,25,000	
Less: Sale of product A	62,500	62,500
Differential costs (a)		1,05,250
Cash disadvantage		42,750

Question 4

(a) *"Costs may be classified in a variety of ways according to their nature and the information needs of the management" Explain.* *(Nov. 96)*

(b) *Indicate the major areas of short-term decisions in which differential cost analysis is useful.*

(Nov. 96)

(c) *"Relevant cost analysis helps in drawing the attention of managers to those elements of cost which are relevant for the decision." Comment.* *(Nov. 96)*

Answer

(a) Cost classification is the process of grouping costs according to their characteristics. Costs are classified or grouped according to their common characteristics. Costs may be classified according to elements, according to functions or operations, according to their behaviour, according to controllability or according to normality.

The break up of the aggregate costs into relevant types, is an essential pre-requisite of decision making as well as of controlling costs. Classification of costs on different bases is thus necessary for various purposes. For the purpose of decision-making and control, costs are distinguished on the basis of their relevance to different type of decisions and control functions. The importance of distinguishing cost as direct or indirect lies in the fact that direct costs of a product or an activity can be accurately allocated while indirect costs have to be apportioned o the basis of certain assumptions. This is so because direct costs are controllable at the operational level whereas indirect costs are not amenable to such control.

(b) Cost information is required both for short-term and long-run managerial problems. Differential costs are of particular use in short-term problems which are non-repetitive, onetime, ad-hoc problems. The following are the most common short-term problems and areas where differential costs analysis may be deployed.

1. Accept – or – reject special order decisions.
2. Make – or – buy decisions.
3. Sell – or – process decisions.
4. Reduce – or – maintain price decisions.
5. Add – or – drop product decisions.
6. Operate – or shut down decisions.

(c) Relevant costs are pertinent or valid costs for a decision. These bear upon or 'influence decision' and are directly related to the decisions to be made. These are critical to the decisions, and have significance for it. These are the cots whish generally respond to managerial decision making, and have significance in arriving at correct conclusions. These costs are capable of making of difference in user-decisions and enter into a choice between alternative courses of action. In specific terms relevant costs for decisions are defined as "expected future costs that will differ under alternatives".

Relevant costs are futuristic in nature. These are the costs that are expected to occur during the time period covered by the decisions. These costs are different between alternative being considered. Only costs that differ among decisions alternatives are relevant to a decision.

Question 5

(a) A Ltd produces and markets a range of consumer durable appliances. It ensures after sales service through X Ltd. The big appliances are serviced at customer's residence while small appliances are serviced at workshop of X Ltd.

The material supplied to X Ltd is charged at cost at 10%. X Ltd. charges customers at 25% over the above price. For labour, the company receives 10% of the rate fixed for work doe under the after sales service agreement and 15% of the rate fixed in case of jobs not covered under the agreement from X Ltd 60% by value of the total work undertaken by X Ltd was for big appliances and rest accounted for small appliances during the previous year.

The company decided to carry out all or some of the work itself and has chosen one area in the first instances. During the previous year the company earned a profit of Rs.2,16,000 as detailed below from X Ltd. for the area chosen.

	Material	*Labour*
	Rs.	*Rs.*
Under after-sales service agreement	*60,000*	*1,00,000*
For jobs not covered	*20,000*	*36,000*

The company forecast same volume of work in that area for the ensuing period. The following three options are under consideration of the management.

(1) To set up a local service centre to provide service for small appliance only. The existing system is to continue for big appliances.

(2) To set up a local service centre to provide service for big appliances only. The existing system is to continue for small appliances.

(3) To set up a local service centre to provide service to all appliances. The existing system then stands withdrawn.

The relevant costs for carrying out jobs under the above options are as under:

	(Rs.'000) *Option – 1*	*Option – 2*	*Option – 3*
Heat, rent light etc.	*125*	*50*	*150*
Management costs	*108*	*83*	*150*

Service staff costs	*230*	*440*	*750*
Transport costs	*25*	*220*	*230*

You are required to find out the most profitable option.

(b) *Briefly explain the concept of 'Opportunity Costs'.* *(Nov 1996)*

Answer

(a) Statement showing value of total work undertaken by X Ltd. at customer's price

	(Rs.'000)
Material costs (for appliances covered under agreement) [Rate to working note 1 (i)]	825
Material costs (for appliances not covered under agreement) [Refer to working note 2 (i)]	275
Labor cost (for appliances covered under agreement) [Refer to working note 1 (ii)]	1,000
Labour cost (for appliances not covered under agreement) [Refer to working note 2 (ii)]	240
Total receipts	2,340

Break up of receipts:

Big appliances	60%	1.404
Small appliances	40%	936

Profitability Statement

(Rs.'000)

	Option 1	Option 2	Option 3
Income			
Big appliances	129.6 (60%×Rs.216)	1,404	1.404
Small appliances	936	86.4 (40%×Rs.216)	936
Total receipts: (A)	1,065.6	1,490.4	2,340
Costs:			
Material	320 $\frac{40\%\times(825+275)}{137.5\%}$	480 $\frac{60\%\times(825+275)}{137.5\%}$	800 $\frac{(825+275)}{137.5\%}$
Heat, rent, light etc.	125	50	150
Management costs	108	83	150
Service staff costs	230	440	750
Transport costs	25	220	230
Total costs: (B)	808	1,273	2,080
Profit: [(A) – (B)]	257.6	217.4	260

Recommendation:

Option 3 is most profitable one.

Working Notes:

1. Material and labour cost (for appliances under after sales agreement):

Rs.

(i) Cost of Material pre unit charged to customer's by X Ltd.

	(Rs.100 = × 10% × Rs.100 × 25% × Rs.110)	137.50
	Cost of material charged to customer's by X Ltd.	
	$\left(\frac{\text{Rs.60,000}}{\text{Rs.10}}\right) \times$ Rs.137.50	8,25,000
(ii)	Cost of labour charged to customer by X Ltd.	
	$\left(\frac{\text{Rs.1,00,000}}{\text{Rs.10}}\right) \times$ Rs.100	10,00,000

2. Material and labour cost (for appliances not covered under sales agreement):

		Rs.
(i)	Cost of material charged to customer by X Ltd.	
	$\left(\frac{\text{Rs.20,000}}{\text{Rs.10}}\right) \times$ Rs.137.50	2,75,000
(ii)	Cost of labour charged to customer by X Ltd.	
	$\left(\frac{\text{Rs.36,000}}{\text{Rs.15}}\right) \times$ Rs.100	2,40,000

(b) Opportunity Cost:

Opportunity cost is primarily an economic concept. In Economics, the opportunity cost of a designated alternative is the greatest net benefit lost by selecting an alternative. It is the benefit given by rejecting one alternative and, selecting another.

Accounting takes the same view and defines it as the benefits forgone by rejecting the second best alternative in favour of the best. Opportunity costs represent the measurable value of opportunity bypassed by rejecting an alternative use of resources. It is the value in its best alternative use – the profit that is lost by the diversion of an input factor from one use to another. It is defined as the maximum contribution that is forgone by using limited resources for a particular purpose.

Opportunity cost concept is helpful to the management is making profitability calculations when one or more of the inputs required by one or more of the alternative courses of action is already available.

Question 6

The trading results of ZED Ltd. for 1995-96 and 1996-97 are as follows:

	1995-96	*1996-97*
	Rs.	*Rs.*
Material	*1,60,000*	*2,05,200*
Wages	*96,000*	*1,32,000*
Variable Overheads	*40,000*	*46,000*
Fixed Overheads	*50,000*	*54,800*
Total Costs	*3,46,000*	*4,38,000*
Profit	*54,000*	*90,000*
Sales	*4,00,000*	*5,28,000*

Selling price was enhanced by 10% 1996-97. Material prices and wage rates too have increased by 8% respectively.

Prepare a statement showing how much each factor has contributed to the variation in profit.

(May 1997)

Answer

Working notes:

1. Rise in the sales figure of 1996-97 due to 10% increase in selling price:

   $= \text{Rs.}5,28,000 \times \frac{10}{110} = \text{Rs.}48,000$

2. Rise in the figure of sales volume in 1996-97

   = Difference in the sales figures of two consecutive years – Rise in selling price.

   = (Rs.5,28,000 – Rs.4,00,000) – Rs.48,000 = Rs.80,000

3. Percentage rise in the figure of sales volume in 1996-97

   $= \frac{\text{Rise in the figure of sales volume in 1996 - 97}}{\text{Sales figure of 1995} - 96} \times 100$

   $= \frac{\text{Rs.}80,000}{\text{Rs.}4,00,000} \times \text{Rs.}100 = 20\%$

4. Increase in material prices in 1996-97 due to 8% price increase:

   $= \frac{\text{Rs.}2,05,200}{108} \times 8 = \text{Rs.}15,200$

5. Increase in wages due to 10% increase in wage rates:

   $= \frac{\text{Rs.}1,32,000}{110} \times 10 = \text{Rs.}12,000$

6. Increase in material, wages and overheads by 20% due to rise in sales volume are Rs.32,000; Rs.19,200 and Rs.8,000 respectively.

	1995-96	*1996-97*	*Difference figure*	*Due to price changes*	*Due to volume changes*	*Due to other factors*
	Rs.	*Rs.*	*Rs.*	*Rs.*	*Rs.*	*Rs.*
	(a)	*(b)*	*(c)=(b)-(a)*	*(d)*	*(c)*	*(f)=(c)-(d)-(e)*
Sales : A	4,00,000	5,28,000	1,28,000	48,000	80,000	-
Material	1,60,000	2,05,200	45,200	15,200	32,000	(-2,000)
Wages	96,000	1,32,000	36,000	12,000	19,200	4,800
Variable Overheads	40,000	46,000	6,000	-	8,000	(-2,000
Fixed Overheads	50,000	54,800	4,800	-	-	4,800
Total Costs : (B)	3,46,000	4,38,000	92,000	27,200	59,200	5,600
Profit : [(A)-(B)]	54,000	90,000	36,000	20,800	20,800	(-5,600)

Question 7

Why is meant by incremental Revenue? *(Nov 1997)*

Answer

Incremental Revenue: Incremental revenue is the additional revenue that arise from the production or sale of a group of additional units. It is one of the two basic concepts the other being incremental cost which go together with differential cost analysis. Incremental cost in fact is the added cost due to change either in the level of activity of in the nature of activity.

Question 8

'Costs may be classified in a variety of ways according to their nature and information needs of the management. 'Discuss. *(Nov 1997)*

Answer

Costs can be classified according to their nature and information needs of the management in the following manner:

(i) *By element:* Under this classification costs are classified into (a) direct costs and (b) Indirect costs according to elements viz., materials, labour and expenses.

(ii) *By function:* Here costs are classified as: Production cost; administration cost; selling costs; distribution cost; research; development costs, etc.

(iii) *By behaviour:* According to this classification costs are classified as fixed; variable and semi variable costs. Fixed costs can be further classified as committed and discretionary.

(iv) *By controllability:* Costs are classified as controllable and non-controllable costs.

(v) *By normality:* Under this classification cost are segregated as normal and abnormal costs.

Management of a business house requires cost information for decision making under different circumstances. Fr example they require such information for fixing selling price, controlling and reducing costs. To perform all these functions a classification of cost according to their nature and information needs in an essential pre-requisite of the management.

Question 9

A company produces and sells four types of dolls for children. It also produces and sells a set of dress kit for the dolls.

The company has worked out the following estimates fort the next year :

Doll	*Estimated Demand*	*Standard Material Cost*	*Standard Labour Cost*	*Estimated Sales Per Unit*
		(Rs.)	*Rs.*	*(Rs.)*
A	*50,000*	*20*	*15*	*60*
B	*40,000*	*25*	*15*	*80*
C	*35,000*	*32*	*18*	*100*
D	*30,000*	*50*	*20*	*120*
Dress Kit	*2,00,000*	*15*	*5*	*50*

To encourage the sale of dress kits, a discount of 20% in its price is offered if it were to be purchased along with the doll. It is expected that all the customer, buying dolls will also buy the dress kit.

The company's factory has effective capacity of 2,00,000 labour hours per annum on a single-shift basis and it produces all the products on that basis. The labour hour rate is Rs.15 Overtime of labour has to be paid at double the normal rate.

Variable cost works out to 50% of direct labour cost. Fixed costs are Rs.30 lakhs per annum.

There will be no inventory at the end of the year.

You are to draw a conservative estimate of the year's profitability. *(May 1998)*

Answer

Working notes :

1. Total labour hours required to meet estimated demand of four types of dolls and their dress kit :

Doll	Estimated Demand (units)	*Std labour time per doll	Total labour hours
(a)	(b)	(c)	(d) = (b) × (c)
A	50,000	1 hr	50,000.00
B	40,000	1 hr	40,000.00
C	35,000	1.2 hrs	42,000.00
D	30,000	1.33 hrs	40,000.00
Dress Kit	2,00,000	0.33 hrs	66,666,66
Total labour hours to meet estimated demand			2,38,666,66

*Standard labour time per doll has been calculated by dividing standard labour cost (per doll) by Rs.15.

Since the total available hours are only 2,00,000 therefore 38,666.66 hours will be utilised by employing the labour on overtime basis.

2. Total discount on the sale of dress kit.

Out of 2,00,000 dress kits, 1,55,000 were sold along with four type of dolls. Each unit of sale of dress kit along with a unit of doll is entitled for a discount of 20% of Rs.50 i.e. Rs.10. The total discount amount on the sale of 1,55,000 dress kit comes to Rs.15,50,000.

Statement of Conservative Estimate of the Year's Profitability

	Doll A	*Doll B*	*Doll C*	*Doll D*	*Dress Kit*
Estimated demand (units)	50,000	40,000	35,000	30,000	2,00,000
	Rs.	Rs.	Rs.	Rs.	Rs.
Selling price per unit: (A)	60	80	100	120	50
Material cost per unit	20	25	32	50	15
Labour cost	15	15	18	20	5
Variable cost	6	6	7.20	8	2
*40% of labour cost					
Total marginal cost: (B)	41	46	57.20	78	22
Contribution p.u. (C):{(A) – (B)}	19	34	42.80	42	28
Total contribution	9,50,000	13,60,000	4,98,000	12,60,000	56,00,000
On estimated demand	(50,000×Rs.19)	(40000×Rs.34	(35000×Rs.42.80	(30000×Rs.42)	(200000×Rs.28)
Less: Discount on dress kits					(15,50,000)

(Refer to working note 2)					
Net contribution	9,50,000	13,60,000	4,98,000	12,60,000	40,50,000
Total net contribution (Rs.)		91,18,000			
Less: Overtime premium (Rs.)		5,80,000			
(38,666,66 hrs × Rs.)15)					
(Refer to working note 1)					
Less: Fixed cost (Rs.)		30,00,000			
Profit (Rs.)		55,38,000			

Question 10

Gemini Enterprises currently makes as many units of part no. X- 248 as it needs. Sen, General Manager of Gemini Enterprises, has received a quotation from another company for making part no. X- 248. Zedco will supply 1,000 units of part no. X-248 per year at Rs.50 per unit. Zedco can begin supply on 1st July 1998 and continue for 5 years, after which Gemini will not need the part, Zedco can accommodate any change in Gemini's demand for the part and will supply it for Rs.50 regardless of quantity.

Shah, the Controller of Gemini enterpirses, reports the following costs for manufacturing 1,000 units of part No. X-248.

	Rs.
Direct Materials	*22,000*
Direct Labour	*11,000*
Variable Manufacturing Overhead	*7,000*
Depreciation on Machine	*10,000*
Product and Process Engineering	*4,000*
Rent	*2,000*
Allocation of General Plant overhead costs	*5,000*
Total Costs	*61,000*

The following additional information is available:

(a) *Part X-248 is made on a machine used exclusively for its manufacture. The machine was acquired on 1st July, 1997 at a cost of Rs.60,000. The machine has a useful life of six years and a zero terminal disposal price. Depreciation is calculated on straight-line basis.*

(b) *The machine could be sold today for Rs.15,000.*

(c) *Product and process engineering costs are incurred to ensure that the manufacturing process for part No. X-248 works smoothly. Although these costs are fixed in the short run, with respect to units of part no. X-248, they can be saved in the long run if part no. X-248 is no longer produced. If part no. X-248 is outsourced, product and process engineering costs of Rs.4,000 will be incurred for 1997-98 but not thereafter.*

(d) *Rent costs of Rs.2,000 are allocated to products on the basis of the floor space used for manufacturing the product. If part number X-248 is discontinued, the space currently used to manufacture it would become available. The company could then use the space for storage purposes and saves Rs.1,000 currently paid for outside storage.*

(e) *General plant overhead costs are allocated to each department on the basis of direct manufacturing labour costs. The costs will not change in total. But no general plant overhead will be allocated to part number X-248 if the part is outsourced.*

Assume that Gemini requires a 12%, rate of return for this project. The following information may be useful:

Year	*Present Value Factor at 12%*
0	*1.000*
1	*0.893*
2	*0.797*
3	*0.712*
4	*0.636*
5	*0.567*

Required:

(i) Should part number X-248 be outsourced? Prepare a quantitative analysis.

(ii) State any sensitivity analysis that seems to be advisable. Do not perform any sensitivity calculations.

(iii) Sen is particularly concerned about his bonus for 1997-98. The bonus is based on the accounting income of Gemini Enterprises. What decision will Sen make if he wants to maximize his bonus for 1997-98?
(May 1998)

Answer

(i) Relevant operating cash outflows and operating cash savings each year if the part is outsourced

	Product X-248 may be outsourced from July'98 for five years Rs.
Operating cash outflows for purchasing the part: (A)	(50,000)
Relevant operating cash flows from outsourcing the part:	
Direct material	22,000
Direct labour	11,000
Variable overhead	7,000
Product and process engineering	4,000
Rent	1,000
Total relevant operating cash outflow per annum	
Net relevant operating cash outflow per annum (if purchased from outside) {A – B}	(5,000)

Net present value of cash-in-flows and outflows if the part is outsourced

		Amount Rs.	*PV Factor*	*P.V. Rs.*
Disposal price of machine	Year 0	15,000	1	15,000
Recurring operating cash flow	Year 1	5,000	0.893	(4,465)
	Year 2	5,000	0.797	(3,985)
	Year 3	5,000	0.712	(3,560)
	Year 4	5,000	0.636	(3,180)
	Year 5	5,000	0.567	(2,835)
	NPV			(3,025)

Since the purchase option has negative NPV, therefore, part should continue to be made internally.

Notes:

1. Equipment depreciation is a non-cash cost item. Therefore, it is not relevant.
2. Product and process engineering cost is relevant for the entire period of outsourcing i.e. for 5 years.
3. Allocated rent is irrelevant but rent saved (i.e. Rs.1,000) is relevant.
4. Allocated general plant overhead is irrelevant.

(ii) Sensitivity ‘analysis with respect to quantity is desirable:

- If demand far the part decreases vendor is willing to supply a lower quantity at the same price (Rs.50/-).
- If the part is continued to be made internally, the casts would not decrease quite fast with lower quantities because of fixed cost.
- Net cash outflows of outsourcing will be smaller if lower quantities of the part are demanded. But if the demand increases, it would be preferable to make the part-in house.

Non-financial factors:

- Will the units of part required be delivered on schedule?
- Will quality be maintained?
- Can suggested modifications be really accommodated?
- Will the subcontractor remain in business for next five years?

(iii) As the outsourcing of part X-248 will start from July’1998. The bonus of Gemini Enterprises based on the accounting income, which Mr. Sen wishes to maximize will remain unchanged for the year 1997-98.

Question 11

ACE Ltd. has an inventory of 5,000 units of a product left over from last years’ production. This model is no longer in demand. It is possible to sell these at reduced prices through the normal distribution channels. The other alternative is to ask someone to take them on “as is where is” basis. The latter alternative will cost the company Rs.5,000.

The company produced 2,40,000 units of the product, last year, when the unit costs were as under:

Manufacturing Costs:		
Variable	*6.00*	
Fixed	*1.00*	*7.00*
Selling & Distribution Cost:		
Variable	*3.00*	
Fixed	*1.50*	*4.50*
Total Cost		*11.50*
Selling Price per Unit		*14.00*

Required:

Should the company scrap the items or sell them at a reduced price? If you suggest the latter, what minimum price would you recommend? *(May 1998)*

Answer

Minimum recommended price per unit of 5,000 units of a product (obsolete model) of ACE Ltd.

(i) Historical cost of Rs.11.50 per unit of 5,000 units of a product is irrelevant (as it is a sunk cost) for determining the recommended price per unit.

(ii) If at all this model is sold in the market through normal distribution channels it will entail a variable selling and distribution cost of Rs.3 per unit.

(iii) If the stock is disposed off by asking someone to take them on "as is where is basis", the company would have to spend Rs.5,000 over 5,000 units i.e. Rs.1/- per unit.

(iv) In view of (ii) and (iii) the option of selling 5,000 obsolete units of the model using regular channels will nave a differential cost of Rs.2 (Rs.3 – Re.1) per unit.

Recommendation:

Hence, if the company can get anything more than Rs.2/- per unit, then it is worthwhile to sell the stock of 5,000 units and earn an additional contribution.

Question 12

What are incremental costs and sunk costs? Discuss. *(Nov 1998)*

Answer

Incremental costs: The difference in total cost between two alternatives is an incremental cost. It is synonymous to differential cost. Incremental cost arises due to change of the level of activity. The change may be due to adding to a new product; change of channels of distribution, adding capacity etc. Incremental costs are not necessarily variable in nature.

Sun costs: Costs which do not change under given circumstances and do not play any role in decision making process are known as sunk costs. They are historical costs incurred in the past. In other words, these are the costs which have been incurred by a decision made in past and cannot be changed by any decision made in the future. These costs are, however, best basis of predicting future costs. Amortisation of past expenses is the clearest kind of sunk cost.

Question 13

What are relevant costs? Identify two common pitfalls in relevant cost analyse. *(Nov 1998)*

Answer

Relevant costs:

Relevant costs are those expected future costs which are essential to a decision. The two key aspect of these costs are as follows:

(i) They must be expected future costs.

(ii) They must be different among the alternative courses of action.

For example, in a decision relating to the replacement of an old machine, the written down value of the existing machine is not relevant but its sale price is relevant.

Relevant cost analysis helps in drawing the attention of managers to those elements of costs which are relevant for the decision. Two common pitfalls in relevant cost analysis are as under:

First pitfall in relevant cost analysis is to assume that all variable costs are relevant : All variable costs are not relevant. Even among future costs, those variable costs which will not differ under various alternatives are irrelevant. For example, a company proposes to rearrange plant facilities and estimates its future costs under two alternatives, as under:

Particulars	*Do not re-arrange*	*Re-arrange*
	Rs.	Rs.
Direct material cost / unit	10	10
Direct labour cost / unit	05	04

In the above example, the direct material cost (variable cost) remains constant under both alternatives, hence it is irrelevant to the decision as to whether plant facilities are to be re-arranged or not.

Second pitfall is to assume that all fixed costs are irrelevant. All fixed costs are not irrelevant. If fixed expenses remain unchanged under different alternatives such expenses are only irrelevant to the decisions at hand but if they are expected to be altered they should be considered as relevant.

For example, if the plant capacity is 50,000 units and additional 10,000 units can only be manufactured by expanding capacity which entails additional fixed expenses of Rs.50,000. This increase in fixed expenses is relevant to the decision whether the firm should accept order for additional 10,000 units or not.

Question 14

Carcare Corporation has just today paid for and installed a special machine for polishing cars at one of its prestigious outlets. It is the first day of the company's fiscal year. The machine costs Rs.20,000. Its annual operating costs total Rs.15,000 exclusive of depreciation. The machine will have a four-year useful life and a zero terminal disposal value.

After the machine has been used for one day, a machine salesman walks in. He offers a different machine that promises to do the same job at a yearly operating cost of Rs.9,000, exclusive of depreciation. The new machine will cost Rs.24,000 in cash, duly installed. The "old" machineiso unique and can be sold outright for only Rs.10,000 minus Rs.2,000 removal cost. The new machine, like the old one, will have a four-year useful life and zero terminal disposal value.

For simplicity, ignore income taxes, interest and present value considerations.

Sales, all in cash, will be Rs.1,50,000 annually and other cash costs will be Rs.1,10,000 annually, regardless of this decision.

Required:

(a) Prepare a statement of cash receipts and disbursements for each of the four years under both alternatives. What is the cumulative difference in cash flows for the four years taken together?

(b) Prepare Income Statements for each of the four years under both alternatives. Assume straight-line depreciation. What is the cumulative difference in operating income for the four years taken together?

(c) What are the irrelevant items in your presentations in requirements (a) and (b)? Why are they irrelevant?

(d) Suppose the cost of the "old" machine was Rs.10,00,000 rather than Rs.20,000. Nevertheless, the old machine can be sold outright for only Rs.10,000 minus Rs.2,000 removal cost. Would the net differences in requirements (a) and (b) change? Explain.

(e) "To avoid a loss, we should keep the old machine." What is the role of book value in decisions about replacement of machines? *(Nov 1998)*

Answer

(a) Statement of Cash Receipts, Disbursements and cumulative difference in Cash flows for four years taken together under both alternatives

(Rs. in thousands)

Alternatives	*Keep old machine*			*Buy new machine*			
	Year 1	*2nd 3rd & 4th year each*	*All 4 years*	*Year 1*	*2nd 3rd & 4th year each*	*All 4 years*	*Cumulative difference in cash flows for four years taken together*
Receipts							
Sales revenue	150	150	600	150	150	600	

Self of old equipment	-	-	-	8	-	8	
Total receipts : (A)	150	150	600	158	150	608	
Disbursements							
Annual operating cost	15	15	60	9	9	36	
Other cash costs	110	110	440	110	110	440	
Purchase cost of "old" machine	20	-	20	20	-	20	
Purchase of "new" machine	-	-	-	24	-	24	
Total disbursements : (B)	145	125	520	163	119	520	
Net cash in-flows: (A)-(B)	5	25	80	(5)	31	88	08

(b) Statement of income for each of the four years and cumulative difference in operating income.

Alternatives	*Keep old machine*		*Buy new machine*			
	1st, 2nd 3rd & 4th year each	*All years*	*Year 1*	*2nd 3rd & 4th year each*	*All 4 years*	*Cumulative difference operating income*
Income						
Sales revenue	150	600	150	150	600	
Total revenue : (A)	150	600	150	150	600	
Costs:						
Annual operating cost	15	60	9	9	36	
Other cash costs	110	440	110	110	440	
Depreciation	5	20	6	6	24	
(Refer to working note 1)						
Loss on the disposal of old machine	-	-	12	-	12	
(Refer to working note 2)						
Total costs: (B)	130	520	137	125	512	
Operating income: (A)-(B)	20	80	13	25	88	08

(c) The purchase of cost old machine Rs.20,000; the sale revenue Rs.1.50,000 and other cash costs of Rs.1,10,000 as irrelevant items for the presentation in requirements (a) and (b) above. These items are irrelevant because their amounts are common to both the alternatives.

(d) The net difference in requirements under (a) and (b) will not change if the cost of 'old' machine becomes Rs.10,00,000 instead of Rs.20,000. This is so because the cost of old machine is common for both the alternatives.

(e) In the decision about eh replacement of machine the book value of the machine is irrelevant because it is a past (historical) cost. All past costs are down the drains. Nothing can change what has already happened.

As apparent from (a) and (b) above; we can completely ignore the cost of old machine i.e. Rs.20,000 and still have a correct analysis.

Working note:

1. Depreciation (according to straight line method):

		Old machine	New machine
(i)	cost of machine (Rs.)	20,000	24,000
(ii)	Terminal disposal value	Zero	Zero
(iii)	Useful life	4	4
	Depreciation $\left(\frac{\text{(i) - (ii)}}{\text{(iii)}}\right)$ Rs.	5,000	5,000

2. Loss on the disposal of old machine:

	Rs.	Rs.
Purchase price of old machine		20,000
Disposal value	10,000	
Less: Removal cost	2,000	8,000
		12,000

Question 15

Distinguish between "Marginal cost" and 'Differential Cost". *(May 1999)*

Answer

Marginal cost represents the increase or decrease in total cost which occurs with a small change in output say, a unit of output. In Cost Accounting variable costs represent marginal cost.

Differential cost is the change (increase or decrease) in the total cost (variable as well as fixed) due to change in the level of activity, technology or production process or method of production.

In other words, it can be defined as the cost of one unit of product or service which would be avoided if that unit was not produced or provided.

The main point which distinguishes marginal cost and differential as that change in fixed cost when volume of production increases or decreases by a unit of production. In the case of differential cost variable as well as fixed cost. i.e. both costs change due to change in the level of activity, whereas under marginal costing only variable cost changes due to change in the level of activity.

Question 16

Mahila Griha Udyog Industries is considering to supply its products – a special range of namkeens – to a departmental store. The contract will last for 50 weeks, and the details are given below:

Material:		*Rs.*
	X (in stock – at original cost)	*1,50,000*
	Y (on order – on contract)	*1,80,000*
	Z (to be ordered)	*3,00,000*
Labour		
	Skilled	*5,40,000*
	Non-skilled	*3,00,000*
	Supervisory	*1,00,000*

General overheads	*10,80,000*
Total cost	*26,50,000*
Price offered by department store	*18,00,000*
Net Loss	*8,50,000*

Should the contract be accepted if the following additional information is considered?

(i) Material X is an obsolete material. It can only be used on another product, the material for which is available at Rs.1,35,000 (Material X requires some adaptation to be used and cost Rs.27,000).

(ii) Material Y is ordered for some other product which is no longer required. It now has residual value of Rs.27,000).

(iii) Skilled labour can work on other contracts which are presently operated by semi-skilled labour at a cost of Rs.5,70,000.

(iv) Non-skilled labour are specifically employed for this contract.

(v) Supervisor staff will remain whether or not the contract is accepted. Only two of them can replace other positions where the salary is Rs.35,000.

Overheads are charged at 200% of skilled labour. Only Rs.1,25,000 would be avoidable, if the contract is not accepted. *(May 1999)*

Answer

Statement of relevant cost of Mahila Griha Udyog Industries

If the contract is accepted/rejected

Decision	*Relevant costs (if contract is accepted) Rs.*	*Relevant costs (if contract is rejected) Rs.*
Cash inflows		
Contract price	18,00,000	-
Sale of material Y	-	2,10,000
(Refer to working note I)		
Total cash inflows: (A)	18,00,000	2,10,000
Cash outflows		
Material X substitute	1,35,000	-
(Refer to working note 2)		
Adaptation required for the use of obsolete material X	-	27,000
Material Z	3,00,000	-
Replacement of semi-skilled labour by skilled labour	5,70,000	-
(Refer to working note 3)		
Non-skilled labour cost	3,00,000	-
(Refer to working note 4)		
Supervisory staff cost	35,000	-
(Refer to working note 5)		
Avoidable overheads	1,25,000	-
(Refer to working note 6)		

Total cash outflows: (B)	14,65,000	27,000
Net cash inflows: (A) – (B)	3,35,000	1,83,000

The net benefit on accepting the contract is : Rs.3,35,000 – Rs.1,83,000 = Rs.1,52,000.

Conclusion

The contract should be accepted as it yields a net incremental cash inflow of Rs.1,52,000.

Working notes:

1. Material Y will have to be paid for whether or not the contract is accepted, therefore its cost is irrelevant. The relevant cost figure here is that which has an opportunity cost of Rs.2,10,000. This means that the company can resell material Y at this price.
2. Regarding material X, if the contract is accepted, alterative material will have to be purchased for the other product at a cost of Rs.1,35,000. If the contract is rejected material X will be adapted for a product not included in the list of special range of namkeens at a cost of Rs.27,000.
3. The relevant skilled labour cost of Rs.5,70,000 is the extra cost to the company because of this contract. It is the replacement cost of semi-skilled labour by skilled labour.
4. Non-skilled labour cost is the incremental cost of the contract.
5. If the company accepts the contract it will have to pay Rs.35,000 for the two position that the supervisory staff can replace.
6. Only Rs.1,25,000 of avoidable overheads are relevant to this contract.

Question 17

Ranka Builders has been offered a contract by Excel Ltd. to build for it five special Guest Houses for use by top management. Each Guest House will be an independent one. The contract will be for a period of one year and the offer price is Rs. One crore. In addition Excel Ltd. will also provide 2 grounds of land free of cost for the purpose of construction. The Chief Accountant of Ranka Builders has prepared an estimate o the basis of which he has advised that the contract should not be accepted at the price offered. His estimate was as follows:

		Rs. in Lacs
Land (3 Grounds at Rs.20 lacs each)		*60*
Drawings and design		*7*
Registration		*10*
Materials:		
	Cement and Sand	*6*
	Bricks and Tiles	*4*
	Steel	*10*
	Others (including interior decoration)	*10*
Labour – Skilled		*12*
	- Unskilled	*8*
	- Supervisor's Salary	*5*
Overheads General		*12*
	Depreciation	*006*
	Total Cost	*150*

The Accountant also provides the following information:

Land : The total requirement of land is 3 grounds costing Rs.20 lacs per ground Excel Ltd. will provide 2 grounds free of cost.

Drawing and Design : These have already been prepared and 50% of the cost has already been incurred.

Materials :

(i) Cement and sand are already in stock and are in regular use. If used for this contract, they have to be replaced at a cost of Rs.8 lacs.

(ii) Bricks and tiles represent purchases made several months before for a different contract, they have to be sold readily for a net Rs.5 lacs after meeting all further expensed.

(iii) Others: Material worthRs.2 lacs relating to interior decoration are in stock for which no alternative use is expected in the near future. However they can be sold for Rs.1 lac.

Labour :

(i) Skilled workers will be transferred to this project from another project. The Project Manager claimed that if the men were returned to him, he could have earned the company an additional Ps.2 lacs in terms of profits.

(ii) The supervisor undertakes various tasks in the sites and his pay and continuity of employment will not be affected by the new contract if the contract is taken, he will devote half of his time.

Overheads :

(i) The equipment that would be used on the contract was bought one year before for Rs.30 lacs and is expected to last for five years. It can also be used on other contracts and the current replacement price will be Rs.32 lacs and in a year's time it will be Rs.25 lacs.

(ii) The general overheads includes both specific and absorbed overheads. If the contract is not undertaken, Rs.4 lacks of the same can be avoided.

Ranka Builders has also on hand another project, which would not be executed if the contract from Excel Ltd. were to be accepted. The estimated profit on that project is Rs.10 lacs.

In the light of information given above, you are required to indicate with reasons whether the contract from Excel Ltd. should be accepted or not. (Nov 1999)

Answer

M/s Ranka Builder's

Statement of relevant costs on the

Acceptance of contract form Excel Ltd.

(Figure in laksh of Rs.)

S.No.	*Particulars*	*Basis for the cost to be relevant*	*Relevant cost if contract is accepted Rs.*	*Irrelevant cost if the contract is accepted Rs.*
1.	Land cost		20	
	(Refer to working note 1)			
2.	Drawings and design		-	7 (Sunk cost)
3.	Registration	Incremental	10	-
4.	Materials :			
	Cement and sand	Replacement	8	
	Bricks and Tiles	Opportunity	5	
	Steel	Incremental	10	
	Others		9	

	(Refer to working note 2)			
5.	Labour :			
	Skilled	Opportunity	2	
	Unskilled	Incremental	8	
	Supervisor's Salary			5 (Sunk Cost)
6.	Overheads :			
	General	Relevant (avoidable)	4	
	Depreciation		-	6 (Sunk Cost)
	Replacement cost of machine		7	
7.	Estimated profit foregone on other project	Opportunity foregone	10	
	Total		93	

Decision : Since the offer price of contract is Rs.1 crore and its total relevant cost is Rs.93 lacs; these figures clearly shows that the offer should be accepted.

Working notes :

1.

	Rs. (Lacs)
Total cost of 3 grounds of land	60
Cost of ground of land will be borne by Excel Ltd.	40
Cost of 1 ground of land will be borne by M/s Ranka Builders	20

2. Others material cost is Rs.10 lacs, it includes material worth Rs.2 lacs, relating to interior decoration, which is a sunk cost, this material can be sold for Rs.1 lac, (which is a relevant opportunity cost) and Rs.8 lacs, material is an incremental cost. Hence total relevant cost of others material is Rs.9 lacs. (Rs.8 lacs, incremental + Rs.1 lac, opportunity cost).
3. Since the equipment can also be used on ths contract. Its current replacement price is Rs.32 lacs, and after one year its cost will be Rs.25 lacs. Therefore the relevant opportunity cost of machine is : (Rs.32 lacs – Rs.25 lacs).

Question 18

(a) Explain the concept of discretionary costs. Give three examples.

(b) Discuss, how control may be exercised over discretionary costs. (Nov 1999)

Answer

(a) Discretionary costs can be explained with the help of following two important features

(i) They arise from periodic (usually yearly) decisions regarding the maximum outlay to be incurred.

(ii) They are not tied to a clear cause and effect relationship between inputs and outputs.

Examples of discretionary costs includes: advertising, public relations, executive training, teaching, research, health care and management consulting services.

The note worthy feature of discretionary costs is that mangers are seldom confident that the "correct" amounts are being spent.

(b) Control over discretionary costs : To control discretionary costs control points/parameters may be established. But these points need to be divised individually. For research and development function to control discretionary costs, dates may be established for submitting major reports to management. For advertising and sales promotion, such costs may be controlled by pre-setting targets. In the case of employees benefits, discretionary costs may be controlled by calling a meeting of employees union and making them aware that the company would meet only the fixed costs and the variable costs should be met by them.

Question 19

What are the applications of incremental cost techniques in making managerial decisions?

(May 2000)

Answer

Incremental cost technique: It is a technique used in the preparation of ad-hoc information in which only cost and income differences between alternative courses of action are taken into consideration. This technique is applicable to situations where fixed costs alter.

The essential pre-requisite for making managerial decisions by using incremental cost technique, is to compare the incremental costs with incremental revenues. So long as the incremental revenue is greater than incremental costs, the decision should be in favour of the proposal.

Applications of incremental cost techniques in making managerial decisions

The important areas in which incremental cost analysis could be used for managerial decision making are as under :

(i) Introduction of a new product

(ii) Discontinuing a product, suspending or closing down a segment of the business

(iii) Whether to process a product further or not

(iv) Acceptance of an additional order form a special customer at lower than existing price

(v) Opening of new sales territory and branch.

(vi) Optimizing investment plan out of multiple alternatives.

(vii) Make or buy decisions

(viii) Submitting tenders

(ix) Lease or buy decisions

(x) Equipment replacement decisions

Question 20

AB Ltd. manufactures product 'X'. the company operates single shift of 8 hours for 300 days in a year. The capital employed in the business is Rs.18 crores.

The manufacturing operations of the company comprise of four production departments. The company at present produces 9,000 units of product 'X' at maimum capacity. However, the capacity utilization of all the four departments are not equal and the present individual capacity utilizations are as under :

		Department
Capacity Utilisation %	*A*	*75*
	B	*100*
	C	*70*
	D	*50*

The present return on capital of the company has gone down to 10% from the earlier cut-off rate of 15% due to increased cost of production.

As the company cannot operate more than one shift, the management is considering two alternative proposals to increase the return on capital employed.

Alternative I

To hire out the surplus capacity of departments A, C and D. The cost and revenue projections are as under:

Department	*Hire Charges per Hour*	*Incremental Cost per Hour*
A	*2,500*	*2,000*
C	*1,800*	*1,500*
D	*1,600*	*1,200*

Alternative II

To increase the installed capacity of the factory to 12,000 units by adding plant and machinery in department B at a capita cost of Rs.4 crore. Any Balance surplus capacity in other departments after meeting the increased volume to be hired out as per alternative I. The additional units would fetch incremental revenue of Rs.1,600 per unit.

You are required to evaluate the two proposals and suggest to the management, which of the two proposals is to be accepted. *(May 2000)*

Answer

Working notes:

1. Statement of total available, utilized and surplus capacity hours when 9,000 units of product 'X' are produced.

Departments	*Available Capacity hours*	*Capacity utilized*		*Surplus Capacity hours*
		(in %	*(in hours)*	
(1)	(2)	(3)	(4) = (2)×(3)	(5)=(2)-(4)
A	2,400 (300 days × 8 hours)	75	1,800	600
B	2,400	100	2,400	NIL
C	2,400	70	1,680	720
D	2,400	50	1,200	1,200

2. Statement of total available, utilized and surplus capacity hours when 12,000 units of product 'X' are produced.

Production Department	*Available capacity hours*	*Capacity utilization on 9,000 units Hours*		*Balance capacity hours*	*Unit per hour*	*Hours required for 3,000 additional units*	*Surplus capacity hours*
(1)	(2)	(3)	(4)=(2)×(3)	(5)	(6)	(7)	(8)=(5)-(7)
A	2,400	75	1,800	600	5 $\left(\frac{9{,}000\text{ units}}{1{,}800\text{ hrs.}}\right)$	600	Nil
B	2,400	100	2,400	Nil	3.75	800	Nil

					$\left(\frac{9{,}000 \text{ units}}{2{,}400 \text{ hrs.}}\right)$		
C	2,400	70	1,680	720	5.36	560	160
					$\left(\frac{9{,}000 \text{ units}}{1{,}680 \text{ hrs.}}\right)$		
D	2,400	50	1,200	1,200	7.5	400	800
					$\left(\frac{9{,}000 \text{ units}}{1{,}200 \text{ hrs.}}\right)$		

Alternative I

Statement of net Revenue (Under Alternative I)

Production	*Surplus capacity hours (Refer to W.N.-1*	*Hire charges per hour*	*Total revenue in (Rs. Lacs)*	*Incremental costs per hour Rs.*	*Total cost in (Rs. Lacs)*	*Net revenue in (Rs.)*
	(a)	(b)	(c)=(a)×(b)	(d)	(e)=(a)×(d)	(f)=(c)-(e)
A	600	2,500	15.00	2,000	12.00	3.00
B	720	1,800	12.96	1,500	10.80	2.16
D	1,200	1,600	19.20	1,200	14.40	4.90
Total			47.16		37.20	9.96
Add: present income (10% of Rs.1,800 lacs)						180.00
Total return						189.96

Return on investment

$$= \frac{\text{Total return}}{\text{Total investment}} \times 100 = \frac{189.96}{1{,}800} \times 100 = 10.553\%$$

Alternative II

Statement of Net Revenue when 12,000 units of product 'X' are produced and surplus plant capacity (hours) in departments C and D hired out.

Production	*Surplus capacity hours (Refer to W.N.-2)*	*Hire charges per hour*	*Total revenue in (Rs.Lacs)*	*Incremental costs per hour Rs.*	*Total cost in (Rs. Lacs)*	*Net revenue in (Rs. Lacs)*
	(1)	(2)	(3)=(1)×(2)	(4)	(5)=(1)×(4)	(6)=(3)-(5)
C	160	1,800	2.88	1,500	2.40	0.48
D	800	1,600	12.80	1,200	9.60	3.20
Total			15.68		12.00	3.68
Add: Revenue (in lacs) earned on 3,000 additional units sale (3,000 units is × Rs.1,600)						48.00
Add: Present income on investment (10% × Rs.1,800 lacs)						180.00
Total Return (in lacs)						231.69

Return on investment = $\frac{231.68 \text{ lacs}}{2{,}200 \text{ lacs}} \times 100 = 10.53\%$

Evaluation of two alternative proposals :

Since the return on investment under alternative I is more than that under alternative II; therefore it should be accepted.

Question 21

B Ltd. is a company that has, in stock, materials of type XY that cost Rs.75,000, but that are now obsolete and have a scrap value of only Rs.21,000. Other than selling the material for scrap, there are only two alternative uses for them.

Alternative 1 – Converting the obsolete materials into a specialized product, which would require the following additional work and materials:

Material A	*600 units*
Material B	*1,000 units*
Direct Labour	
5,000 hours unskilled	
5,000 hours semi skilled	
5,000 hours highly skilled	
Extra selling and delivery expenses	*Rs.27,000*
Extra advertising	*Rs.18,000*

The conversion would produce 900 units of saleable product and these could be sold for Rs.300 per unit.

Material A is already in stock and is widely used within the firm. Although present stocks together with orders already planned, will be sufficient to facilitate normal activity and extra material used by adopting this alternative will necessitate such materials being replaced immediately. Material B is also in stock, stock, but is unlikely that any additional supplies can be obtained for some considerable time, because of an industrial dispute. At the present time material B is normally used in the production of product Z, which sells at Rs.390 per unit and incurs total variable cost (excluding Material B) of Rs.210 per unit. Each unit of product Z uses four units of Material B. The details of Materials A and B are as follows:

	Material A	*Material B*
	(Rs.)	*(Rs.)*
Acquisition cost at the time of purchase	*100 per unit*	*Rs.10 per unit*
Net realizable value	*85 per unit*	*Rs.18 per unit*
Replacement cost	*90 per unit*	*-*

Alternative 2 – Adopting the obsolete materials for use as a substitute for a sub-assembly that is regularly used within the firm. Details of the extra work and materials required are as follows:

Material C	*1,000 units*
Direct Labour :	
4,000 hours unskilled	
1,000 hours semi-skilled	
4,000 hours highly skilled	

1,200 units of the sub-assembly are regularly used per quarter at a cost of Rs.900 per unit. The adaptation of material XY would reduce the quantity of the sub-assembly purchased from outside the firm to 900 units for the *next quarter only. However, since the volume purchased would be reduced, some discount would be lost and the price of those purchased from outside would increase to Rs.1,050 per unit for that quarter.*

Material C is not available externally thought 1,000 units required would be available from stocks, it would be produced as extra production. The standard cost per unit of Material C would be as follows:

	Rs.
Direct labour, 6 hour unskilled labour	*18*
Raw materials	*13*
Variable overhead: 6 hours at Re.1	*06*
Fixed overhead : 6 hours at Rs.3	*18*
	55

The wage rate and overhead recover rates for B Ltd. are:

Variable overhead	*Re.1 per direct labour hour*
Fixed overhead	*Re.2 per direct labour hour*
Unskilled labour	*Re.3 per direct labour hour*
Semi-skilled labour	*Re.4 per direct labour hour*
Highly skilled labour	*Re.5 per direct labour hour*

The unskilled labour is employed on a casual basis and sufficient labour can be acquired to exactly meet the production requirements. Semi-skilled labour is part of the permanent labour force, but the company has temporary excess supply of this type of labour at the present time. Highly skilled labour is in short supply and cannot be increased significantly in the short-term, this labour is presently engaged in meeting the, demand for product L, which requires 4 hours of highly skilled labour. The contribution from the sale of one unit of product L is Rs.24.

Given the above information, you are required to present cost information advising whether the stocks of Material XY should be sold, converted into a specialized product (Alternative 1)) or adopted for use as a substitute for a sub-assembly (Alternative 2). *(Nov. 2000)*

Answer

Alternative 1 – (Conversion versus immediate sale)

	Rs.	*Rs.*	*Rs.*
Sales revenue 900 units at Rs.300 per unit (Refer to working note 1)			2,70,000
Less: Relevant costs			
Material XY opportunity cost (Refer to working note 2)		21,000	
Material A – units @ Rs.90 per unit (Refer to working note 3		54,000	
Material B – 1,000 units @ Rs.45 per unit (Refer to working note 4)		45,000	
Direct Labour :			
Unskilled – 5,000 hours @ Rs.3 per hour	15,000		
Semi-skilled	Nil		
Highly skilled – 5,000 hours @ Rs.11 (Refer to working note 5)	55,000	70,000	

Variable overheads 15,000 hours @ Re.1 (Refer to working note 6)		15,000	
Extra selling and delivery expenses	27,000		
Extra advertising	18,000	45,000	2,50,000
Fixed advertising		Nil	
(To remain same, not relevant)			______.
Excess of relevant revenues			20,000
Alternative 2 – (Adaptation versus Immediate Sale)			
Saving on purchase of sub-assembly			
Normal spending – 1,200 units @ Rs.900 per unit		10,80,000	
Less: Revised spending – 900 units @ Rs.1,050 per unit (Refer to working note 7)		9,45,000	1,35,000
Less: Relevant costs:			
Material XY opportunity cost (Refer to working note 2)		21,000	
Material C – 1,000 units @ Rs.37 (Refer to working note 8)		37,000	
Direct labour			
Unskilled – 4,000 hours @ Rs.3 per hour	12,000		
Semi-skilled	Nil		
Highly skilled – 4,000 hours @Rs.11 per hour (Refer to working note 5, 6)	44,000	56,000	
Variable Overheads – 9,000 hours @ Re.1/- per hour (Refer to working note 6)		9,000	1,23,000
Fixed overheads	Nil		______.
Net relevant savings			12,000

Evaluation :

The evaluation of two alternatives clearly shows that Alternative 1, yields higher net revenue of Rs.8,000 (Rs.20,000 – Rs.12,000). Hence because of higher net revenue of Alternative 1, it is advisable to convert material XY into a specialized product.

Working notes :

1. There will be a additional sales revenue of Rs.2,70,000 if Alternative 1 is chosen.
2. Acceptance of either Alternative 1 or 2 will mean a loss of revenue of Rs.21,000 from the sale of the obsolete material XY and hence it is an opportunity cost for both of the alternatives. The original purchase cost of Rs.75,000 is a sunk cost and thus not relevant.
3. Acceptance of Alternative 1 will mean that material A must be replaced at an additional cost of Rs.54,000.
4. Acceptance of Alternative 1 will mean diversion of material B from the production of product Z. The excess of relevant revenues over relevant cost for product Z is Rs.180 (Rs.390 – Rs.210) and each unit of product Z uses four units of material B. The lost contribution (excluding the cost of material B which is incurred for both alternatives) will therefore be Rs.45 for each unit of material B that is used for converting the obsolete materials into a specialised product.
5. Unskilled labour can be matched exactly to the company's production requirements. Hence acceptance of either alternative 1 or 2 will cause the company to incur additional unskilled labour cost at Rs.3 for each hours. It is assumed that the semi-skilled labour will be able to meet the extra requirements of either

alternatives at no extra cost to the company. Hence, cost of semi-skilled labour will not be relevant. Skilled labour is in short supply and can only be obtained by reducing the production of product L, resulting in a loss of contribution of Rs.24 (given) or Rs.6 per hour of skilled labour. Hence the relevant labour cost will be Rs.6 (contribution lost per hour) + Rs.5 (hourly rate of skilled labour) i.e. Rs.11 per hour.

6. It is assumed that for each direct labour of input, variable overhead will increase by Re.1 hence for each alternative using additional direct labour hours, variable overheads will increase.
7. The cost of purchasing the sub-assembly will be reduced by Rs.1,35,000 if the second alternative is chosen and so these savings are relevant to the decision.
8. The company will incur additional variable costs, of Rs.37 for each unit of material C that is manufactured, so the fixed overheads for material C viz. Rs.18/- per unit is not a relevant cost.

Question 22

(a) Comment on the use of opportunity cost for the purpose of :

(i) decision-making and

(ii) cost control (May 2001)

(b) State three applications of direct costing. (May 2001)

(c) A company had nearly completed a job relating to construction of a specialised equipment, when it discovered that the customer had gone out of business. At this stage, the position if the job was as under:

	Rs.
Original cost estimate	*1,75,200*
Costs incurred so far	*1,48,500*
Costs to be incurred	*29,700*
Progress payment received from original customer	*1,00,000*

After searches, a new customer for the equipment has been found. He is interested to take the equipment, if certain modifications are carried out. The new customer wanted the equipment in its original condition, but without its control device and with certain other modifications. The costs of these additions and modifications are estimated as under:

Direct materials (at cost)		*Rs.1,050*
Direct Wages Dept. :	*A*	*15 man days*
Dept. :	*B*	*25 man days*
Variable overheads		*25% of direct wages in each dept.*
Delivery costs		*Rs.1,350*

Fixed overheads will be absorbed at 50% of direct wages in each department.

The following additional information is available :

(1) The direct materials required for the modification are in stock and if not used for modification of this order, they will be used in another job in place of materials that will now cost Rs.2,250.

(2) Department A is working normally and hence any engagement of labour will have to be paid at the direct wage rate of Rs.120 per man day.

(3) Department B is extremely busy. Its direct wages rate is Rs.100 per man day and it is currently yielding a contribution of Rs.3.20 per rupee of direct wages.

(4) Supervisory overtime payable for the modification is Rs.1,050.

(5) The cost of the control device that the new customer does not require is Rs.13,500. If it is taken out, it can be used in another job in place of a different mechanism. The latter mechanism has otherwise to be

bought for Rs.10,500. The dismantling and removal of the control mechanism will take one man day in department A.

(6) If the convention is not carried out, some of the materials in the original equipment can be used in another contract in place of materials that would have cost Rs.12,000. It would have taken 2 man days of work in department A to make them suitable for this purpose. The remaining materials will realize Rs.11,400 as scrap. The drawings, which are included as part for the job can he sold for Rs.1,500.

You are required to calculate the minimum price, which the company can afford to quote for the new customer as staled above. *(May 2001)*

Answer

(a) (i) Decision making: Opportunity costs apply to the use of scarce resources, where resources are not secure, there is no sacrifice from the use of these resources.

Where a course of action requires the use of scarce resources, it is necessary to incorporate the lost profit which will be foregone from using scarce resources.

If resources have no alternative use only the additional cash flow resulting from the course of action should be included in decision making as relevant cost.

(ii) Cost control: The conventional variance analysis will report an adverse usage variance and adverse sales volume variance. However, the failure to achieve the budgeted optimum level of output may be due to inefficient usage of scarce resources. The foregone contribution should therefore be charged to the manger responsible for controlling the usage of scarce resources and not to the sales manager because the failure to achieve the budgeted sales is due to the failure to use scarce resources efficiently.

Thus if resources are scarce, the usage variance should reflect the acquisition cost plus budgeted contribution per unit of the scarce resources.

If the lost sales is made good in subsequent periods, the real opportunity cost will consists of lost interest arising from delay in receiving the net cash-flows and not the foregone contribution.

(b) Three applications of direct costing are as follows:

(i) Stock valuation

(ii) Minimum quantity to be produced to recover pattern or mould cost,

(iii) Close down decisions – like closing down of a department or shop.

Statement of minimum price which the company can afford to quote for the new customer (based on relevant cost)

	Rs.
Cost to be incurred to bring the equipment in its original condition.	29,700
Opportunity cost of the direct material	2,250
Direct wages:	
Dept. A : 15 man days × Rs.120	1,800
Dept. B : 25 man days × Rs.100	2,500
Opportunity cost of contribution lost by department B (Rs.2,500 × Rs.2.30)	8,000
Variable overheads	1,075
25% × (Rs.1,800 + Rs.2,500)	
Delivery costs	1,350
Supervisory overtime payable for modification	1,050

Control device to be used in another job (Refer to working note 1)	(10,350)
Net loss on material cost savings, in the original equipment (Refer to working note)	11,700
Opportunity cost of remaining materials which can be sold as scrap	11,400
Opportunity cost of sale drawings	1,500
Total minimum price which may be quoted	61,975

Working notes:

1. Cost of control device to be used in another job:

	Rs.
Cost of control device	10,500
Less: Dismantling & removal cost of control mechanism (1 man day × Rs.120)	120
Less: Variable cost)25% × Rs.120)	30
Balance cost of control device	10,350

2. Net loss on material cost saving of equipment:

Loss on material cost saving of equipment	12,000
Less: Conversion cost	
(2 man days × Rs.120)	240
Less: Variable overheads (25% × Rs.240)	60
Net loss on material cost saving of equipment	11,700

Question 23

Explain with one example each that sun cost is irrelevant in making decisions, but irrelevant costs are not sunk costs. *(May 2001)*

Answer

Sunk cost is a historical cost incurred in the past. In other words it is a cost of a resource already acquired. Future decisions in respect of this resource will not be affected by it. For example, book value of machinery. Hence sunk costs are irrelevant in decision making.

Irrelevant costs are not necessary sunk costs. For example, when a comparison of two alternative production methods using the same material quantity is made, then direct material cost is not affected by the decision but this material cost is not sunk cost.

Question 24

A company operates its plant on single shift basis. It can produce upto 8,000 units of output per month without overtime. The fixed costs on single shift basis of operation amount to Rs.30,000 per month. The average variable cost per unit is Rs.10.

The output can be increased upto 15,000 units per month by working overtime. This entails no increase infixed costs, but the variable costs per unit during overtime will be Rs.12 inc excess of 8,000 units upto the capacity of 75,000 units.

If a second shift is worked, the maximum capacity of the second shift is 8,000 units per month. The variable cost on second shift operation is Rs.10.50 per unit and the incremental fixed cost involved in the second shift is Rs.6,000 per month.

Required

(i) If the company's demand for the product is 10,000 units, should the company work overtime or second shift?

(ii) At what level of output will the company consider working second shift instead of working overtime? State the range of output for overtime working and second shift operation.

(iii) During a particular month, the company predicted its demand to be 14,000 units and worked second shift. At the end of the month it was discovered that the company's demand was only 11,000 units and the company accordingly produced only 11,000 units. Calculate the cost of prediction error.
(May 2001)

Answer

(i) Comparative Statement of Cost

(When demand for the product is 10,000 units)

	Working overtime for producing 2,000 units	*Working second shift for producing 2,000 units*
Variable cost	24,000	21,000
Fixed cost	Nil	6,000
Total cost	24,000	27,000

* 8000 units in fact are produced in the single shift.

Decision: The above comparative statement of cost clearly shows that resorting to overtime for producing additional 2,000 units and 8,000 units in the single shift will be beneficial to the exend of Rs.3,000 (Rs.27,000 – Rs.24,000).

(ii) Range of output for overtime working and second shift operation:

Let x be the number of units at which their total cost under overtime working and second shift operation equalizes, i.e.

x units × Rs.12 + Rs.30,000 = x units × Rs.10.50 + Rs.36,000

On solving the above relation we get x = 4,000 units.

Range	Method to be adopted
Above 8,000 units but less than 12,000 units	Overtime working
At 12,000 units	Any one method may be adopted
12,001 to 16,000 units	Second shift working

(iii) Computation of Prediction error:

Cost Statement of producing 11,000 units

	Options	
	Working overtime for producing 3,000 additional units	*Working second shift for producing 3,000 additional units*
	Rs.	*Rs.*
Cost of producing 8,000 units in first shift (8,000 units × Rs.10 + Rs.30,000)	1,10,000	1,10,000
Addition cost of producing 3,000 units	36,000	37,500
	(3,000 units × Rs.12)	(3,000 units × Rs.10.50 + Rs.6,000)
Total cost	1,46,000	1,47,500

Prediction error: A comparison of total cost o producing 11,000 units under overtime working and second shift working clearly shows a difference of Rs.1,500 (Rs.1,47,500 – Rs.1,46,000) The difference of Rs.1,500 is due to prediction error.

Question 25

The following are cost data for three alternative ways of processing the clerical work for cases brought before the LC Court System:

	A Manual (Rs.)	B Semi Automatic (Rs.)	C Fully Automatic (Rs.)
Monthly fixed costs			
Occupancy	*15,000*	*15,000*	*15,000*
Maintenance contract	*0*	*3,000*	*10,000*
Equipment lease	*0*	*25.000*	*1,00,000*
	15,000	*45,000*	*1,25,000*
Unit variable costs (per report):			
Supplies	*40*	*80*	*20*
Labour	*5 hrs × 40*	*1 hr × 60*	*0.25 hr × 80*
	or 200	*or 60*	*or 20*
	240	*140*	*40*

Required:

(i) Calculate cost indifference points. Interpret your results.

(ii) If the present case load is 600 cases and it is expected to go up to 850 cases in near future, which method is most appropriate on cost considerations? *(May 2002)*

Answer

(i) Statement of cost indifference points between ways of processing the clerical work for cases.

	A and B (Rs.)	A and C (Rs.)	B and C (Rs.)
Differential fixed costs: (I)	30,000 (Rs.45,000 – Rs.15,000)	1,10,000 (Rs.1,25,000 – Rs.15,000)	80,000 (Rs.1,25,000 – Rs.45,000)
Differential variable costs per case : (II)	100 (Rs.240 – Rs.140)	200 (Rs.240 – Rs.40)	100 (Rs.140 – Rs.40)
Cost indifference point (I/II) (Differential fixed costs / Differential variable costs per case)	300 Cases	550 Cases	800 Cases

Interpretation of results:

At activity level below the indifference points, the alternative with lower fixed costs and higher variable costs should be used. At activity level above the indifference point alternative with higher fixed costs and lower variable costs should be used.

Thus, it expected number of cases is below 300, alternative A should be used. If expected number of cases are between 301 and 800 use alternative B. If expected number of cases is above 800, use alternative C.

(ii) Present case load is 600. Therefore, alternative B is suitable. As the number of cases is expected to go upto 850 cases, alternative C is most appropriate.

Question 26

Determine the selling price per unit to earn a return of 12% net on capital employed (net of Tax @ 40%).

The cost of production and sales of 80,000 units per annum are:

Material	*Rs. 4,80,000*	*Labour*	*Rs. 1,60,000*
Variable overhead	*Rs. 3,20,000*	*Fixed overhead*	*Rs. 5,00,000*

The fixed portion of capital employed is Rs. 12 lacs and the varying portion is 50% of sales turnover.

Answer

Return of 12% net (after tax of 40%) on capital employed is equivalent to 12% ÷ (1 – 0.4) = 20% (gross) on capital employed.

Let selling price per unit to be ‘x’

Since Total sales = Total cost + profit

i.e. $80,000\ x = 14,60,000 + 20\%\ (12,00,000 + 0.5 \times 80,000x)$

or, $80,000\ x = 14,60,00 + 2,40,000 + 8,000x$

or, $72,000\ x = 17,00,000$

or, $‘x’ = \frac{17,00,000}{72,000} = \text{Rs. } 23.61$

Hence selling price per unit will be Rs. 23.61

Question 27

A businessman employees 20 swing machinists, but he is aware that ten are the better workers than others. He is considering to conduct a training programme for his ten less efficient mechanists to increase their efficiency to be equal to that achieved by “better” workers. Relevant data are as follows;

- *There is one sewing machine for each machinist.*
- *All the machinists are engaged on similar work and are paid Rs2.20 each good garment produced on piece work system.*
- *To rectify each rejected garment costs Rs4, this work is done by subcontractor.*
- *Garment machining department operates 2,000 hours a year.*
- *Average output of per machinist (on the basis of all 20 machinists) is 12 good garments with one rejected per worker per hour. However 10 less efficient machinists’ averages only 10 good garments with 1.5 rejected per worker per hour.*
- *Depreciation of each sewing machine is Rs10, 000 per year and the variable cost of power, cleaning and preventive maintenance is Rs5 per hour per machine.*
- *Fixed production overhead other than depreciation is Rs20 per machine hour.*
- *Selling price per garment is Rs18.*
- *Direct material cost per garment is Rs12.*
- *Training will not reduce productive hours.*
- *There is no problem in selling increased output.*

You are required

(a) To prepare a statement of comparative costs for the “better” worker and the “less efficient” workers excluding material costs.

(b) *To find out the benefit derived over a one year period, if Rs1,00,000 is spent on a training course for the "less efficient" workers to match the efficiency with the "better" workers.*

Answer

(a) Average output of all 20 machinist is 12 good units and 1 rejected piece while average output of 10 "less efficient' workers is 10 good units and 1.5 rejected pieces. Hence average output of 10 "better worker" is 14 good units and 0.5 rejected piece.

Statement showing annual comparative cost for the "better machinist" and the "less efficient' machinist excluding direct material cost.

		Better Worker		Less Efficient worker
Good Units				
(14×2000×100 efficient workers)		2,80,000		
(10×2000×10 less efficient worker)				2,00,000
Rejects after correction				
(2000 hrs ×0.5×10)		10,000		
(2000 hrs ×1.5×10)				30,000
		Rs		Rs
Labour cost				
(280000×2.20)		616000		
(200000×2.20)				440000
Rectification Cost				
(10000×4)		40000		
(30000×4)				120000
Variable production cost				
(2000×5×10)		100000		100000
		756000		660000
(b) Sales				
(290000×18)		5220000		
(230000×18)				4140000
Direct material				
(290000×12)	3480000			
(230000×12)			2760000	
Variable Cost as per (a)	756000	4236000	660000	3420000
Contribution		984000		720000
After training increase in contribution			264000	
(984000 – 720000)				
Cost of training			100000	

Benefit from training	164000

Question 28

"Sunk cost is irrelevant in decision-making, but irrelevant costs are not sunk costs". Explain with example.

Answer

Sunk costs are costs that have been created by a decision made in the past and that cannot be changed by any decision that will be made in the future. For example, the written down value of assets previously purchased are sunk costs. Sunk costs are not relevant for decision making because they are past costs.

But not all irrelevant costs are sunk costs. For example, a comparison of two alternative production methods may result in identical direct material costs for both the alternatives. In this case, the direct material cost will remain the same whichever alternative is chosen. In this situation, though direct material cost is the future cost to be incurred in accordance with the production, it is irrelevant, but, it is not a sunk cost.

Question 29

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

Answer

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

1. *Direct cost*: As many total costs relating to cost objects as feasible are classified into direct cost. The objective is to trace as many costs as possible in to direct and to reduce the amount of costs classified into indirect because the greater the proportion of direct costs the greater the accuracy of the cost system.
2. *Indirect cost pools*: Increase the number of indirect cost pools so that each of these pools is more homogeneous. In a homogeneous cost pool, all the costs will have the same cause-and-effect relationship with the cost allocation base.
3. Use cost-and-effect criterion for identifying the cost allocation base for each indirect cost pool.

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

2

MARGINAL COSTING

Question 1

AB Ltd. Manufacture foam, carpets and upholstery in its there divisions. Its operating statement for 1995-96 showing the performance of these divisions drawn for the use of management is reproduced below:

(Rupees in '000)

	Manufacturing Divisions			*Total*
	Foam	*Carpets*	*Upholstery*	
Sales revenue	*1,600 (A)*	*1,200*	*1,200*	*4,000*
Manufacturing Costs Variable	*1,200*	*700*	*680*	*2,580*
Fixed (Traceable)	*-*	*100*	*20*	*120*
	1,200	*800*	*700*	*2,700*
Gross Profit	*400*	*400*	*500*	*1,300*
Expenses: Administration	*134*	*116*	*172*	*422*
Selling	*202*	*210*	*232*	*644*
	336	*326*	*404*	*(B) 1,066*
Net Income	*64*	*74*	*96*	*234*
Division's Ranking	*3rd*	*2nd*	*1st*	*-*

(A) Sales include foam transferred to the Upholstery division at its manufacturing cost Rs.2,00,000.

(B) Common expenses of Rs.1,30,000 and Rs.1,00,000 on account of administration and selling respectively stand apportioned to these divisions at 10% of Gross Profit in case of administration and 2.5 % of Sales in case of selling expense. Rest of Rs.8,36,000 of the expense are traceable to respective divisions.

The manager of the foam division is not satisfied with the above approach of presenting operating performance. In his opinion his division is best among all the divisions. He requests the management for preparation of revised operating statement using contribution approach and showing internal transfer at market price.

You are required to:

(a) Draw the revised operating Statement using contribution approach and pricing the internal transfer at market price.

(b) Compute relevant rations to show comparative profitability of these division and rank them in the light of your answer at (a) above. Further, other your comments on the contention of the manager of foam division.

(c) State why the contribution approach and pricing of internal transfer at market price are more appropriate in realistic assessment of the performance of various divisions. *(May 1996)*

Answer

(a) Revised Operating Statement using Contribution approach

(Rs.'000)

Divisions	*Foam*	*Carpets*	*Upholstery*	*Total*

Sales revenue (Refer to working note 1)	1,680	1,200	1,200	4,080
Less: Variable manufacturing costs (Refer to working note 2)	1,200	700	760	2,660
Contribution: (A)	480	500	440	1,420
Fixed manufacturing costs	-	100	20	120
Administration expenses (Refer to working note 3)	94	76	122	292
Selling expenses (Refer to working note 4)	162	180	202	544
Total: (B)	256	356	344	956
Net Contribution expenses (Rs.130 + Rs.100)				
Net Income of the company				234

Working Notes:

1. Computation of sale revenue of Foam division

	(Rs.'000)
Sales of foam division to outside customers	1,400
(Rs.1,600 – Rs.200)	
Less: Variable manufacturing costs	1,000
(Rs.1200 – Rs.200)	
Mark-up on outside sale	400
Percentage of mark-up 40 %	
(Rs.400 / Rs.1,000) x 100	
Transfer price of foam to upholstery division	280
Sales of foam division to outside customers	1,400
Total	1,680

2. Computation of variable manufacturing costs of Upholstery Division in (Rs.'000)

   (Rs.680 – Rs.200 + Rs.280) = Rs.760

3. Computation of Traceable Administration Expenses

Divisions	*Foam*	*Carpets*	*Upholstery*	*Total*
Given Selling expenses	202	210	232	644
Less: Common expenses (10% of Gross Profit)	40	30	30	100
Traceable selling expenses	162	180	202	544
Fixed manufacturing costs	-	100	20	120
Administration expenses (Refer to working note 3)	94	76	122	292
Selling expenses (Refer to working note 4)	162	180	202	544
Total: (B)	256	356	344	956
Net Contribution expenses (Rs.130 + Rs.100)				
Net Income of the company				234

4. Computation of Traceable Selling Expenses

				(Rs.'000)
Divisions	*Foam*	*Carpets*	*Upholstery*	*Total*
Given Selling expenses	202	210	232	644
Less: Common expenses (10% of Gross Profit)	40	30	30	100
Traceable Selling expenses	162	180	202	544

(b) Comparative Profitability & Rank

(based on contribution approach relevant ratios calculated by using figures of (a) part)

			(Rs.'000)
Divisions	*Foam*	*Carpets*	*Upholstery*
Contribution	28.57	41.67	36.67
Margin ratio	(Rs.480/1680) × 100	(Rs.500/1200) × 100	(Rs.440/1200) × 100
(in %)			
Ranking	III	I	II
Net Contribution	13.33	12	8
Ratio (in %)	(Rs.244/1680) × 100	(Rs.144/1200) × 100	(Rs.440/1220) × 100
Or			
(Operating income ratio)			
Ranking	I	II	III

Comment: The Manager of Foam Division appears to be correct in raising objection to the approach used for presenting operating performance of three divisions for the year 1995-96. His division is the best among all, on the basis of (Net Contribution/Sales) ratio which is the highest in spite of its contribution margin ratio to be the lowest.

(c) The use of contribution approach for reporting is more realistic for assessing the performance of various divisions as it considers variable and traceable costs only and avoids common costs while finding out profitability. This approach enables the management to rightly interpret the information. Further pricing of internal transfers at market price will give due credit to specific profit center i.e. transferor.

Question 2

K. Ltd. Manufactures and sells a range of sport goods. Management is considering a proposal for an advertising campaign, which would cost the company Rs.3,00,000. The marketing department has put forward the following two alternative sales budgets for the following year.

		Product ('000)		
	A	*B*	*C*	*D*
Budget 1 – Without Advertising	*216*	*336*	*312*	*180*
Budget – 2 With Advertising	*240*	*372*	*342*	*198*

Selling prices and variable production costs are budgeted as follow:

		Product (Rs. Per unit)		
	A	*B*	*C*	*D*

Selling prices	*11.94*	*14.34*	*27.54*	*23.94*
Variable Production Costs:				
Direct Material	*5.04*	*6.60*	*15.24*	*12.48*
Direct Labour	*2.04*	*2.04*	*3.36*	*3.18*
Variable overheads	*0.72*	*0.72*	*1.20*	*1.08*

Other Data:

(1) The variable overheads are absorbed on a machine hour basis at a rate of Rs.1.20 per machine hour.

(2) Fixed overheads total Rs.30,84,000 per annum.

(3) Production capacity during the budget period 8,15,000 machine hours.

(4) Products A and C could be bought in at Rs.10.68 per unit and Rs.24 per unit respectively.

Required:

(i) Determine whether investment in the advertising campaign would be worthwhile and how production facilities would be best utilised.

(ii) Explain the assumptions and reasoning behind your advise. *(May 1996)*

Answer

Statement of product ranking and machine hours required under

Budget – 1 and Budget – 2

	Products				
	A	*B*	*C*	*D*	*Total*
Selling Price p.u. (Rs.)	11.94	14.34	27.54	23.94	
Less: Variable cost p.u. (Rs.)	7.80	9.36	19.80	16.74	
Contribution p.u. (Rs.)	4.14	4.98	7.74	7.20	
Time in machine (Hrs.)	0.6	0.6	1	0.9	
	$\left(\frac{\text{Rs.}0.72}{1.20}\right)$	$\left(\frac{\text{Rs.}0.72}{1.20}\right)$	$\left(\frac{\text{Rs.}1.20}{1.20}\right)$	$\left(\frac{\text{Rs.}1.08}{1.20}\right)$	
Contribution per machine hour (Rs.)	6.9	3.3	7.79	8	
Ranking	IV	I	III	II	
Budget-1 (Mc. Hrs.) (Without Advt.)	1,29,600	2,01,600	3,12,000	1,62,000	8,05,200
Budget-2 (Mc. Hrs.) (With Advt.)	1,44,000	2,23,200	3,42,000	1,78,200	8,87,400

Available budget hours viz. 8,15,000 hours are sufficient for Budget-1. However there is a shortfall of 72,400 hours (8,87,400 – 8,15,000) to meet Budget-2, targets. These additional machine hours requirement may be met by way of purchasing either additional units of product A or C, so that the extra cost of buying machine hours is minimum.

Products	*A*	*C*
Additional buying in cost p.u. (Rs.)	2.88	4.20
	(Rs.10.68 – Rs.7.80)	(Rs.24 – Rs.19.80)
Additional buying cost p.u. per machine hour (Rs.)	4.80	4.20
	(Rs.2.88/0.6 hrs.)	(Rs.4.20/1 hr.)

Since additional buying cost per machine hour is minimum in the case of production C, therefore it is advisable to purchase 72,400 units of product C and thus meet fully the gap in the machine hours requirement i.e. 72,400. The extra cost of buying 72,400 machine hours would come to Rs.3,04,080 (72,400 hours × Rs.4.20).

(i) Evaluation of investment in Advertisement campaign

	Products				
	A	*B*	*C*	*D*	*Total*
Additional sales volume ('000 units) : A	24	36	30	18	
Unit Contribution (Rs.) : B	4.14	4.98	7.74	7.20	
Additional Contribution (Rs.'000) : (B×A)	99.36	179.28	232.20	129.60	640.44
Less: Extra machine buying cost (Rs.'000)	-	-	-	-	304.08
Less: Cost of advertisement (Rs.'000)					300.00
Additional Profit					36.36

The generation of additional profit clearly shows that the investment in advertisement campaign is worthwhile.

Statement of production facilities utilisation

Product	*Machine hours utilised*
A	1,44,000
B	2,23,200
C	2,69,600
D	1,78,000
Total	8,15,000

(ii) Assumptions:

1. Fixed costs (other than advertising) will remain unchanged.
2. Variable cost has linear relationship with the volume of production
3. Prices and efficiency will remain unchanged at all levels of output.
4. Sales estimates are sound.

Reasoning:

The reasoning behind the above advice is based on the fact that the additional revenue exceeds the additional relevant costs and the costs are minimised by buying in product C.

Question 3

You have been approached by a friend who is seeking your advice as to whether he should give up his job as an engineer, with a current salary of Rs.14,800 per month and go into business on his own, assembling and selling a component which he has invented. He can procure the parts required to manufacture the component from a supplier.

It is very difficult to forecast the sales potential of the component, but after some research, your friend has estimated the sales as follows:

(i) Between 600 to 900 components per month at a selling price of Rs.250 per component

(ii) Between 901 to 1,250 components per month at a selling price of Rs.220 component for the entire lot.

The cost of the parts required would be Rs.140 for each completed component. However if more than 1,000 components are produced in each month, a discount of 5% would be received from the supplier of parts on all purchases.

Assembly costs would be Rs.60,000 per month upto 750 components. Beyond this level of activity assembly costs would increase to Rs.70,000 per month.

Your friend has already spent Rs.30,000 on development, which he would write-off over the first five years of the venture.

Required:

(i) Calculate for each of the possible sales levels at which your friend could expect to benefit by going into the venture on his own.

(ii) Calculate the break-even point of the venture for each of the selling price.

(iii) Advise your friend as to the viability of the venture. *(Nov 1996)*

Answer

(i) & (ii)

Note:

(a) The salary of Rs.14,800 per month is a benefit foregone by going into business. It should therefore be considered as a minimum profit which must be earned p.m. from the new venture in order to be not worse-off than before.

(b) Sum of Rs.30,000 spend on the development work of the new venture cannot be recovered irrespective of the decision and thus it should be ignored.

At a selling price of Rs.250:

Contribution per unit = Rs.110 (Rs.220 – Rs.140)

Minimum sales unit to recover assembly costs of $= \dfrac{\text{Fixed cost} + \text{Profit}}{\text{Contribution per unit}}$

Rs.60,000 p.m. and earn a profit of Rs.14,800 p.m. or

(Break – even sales level) $= \dfrac{\text{Rs.}60{,}000 + \text{Rs.}14{,}800}{\text{Rs.}110}$

Note that at 600 units and upto 679 units (i.e. units below the break even level) the loss would be Rs.110/- per unit. The total loss would be Rs.8,800 (80 units × Rs.110). From 680 units upto 750 units i.e. on additional 70 units the total profit would be Rs.7,700 (70 units × Rs.110).

Minimum sales units to recover assembly cost of Rs.70,000 p.m. and earn a profit of Rs.14,800 p.m. or

$= \dfrac{\text{Rs.}70{,}000 + \text{Rs.}14{,}800}{\text{Rs.}110}$

(Break – even sales level) = 770.909 units

If the sales units are more than 770.909 units and upto 900 units, profit would be made. The total amount of profit comes to: Rs.14,200 [(900 units – 770.909) × Rs.110]

Conclusion:

It is not worthwhile to proceed if the demand of components is less than 680 units or between 750 to 770.909 units.

At a selling price of Rs.220:

Minimum sales units to recover assembly cost of

Rs.70,000 p.m. and earn a profit of Rs.14,800 p.m. or $= \dfrac{\text{Fixed cost} + \text{Profit}}{\text{Contribution per unit}}$

(Break even – sales level) $= \dfrac{\text{Rs.}70{,}000 + \text{Rs.}14{,}800}{\text{Rs.}220 - \text{Rs.}140}$

$= \dfrac{\text{Rs.}84{,}800}{\text{Rs.}87} = 1{,}060$ units

Minimum sales units to recover assembly cost of

Rs.70,000 p.m. and earn a profit of Rs.14,800 p.m.;

After availing a discount of 5% on the purchases

Af all parts $= \dfrac{\text{Rs.}70{,}000 + \text{Rs.}14{,}800}{\text{Rs.}220 - \left(\text{Rs.}140 - \dfrac{5}{100} \times 140\right)}$

$= \dfrac{\text{Rs.}84{,}800}{\text{Rs.}87}$

= 974.712 units or (975 units)

Conclusion:

It is not worthwhile to sell between 900 and 1,000 units when no discount is available. Also, it is worthwhile selling at Rs.220 if sales units are in excess of 1,000 units and a discount of 5% is available on the purchase of all components – parts.

Profit on the sale of 1,250 units = 1,250 units × Rs.87 – Rs.84,800 = Rs.23,950

(iii) Advice on the viability of the venture:

(a) At a selling price of Rs.250 he will not be at a loss if the demand of the component exceeds 680 units to 749 units and 770.909 units to 900 units.

(b) At a selling price of Rs.220, it is not worthwhile to sell if the demand is less than 1,000 components without availing a discount of 5%.

Question 4

SWEET DREAMS LTD. Manufactures and markets three products A, Band C in the State of Haryana and Rajasthan. At the end of first half of 1996-97 the following absorption based profit statement has been drawn by the accountant:

(Rs. in '000)

	Haryana	*Rajasthan*	*Total*
Sales	*3,000*	*900*	*3,900*
Manufacturing Costs of Sales	*2,331*	*699*	*3,030*
Gross Profit	*699*	*201*	*870*
Administration Expenses (A)	*120*	*36*	*156*
Selling Expenses (B)	*184*	*169*	*353*
Total Expenses	*304*	*205*	*509*
Net Profit	*365*	*(-) 4*	*361*

(A) The expenses are constant and common to both the States. They stand allocated on the basis of Sales.

(B) The expenses are semi-fixed but specifically relate to the respective State.

The management is worried to note that the decision taken to market the products in Rajasthan to utilise idle capacity has proved wrong and wish to cover only Haryana State. The incharge marketing division is not satisfied with the above way of profit presentation. He is of the firm opinion that sales effected in the State of Rajasthan is contributing profits. For the next half year he expects no increase in demand in Haryana while for Rajasthan he anticipates to sell B or C more by 50% of existing sales. This will utilise the idle capacity in full.

The product-wise relevant details for the first half of 1996-97 are:

	A	*B*	*C*
Sales (in Rs.'000):			
Haryana	*1,200*	*900*	*900*
Rajasthan	*300*	*300*	*300*
Variable Costs (as a % on sales) :			
Manufacturing	*40*	*35*	*30*
Selling	*3*	*2*	*2*
Specific fixed manufacturing expenses			
(in Rs.'000)	*570*	*470*	*610*

You are required to:

(a) *Prepare s State-wise profit statement for the first half of 1996-97 using contribution approach. Also offer your views on the contention of the management and opinion expressed by incharge marketing division.*

(b) *Prepare a product wise profit statement for the same period using contribution approach.*

(c) *Submit your well thought out recommendation as to which product should be produced to utilise idle capacity.* *(Nov 1996)*

Answer

Working Notes:

1. Variable manufacturing and selling costs (in Rs.'000):

Product	*Sales*		*Mfg. Costs*			*Selling costs*		
	Haryana	*Rajasthan*	*%of*	*Haryana*	*Rajasthan*	*%of sales*	*Haryana*	*Rajasthan*
A	1,200	300	40	480	120	3	36	9
B	900	300	35	315	105	2	18	6
C	900	300	30	270	90	2	18	6
		Total:		1,065	315		72	21

2. Specified fixed expenses (in Rs.'000):

	Manufacturing			*Selling*		
	Haryana	*Rajasthan*	*Total*	*Haryana*	*Rajasthan*	*Total*
Total manufacturing :						
Cost of sales	2,331	699	3,030	184	169	353
Less: Variable manufacturing and selling costs						
(Refer to Working note 1)	1,065	315	1,380	72	21	93
Specified fixed cost	1,266	384	1,650	112	148	260

3. Product wise specified fixed selling expenses (in Rs.'000)

	Total	*A*	*B*	*C*
Fixed selling expenses of Haryana and Rajasthan apportioned in proportion of their sales, viz., (15 : 12 : 12)	260	100	80	80

(a) State wise Profit Statement for the First Half of 1996-97

Using contribution approach

(Rs.'000)

	Haryana	*Rajasthan*	*Total*
Sales: (1)	3,000	900	3,900
Variable costs:			
Manufacturing (Refer Working Note1)	1,065	315	1380
Selling : (Refer Working Note 1)	72	21	93
Total: (2)	1,137	336	1,473
Contribution: [(1) – (2)] – (A)	1,863	564	2,427
Specified fixed cost:			
Manufacturing (Refer to Working Note 2)	1,266	384	1,650
Selling	112	148	260
Total : (B)	1,378	532	1,910
Net contribution : [(A) – (B)]	485	32	517
Less : Common fixed costs			156
(Administration)			361
P/V ratio (in %) (C/S × 100)	62.1	62.87	62.23

Views: The contention of the management is not valid i.e. the state of Rajasthan shows Rs.32,000 as contribution to meet the common fixed costs. In case only Haryana state is covered the net profit of the concern would go down form Rs.3,61,000 to Rs.3,29,000.

In view of the above position, the statement made by the incharge of the marketing division appears to be correct.

(b)

Product wise Profit Statement for the first half of 1996-97

Using contribution approach

(Fig. in Rs.'000)

Production	*A*	*B*	*C*	*Total*
Total Sales of Haryana & Rajasthan: (I)	1,500	1,200	1,200	3,900
Variable Cost :				
Manufacturing :				
(1,500 × 40%)				
(1,200 × 35%)				
(1,200 × 30%)	600	420	360	1,380
Selling :				
(1,500 × 3%)				
(1,200 × 2%)				
(1,200 × 2%)	45	24	24	93
Total : (2)	645	444	384	1,473
Contribution : (I – II) = (III)	855	756	816	2,427

Specified fixed cost:				
Manufacturing	570	470	610	1,650
Selling (Refer to Working Note 3)	100	80	80	260
Total : (IV)	670	550	690	1,910
Net Contribution : [(III) – (IV)]	185	206	126	517
Less: Common fixed				
Administration expenses				156
Net Profit				361
P/V ratio (Contribution/Sales) × 100	57%	63%	68%	62.23%

(c) Recommendation for utilising idle capacity:

A review of the above P/V ratio's shows that the increase of output of product C in Rajasthan is the best. The increase of production after utilising the idle capacity in Rajasthan to the extent of Rs.1,50,000 (i.e. 50% of Rs.3,00,000) would increase the contribution of the company in the state of Rajasthan by Rs.1,02,000 (68% × Rs.1,50,000).

Question 5

The relevant data of X Ltd. For its three products A, B and C are as under:

	A	*B*	*C*
Direct Material (Rs./Unit)	*260*	*300*	*250*
Direct Labour (Rs./Unit)	*130*	*270*	*260*
Variable Overheads (Rs./Unit)	*110*	*230*	*180*
Selling Price (Rs./Unit)	*860*	*1040*	*930*
Machine Hours Required (per Unit)	*12*	*6*	*3*

The estimated fixed overheads at four different levels of 3,600; 6,000; 8,400 and 10,800 machine hours are Rs.1,00,000; Rs.1,50,000; Rs.2,20,000 and Rs.3,00,000 respectively. The maximum demand of A, B and C in a cost period are 500; 300 and 1,800 units respectively.

You are required to find out (i) the most profitable product-mix at each level and (ii) the level of activity where the profit would be maximum. *(May 1997)*

Answer

Working Note:

Ranking three products A, B and C

Product	*A*	*B*	*C*
Selling price (p.u.) (Rs.)	860	1,040	930
Less: Variable cost p.u. (Rs.)	500	800	690
Contribution p.u. (Rs.)	360	240	240
Machine hrs. required p.u.	12	6	3
Contribution per machine hour (Rs.)	30	40	80
	(Rs.360/12 hrs)	(Rs.240/6 hrs)	(Rs.240/3 hrs)

Ranking	III	II	I
Maximum demand in units	500	300	1,800

(i)

Statement of the most profitable product mix

At each level of machine hours

	Machine hours			
Product (mix)	3,600	6,000	8,400	10,800
C	12,00 units (3,600 hrs/ 3 hrs p.u.)	1,800 units (5,400 hrs./ 3 hrs. p.u.)	1.800 units	1,800 units
B	-	100 units (600 hrs/ 6 hrs p.u)	300 units (1800 hrs./ 6 hrs. p.u.)	300 units
A	-	-	100 units (1,200 hrs/ 12 hrs p.u)	100 units (3,600 hrs/ 12 hrs p.u.)

(ii) Statement of level of activity where

The profit would be maximum

[Refer to the answer of part (i)]

Level of activity (Machine hours)	*C units*	*Contri-bution Rs.*	*B units*	*Contri-bution Rs.*	*A units*	*Contri-bution Rs.*	*Total Contri-bution*	*Fixed cost (Rs.)*	*Net Profit (Rs.)*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)=(2) + (4)+ (6)*	*(8)*	*(7) – (8)*
3,600	1,200	2,88,000 (1,200 × Rs.240)	-	-	-	-	2,88,000	1,00,000	1,88,000
6,000	1,800	4,32,000 (1,800 × Rs.240)	100	24,000	-	-	4,56,000	1,50,000	3,06,000
8,400	1,800	4,32,000	300	72,000 (300 × Rs.240)	100	36,000 (100 × Rs.360)	5,40,000	2,20,000	3,20,000
10,800	1,800	4,32,000	300	72,000	300	1,08,000	6,12,000 (300 × Rs.360)	3,00,000	3,12,000

Recommendation:

At 8,400 machine hour level of capacity the company would earn maximum profit i.e. Rs.3,20,000.

* Refer to working note.

Question 6

Navbharat Commerce College, Bombay has six sections of B.Com, and two section of M.Com with 40 and 30 students per section respectively. The college plans one-day pleasure trip around the city for the students once in an academic session during winter break to visit park Zoo, planetarium and aquarium.

A transporter used to provide the required number of buses at a flat rate of Rs.700 per bus for the aforesaid purpose. In addition, a special permit fee of Rs.50 per bus is required to the deposited with city Municipal Corporation. Each bus is 52 seater. Two seats are reserved for teachers who accompany in each bus. Each teacher is paid daily allowance of Rs.100 for the day. No other costs in respect of teachers are relevant to the trip.

The approved caterers of the college supply breakfast, lunch and afternoon tea respectively at Rs.7; Rs.30 and Rs.3 per student.

No entrance fee is charged at the park. Entrance fees come to Rs.5 per the zoo and the aquarium. As regards planetarium the authorities charge block entrance fee as under for group of students of educational institutions depending upon the number of students in a group:

No. of students in a Group	*Block Entrance Fee*
Upto 100	*200*
101-200	*300*
201 & above	*450*

Cost of prizes to be awarded to the winner in different games being arranged in the park depend upon the strength of students in a trip. Cost of prizes to be distributed are:

No. of students in a Trip	*Cost of Prizes*
Rs.	
Upto 50	*900*
51-125	*1,050*
126-150	*1,200*
151-200	*1,300*
201-250	*1,400*
251 & above	*1,500*

To meet the above costs the college collects Rs.65 from each student who wish to join the trip. The college release subsidy of Rs.10 per student in the trip towards it.

You are required to:

(a) Prepare a tabulated statement showing total costs at eth levels of 60, 120, 180, 240 and 300 students indicating each item of cost.

(b) Compute average cost per student at each of the above levels.

(c) Calculate the number of students to break even for the trip as the college suffered loss during the previous year despite 72% of the students having joined the trip. *(May 1997)*

Answer

(a) Statement showing total costs indicating each item of cost

No. of students	*60*	*120*	*180*	*240*	*300*
	Rs.	*Rs.*	*Rs.*	*Rs.*	*Rs.*
Variable costs:					
Break fast	420	840	1,260	1,680	2,100
Lunch	1,800	3,600	5,400	7,200	9,000
Tea	180	360	540	720	900
Entrance fee for Zoo &	300	600	900	1,200	1,500

Aquarium					
Total (A)	2,700	5,400	8,100	10,800	13,500
Rent of buses	1,400	2,100	2,800	3,500	4,200
(Refer to working note 1)					
Special permit fee	100	150	200	250	300
(Refer to working note 2)					
Daily allowance paid to teacher (Refer to working table)	400	600	800	1,000	1,200
Block entrance fee	200	300	300	450	450
(Refer to given table)					
Cost of prizes	1,050	1,050	1,300	1,400	1,500
(Refer to given table)					
Total (B)	3,150	4,200	5,400	6,600	7,650
Grand Total (A) + (B)	5,850	9,600	13,500	17,400	21,150

(b) Average cost per student at each of the above levels

No. of students: (A)	60	120	180	240	300
Total Costs (Rs.) : (B)	5,850	9,600	13,500	17,400	21,150
[Refer to (a) Part]					
Average cost (Rs.): (B)/(A)	97.50	80	75	72.50	70.50

(c) Statement showing number of students to break-even

No. of students in the trip	51-100	101-125	126-150	151-200	201-250	251-300
No. of buses	2	3	3	4	5	6
Semi variable costs						
Bus Rent (Rs.)	1,400	2,100	2,100	2,800	3,500	4,200
Permit fee (Rs.)	100	150	150	200	250	300
Block entrance fee (Rs.)	200	300	300	300	450	450
Daily allowance paid to teachers (Rs.)	400	600	600	800	1,000	1,200
Cost of prizes	1,050	1,050	1,200	1,300	1,400	1,500
Total cost (Rs.)	3,150	4,200	4,350	5,400	6,600	7,650
No. of students to break even:	105	140	145	180	220	255
(Total semi variable cost/contribution per student)	(Rs.3,150 / Rs.30	Rs.4,200/ Rs.30	Rs.4,350/ Rs.30	Rs.5,400/ Rs.30	Rs.6,600/ Rs.30	Rs.7,650 / Rs.30

As the figure of 105 and 140 student fall outside the limits (No. of students in the trip), therefore there are four break-even points in this case viz., 145,180, 220 and 255 students.

The college authorities should keep these figures in mind while hiring 3, 4, 5 and 6 buses respectively to avoid losses.

The college incurred loss during the previous year s they hired 5 buses and 72% of total students (216 out of 300 students) joined the trip. The break-even in case college authorities hire 5 buses for the trip comes to 220 students.

Working Notes:

1. No. of buses required and Rent of buses @ Rs.700/- per bus

No. of students	60	120	180	240	300
Bo. of buses	2	3	4	5	6
Rent of buses (Rs.)	1,400	2,100	2,800	3,500	4,200
(No. of buses × Rs.700)					

2. Special permit fee:

No. of buses × Rs.50)	100	150	200	250	300

3. Allowance paid to Teachers (Rs.)

No. of buses × Rs.200)	400	600	800	1,000	1,200

4. Contribution per student towards semi-variable costs

	Rs.
Collection from each student	65
Subsidy provided by the college	10
	75
Less: Variable cost per student	45
Contribution per student	30

Question 7

A Company produces three products from an imported material. The Cost Structure per unit of the products are as under:

	Product		
	A	*B*	*C*
	Rs.	*Rs.*	*Rs.*
Sales Value	*200*	*300*	*250*
Direct Material	*50*	*80*	*60*
Direct Wages Rs.6 per hour	*60*	*120*	*108*
Variable Overheads	*30*	*60*	*54*

Out of Direct Material 80% is of the imported material @ Rs.10 per kg.

Prepare a statement showing comparative Profitability of the three products under the following scenarios.

(i) Imported Material is in restricted supply.

(ii) Production Capacity is limiting factor.

(iii) When maximum sales potential of products A and B are 1,000 units each and that of product 'C' is 500 units for specific requirement, availability of imported material is restricted 10,000 kgs per month, how the profit could be maximised? (Nov 1997)

Answer

Working Note:

Value of imported and indigenous material and quantity of imported material consumed p.u.:

Products	*A*	*B*	*C*
Value of imported material p.u. (Rs.)	40	64	48
Value of indigenous material p.u. (Rs.)	10	16	12
Quantity of imported material consumed p.u. (kg)	4	6.4	4.8

Statement of profitability

Products	*A*	*B*	*C*
Sales value p.u. (Rs.) : (X)	200	300	250
Direct material (Rs.)	50	80	60
Quantity of imported material consumed p.u. (kg)	(10 hrs × Rs.6)	(20 hrs × Rs.6)	(18 hrs × Rs.6)
Variable overheads (Rs.)	30	60	54
Total variable cost (Rs.) : (Y)	140	260	222
Contribution p.u. (Rs.) : (X-Y)	60	40	28
P/V Raio: $\left(\frac{C}{S}\times 100\right)$	30%	13.33%	11.2%
Contribution per kg. of imported material (Rs.) (Refer to Working note)	15	6.25	5.83
Contribution per hour of production (Rs.)	6	2	1.6
	(Rs.60/10 hrs.)	(Rs.40/20 hrs.)	(Rs.28/18 hrs)

(i) When imported material is in restricted supply then product 'A' is most profitable as its contribution pre kilogram is maximum.

(ii) Even when production capacity is limited, product 'A' is the most profitable one.

(iii)

Statement for maximised profit

Products	*A*	*B*	*C*
Maximum sales (units)	1,000	1,000	500
Requirement of imported material per unit (kg)	4	6.4	4.8
Total requirement of imported material for maximum sales (kg)	4,000	6,400	2,400
Contribution per kg (Rs.)	15	6.25	5.83
For maximising profit 10,000 kg of imported material is	4,000	3,600	2,400

to be used for manufacturing those products where contribution per kg is maximum. But 500 units of C must be produced to meet specific requirement. Hence the material utilised will be (kg.)			
No. of units	1,000	562	500

Question 8

Elegant Hotel has a capacity of 100 single rooms and 20 double rooms. It has a sports centre with a swimming pool, which is also used by persons other than residents of the hotel. The hotel has a shopping arcade at the basement and a specialty restaurant at the roof top.

The following information is available:

(i) Average occupancy: 75% for 365 days of the year.

(ii) Current costs are:

	Variable cost	*Fixed cost*
	Rs./per day	*Rs./per day*
Single Room	*400*	*200*
Double Room	*500*	*250*

(iii) Average sales per day of restaurant Rs.1,00,000; contribution is at 30%. Fixed cost Rs.10,00,000.

(iv) The sports centre/swimming pool is likely to be used by 50 non-residents daily; average contribution per day per non-resident is estimated at Rs.50; fixed cost is Rs.5,00,000 per annum.

(v) Average contribution per month from the shopping arcade is Rs.50,000; fixed cost is Rs.6,00,000 per annum.

You are required to find out:

(a) Rent chargeable for singe and double room per day, so that there is a margin of safety of 20% on hire of rooms and that the rent for a double room should be kept at 120% of a single room.

(b) Evaluate the profitability of restaurant, sports centre and shopping arcade separately.

(Nov 1997)

Answer

(a) Working note:

1.	Single room occupancy day in a year	= 100 rooms × 365 days × 75%
		= 27,375
	Double room occupancy day in a year	= 20 rooms × 365 days × 75%
		= 5,475
2.	In terms of single room total room occupancy	= 27,375 + 1.20 × 5,475
	Days in a year	= 27.375 + 6,570
		= 33,945

Statement for calculating the rent chargeable for single ad double room per day

Occupancy	*Variable*	*Fixed cost*	*Total*	*Total fixed*	*Total cost*

	days in a year (refer to working note1)	cost Rs./ day	Rs./day	variable (Rs.)	cost (Rs.)	(Rs.)
	(1)	(2)	(3)	(4)=(1)×(2)	(5)=(1)×(3)	(6)=(4)+(5)
Single	27,375	400	200	1,09,50,000	54,75,000	1,64,25,000
Double room	5,475	500	250	27,37,500	13,68,750	41,06,250

Add:20% margin of safety on hire of room or 25% of Total cost	51,32,812
Total amount of room rent to be received	2,56,64,062
Rent per day of single room (in Rs.)	756 (approx.)
(Refer to working note 2)	
(Rs.2,56,64,,062/33,945)	
Rent per day of double room (in Rs.)	
(Rs.756 × 1.2 times)	907 (approx.)

(b) Profitability of restaurant:

		Rs.
Total sales per annum		
365 days × Rs.1,00,000		3,65,00,000
Contribution per annum		1,09,50,000
(30% of Total sales)	: (A)	
Fixed cost per annum	: (B)	10,00,000
Profit	: [(A) – (B)]	99,50,000

Profitability of sports centre:

		Rs.
Contribution of sports centre per day:		
(50 persons × Rs.50)		2,500
Total contribution per annum		
(Rs.2,500 × 365 days)	: (A)	9,12,500
Fixed cost per annum	: (B)	5,00,000
Profit	: [(A) – (B)]	4,12,500

Profitability of shopping arcade:

	Rs.
Contribution per annum	
(Rs.50,000 × 12 months)	6,00,000
Less : Fixed cost	6,00,000
Profit	Nil

Question 9

What is contribution? How is it related to profit? *(May 1998)*

Answer

Contribution is difference between sales revenue and variable cost.

It is related to profit as apparent from the following relation:

Contribution = Fixed Cost + Profit

Or Profit = Contribution – Fixed Cost

Question 10

ACE Office Supplies Corporation retails two products – a standard and a deluxe version of a designer ball point pen. The budgeted income statement is as under :

	Standard	Deluxe	Total
Sales (in units)	*1,50,000*	*50,000*	*2,00,000*
	Rs.	*Rs.*	*Rs.*
Sales:			
@ Rs.20 per unit	*30,00,000*	*-*	*-*
At Rs.30 per unit	*-*	*15,00,000*	*45,00,000*
Variable Costs:			
At Rs.14 per unit	*21,00,000*	*-*	*-*
At Rs.18 per unit	*-*	*9,00,000*	*30,00,000*
Contribution	*9,00,000*	*6,00,000*	*15,00,000*
Fixed Costs			*12,00,000*
Profit			*3,00,000*

Required:

(i) Calculate the breakeven point in units assuming that the planned sales mix is maintained.

(ii) Calculate the breakeven point in units:

(a) if only standard version is sold, and

(b) if only deluxe version is sold.

(iii) Suppose 2,00,000 units are sold, but only 20,000 units are of deluxe quality. Calculate the profit. Calculate the breakeven points if these relationships persist in the next accounting period. Compare your answer with the original plan and the answer in requirement (b). what is your major finding? *(May 1998)*

Answer

(i) Computation of breakeven point: (assuming budgeted planned sales mix)

Let x be the number of budgeted unit of 'Deluxe ball point pen' to breakeven.

Let 3× be the budgeted number of units of 'Standard ball point pen' to breakeven.

At breakeven point we have :

Sales revenue – Variable cost = Fixed cost

or [(3x × Rs.20 + x × Rs.30) – (3x × Rs.14 + x × Rs.18)] = Rs.12,00,000

or Rs.30x = Rs.12,00,000

or x = 40,000 units (Deluxe ball pen)

and 3x = 1,20,000 units (Standard ball pen)

(ii) Working note:

Contribution per unit of 'Standard ball pen' = Rs.20 – Rs.14 = Rs.6

Contribution per unit of 'Deluxe ball pen' = Rs.30 – Rs.18 = Rs.12

(a) Break even point in units (if only Standard version is sold)

$$= \frac{\text{Fixed cost}}{\text{Contribution per unit (Refer to workng note}}$$

$$= \frac{\text{Rs.12,00,000}}{\text{Rs.6}} = 2,00,000 \text{ units}$$

(b) Break even point in units (if only Deluxe version is sold)

$$= \frac{\text{Rs.12,00,000}}{\text{Rs.12 (Refer to working note)}} = 1,00,000 \text{ units}$$

(iii) Computation of profit (if out of 2,00,000 units 20,000 were of Deluxe quality)

= (Total contribution from the sale of 1,80,000 units of Standard quality and 20,000 units of Deluxe quality) – Fixed costs

= 1,80,000 × Rs.6 + 20,000 × Rs.12 – Rs.12,00,000

= Rs.10,80,000 + Rs.2,40,000 – Rs.12,00,000

= Rs.1,20,000

Computation of break even point (if the ratio of units sold of Standard and Deluxe type is 1,80,000 : 20,000 or 9:1 persists in the next period)

At break even point:

[(9x × Rs.20 + x × Rs.30) – (9x × Rs.14 + Rs.18)] = Rs.12,00,000

or 66x = Rs.12,00,000

or – x = 18,182 units (Deluxe ball pen)

and 9x = 1,63,638 units (Standard ball pen)

Major findings on comparing budgeted sales plan and original sales plan

Sales mix ratio of Standard and Deluxe	*Unites to be sold at breakdown*		*Total units sold*	*Profit on the sale of 2,00,000 unit*
	Standard	Deluxe		
3 : 1 (as per budgeted sales plan)	1,20,000	40,000	1,60,000	3,00,000
9 : 1 (as per original sales plan)	1,63,638	18,182	1,81,820	1,20,000

1. The above figures clearly reflect that a change in sales mix changes breakeven point and profit as well.
2. Though the total figure of budgeted and original actual sales units were identical viz. 2,00,000 units, but the proportion of the product with higher contribution declined.
3. The profit figure fell from Rs.3,00,000 to Rs.1,20,000 and breakeven pint rose from 1,60,000 units to 1,82,820 units.

Question 11

Distinguish between absorption costing and marginal costing. *(May 1998)*

Answer

Main points of distinction between Absorption Costing and Marginal Costing are as follows:

	Absorption Costing	Marginal Costing
1.	It is a total cost technique i.e. both variable and fixed costs are charged to products, processes or operations.	Here only variable costs are charged to products, processes or operations. Fixed costs are charged as period costs to the profit statement of the same period in which they are incurred.
2.	Fixed factory overheads are absorbed by the production units on the basis of a predetermined fixed factory overhead recovery rate based on normal capacity. Under/over absorbed overheads are adjusted before arriving at the figure of profit for a particular period.	The cost of production under this method does not include fixed factory overheads and therefore, the value of closing stock comprises of only variable costs. No part of the fixed expenses is included in the value of closing stock and carried over to the next period.
3.	Inspite of best possible forecast and equitable basis of apportionment/ allocation of fixed costs, under or over recovery of fixed overheads generally arises.	Since fixed overheads are not included in the cost of production, therefore the question of their under/over recovery does not arise.
4.	Managerial decisions under this costing technique are based on profit i.e. excess of sales value over total costs, which may at times lead to erroneous decisions.	Here decisions are made on the basis of contribution i.e. excess of sales price over variable costs. This basis of decision making results in optimum profitability.

Question 12

List out the assumptions of break-even analysis. *(Nov 1998)*

Answer

The assumptions underlying break even analysis are as below:

(i) All costs can be easily classified into fixed and variable components.

(ii) Both revenue and cost functions are linear over the range of activity under consideration.

(iii) Prices of output and input remain unchanged.

(iv) Productivity of the factors of production will remain the same.

(v) The state of technology and the process of production will not change.

(vi) There will be no significant change in the levels of inventory

(vii) The company manufactures a single product.

(viii) In the case of a multi-product company, the sales mix will remain unchanged.

Question 13

What are the limitations of Marginal Costing? Explain. *(Nov 1998)*

Answer

Limitations of Marginal Costing:

1. Marginal Costing assures that all costs can be classified into fixed and variable. But it is not so, as there are costs which are neither fixed or variable. For example, various amenities provided to workers may have to relation either to volume of production or time factor.
2. Contribution of a product itself is not a guide for optimum profitability unless it is linked with the key factor.
3. Marginal Costing ignores time factor and investment. For example, the marginal cost of two jobs may be the same but the time taken for their completion and the cost of machines used may differ. The true cost of a job which takes longer time and uses costlier machine would be higher. This fact is not disclosed by marginal costing.
4. The overheads of fixed nature cannot altogether be excluded particularly in large contracts while valuing work-in-progress. In order to show the correct position, fixed overheads have to be included in work-in-progress.
5. In the long run, the selling prices should be based on total cost i.e. inclusive of fixed cost also. In the short run or in special situations when a product is sold below the total cost customers may insist on the continuation of reduced prices forever which may not be possible in all cases. Further, sales staff may mistake marginal cost for total cost and sell at a price which will result in loss or low profit. Hence, sales staff should be cautioned while giving marginal cost.
6. The main assumptions regarding behaviour of costs are not true. The variable costs do not remain constant per unit of output. There may be changes in the prices of raw materials, wage rates etc. after a certain level of output has been reached due to shortage of material, shortage of skilled labour, concessions of bulk purchases etc. Similarly, the fixed cost does not remain static. They may change from one period to another. For example salaries bill may go up because of annual increments or due to change in pay rate etc.

Question 14

What is margin of Safety? How can margin of safety be improved? *(May 1999)*

Answer

Margin of Safety

Margin of safety is the excess of sales over the break-even sales. It may also be considered as the excess of production over break-even point. It can be expressed in value as well as in percentage. The size of margin of safety shows the strength of the business. Small size of margin of safety indicates that the firm has large fixed expenses and is more vulnerable to changes in sales. In other words, if the margin of safety is large, a slight fall in sales may not affect the business very much but when it is small then a slight fall in sales may adversely affect the business. The margin of safety is calculated by using the following formula:

$$\text{Margin of safety} = \frac{\text{Profit}}{\text{P/V ratio}} \text{ or}$$

$$= \frac{\text{Profit}}{(\text{Contribution/Sales})}$$

Margin of safety is also immensely useful for making inter-firm comparison. This is being done by calculating their margin of safety ratio. This ratio can be calculated by suing the following formula:

$$\text{Margin of safety ratio} = \frac{\text{Margin of Safety}}{\text{Sales}} \times 100$$

$$= \frac{\text{Actual sales - Break even sales}}{\text{Sales}} \times 100$$

Measures for improving margin of safety

Margin of safety can be improved by taking the following measures:

1. Increasing the selling price, provided the demand is inelastic so as to absorb the increased prices.
2. Reduction in fixed expenses.
3. Reduction in variable expenses
4. Increasing the sales volume provided capacity is available.
5. Substitution or introduction of a product mix such that more profitable lines are introduced.

Question 15

Anuradha Enterprises manufactures and sells black phenyl worth Rs.20,000 white phenyl worth Rs.25,000, scented phenyl worth Rs.10,000 and naphthalene balls worth Rs.5,000 every month. The firm's total fixed costs per month are Rs.14,700. The variable costs are: on black phenyl 60% on white phenyl 68%, on scented phenyl 80% and on naphthalene balls 40%.

The proprietor, Ms. Anuradha Shah, being basically a science graduate, wonders at what combined sales volume does she really start earning profit. Please help her in arriving at such a sales volume.
(May 1999)

Answer

Statement of M/s Anuradha Enterprises

(Showing the computation of sales volume at which the concern starts earning profit)

Products	*Sales revenue per month*	*Variable cost of sales per month*	*Contribution*
	Rs.	*Rs.*	*Rs.*
(a)	(b)	(c)	(d) = (b) – (c)
Black phenyl	20,000	12,000	8,000
		(60% × Rs.20,000)	
White phenyl	25,000	17,000	8,000
		(68% × Rs.25,000)	
Scented phenyl	10,000	8,000	2.000
		(80% × Rs.10,000)	
Naphthalene balls	5,000	2,000	3,000
		(40% × Rs.5,000)	
Total	<u>60,000</u>		<u>21,000</u>

$$\text{Combined P/V ratio} = \frac{\text{Total Contribution}}{\text{Total Sales}} \times 100$$

$$= \frac{\text{Rs.}21{,}000}{\text{Rs.}60{,}000} \times 1000 = 35\%$$

Break-even point = $\frac{\text{Fixed Cost}}{\text{P/V ratio}} = \frac{\text{Rs.14,700}}{35\%}$ = Rs.42,000

Conclusion: Ms. Anuradha Shah, proprietor of M/s. Anuradha Enterprises would start earning profit if its combined sales volume increases above Rs.42,000.

Question 16

What are the limitations of a break-even chart? *(May 1999)*

Answer

The limitations of break even chart are as follows:

1. White preparing a break-even chart, it is assumed that revenue and costs can be represented with the help of straight lines. It s not always be true.
2. The preparation of a break-even chart requires the segregation of semi-variable costs into fixed and variable components. It may into always be possible to segregate semi-variable costs into fixed and variable elements accurately. There may be situations when semi-variable costs cannot be split.
3. A break-even chart assumes that selling price and variable cost per unit are constant at all levels of activity. It may not always be true. Selling price as well as variable cost may either increase or decrease with the change in volume. Fixed costs also tend to vary beyond a certain output.
4. When a firm produces a number of products the appointment of fixed expenses over various products may be different and often it may be done arbitrarily.
5. A Break-even chart assumes that business condition will not change. This is hardly so.
6. A break-even chart does not consider the amount of capital employed in the business, a very important factor for determining profitability of a concern.

Question 17

The details of the output presently available from a manufacturing department of Hitech Industries Ltd. Are as follows:

Average output per week 48,000 units from 160 employees

Saleable value of output Rs.6,00,000

Contribution made by the output towards fixed

Expenses and profit Rs.2,40,000

The Board of Directors plans to introduce more automation in the department at a capital cost of Rs.1,60,000. The effect of this will be to reduce the number of employees to 120, but to increase the output per individual employee by 60%. To provide the necessary incentive to achieve the increased output the Board intends to offer a 1% increase in the piecework rate of one rupee per article for every 2% increase in average individual output achieved. To sell the increased output, it will be necessary to decrease the selling price by 4%.

Required:

Calculate the extra weekly contribution resulting from the proposed change and evaluate, for the Board's information, the worth of the project. *(May 1999)*

Answer

Working notes :

1. Present output per employee and total future expected output.

Present output per employee $= \dfrac{\text{Total present output}}{\text{Total number of present employees}}$

$= \dfrac{\text{Rs.48,000 units}}{\text{160 employees}}$ = 300 units

Total future expected output =

$$\text{Total number of future employee} \left(\begin{array}{c}\text{Present output} \\ \text{per employee}\end{array} + \begin{array}{c}\text{60\% of present output} \\ \text{per employee}\end{array} \right)$$

= 120 × (300 units + 60% × 300 units)

= 57,600 units

2. Present and proposed place work rate:

Present piece work rate = Re 1/- per unit

Proposed piece work rate = Present ice work rate + 30% ×Re.1

= Re 1/- + 0.30 P

= Rs.130 per unit

3. Present and proposed sale price per unit:

Present sale price per unit = Rs.12.50/- per unit

(Rs.6,00,000/48,000 units)

Proposed sale price per unit = Rs.12

(Rs.12.50 – 4% × Rs.12.50)

4. Present marginal cost (excluding wages) per unit.

$= \dfrac{\text{Present Sales Value - Contribution towards fixed expenses \& profit - Present wages}}{\text{Present output (units)}}$

$= \dfrac{\text{Rs, 6,00,000 - Rs.2,40,000 - Rs.48,000}}{\text{48,000 units}}$ = Rs.6.50 p.u.

Statement of extra weekly contribution

Resulting from the proposed change of automation

To evaluate the worth of the project for the Board's Information

Sales (units)	57,600
(Refer to working note 1)	
Sales value (A)	Rs.
57,600 units × Rs.12	6,91,200
(Refer working note 3)	
Marginal costs (excluding wages)	3,74,400
57,600 units × Rs.6.50	
(Refer to working note 4)	
Wages	74,880

57,600 units × Rs.1.30	
(Refer to working note 2)	
Total marginal cost : (B)	4,49,280
Marginal contribution : [(A) – (B)]	2,41,920
Less: Present contribution	2,40,000
Increase in contribution (per week)	1,920

Payback period for recovering the capital cost = 83.33 weeks

(Rs.1,60,000 / Rs.1,920)

Evaluation: The project is recommended assuming that the increase in fixed overhead if any, is less than, the increase in contribution.

Question 18

(a) Discuss the relationship between Angle of incidence. Break-even Level and Margin of Safety.
(Nov 1999)

(b) Satish Enterprises are leading exporters of Kid's Toys. J Ltd. of U.S.A. have approached Satish Enterprises for Exporting a special toy named "Jumping Monkey". The order will be valid for next three years at 3,000 toys per month. The export price of the toy will be 84.

Cost data per toy is as follows :

	Rs.
Materials	*60*
Labour	*25*
Variable overheads	*20*
Primary packing of the toy	*15*

The toys will be packed in lots of 50 each. For this purpose a special box, which will contain the 50 toys will have to be purchased, cost being Rs.400 per box.

Satish Enterprises will also have to import a special machine for making the toys. The cost of the machine is Rs.24,00,000 and duty thereon will be at 12%. The machine will have an effective life of 3 years and depreciation is to be charged on straight-line method. Apart from depreciation, annual fixed overheads is estimated at Rs.4,00,000 for the first year with 6% increase in the second year. Fixed overheads are incurred uniformly over the year.

Assuming the average conversion rate to be Rs.50 per $, you are required to:

(i) Prepare a monthly and yearly profitability statements for the first year and second year assuming the production at 3,000 today per month.

(ii) Compute a monthly and yearly break even units in respect of the first year.

(iii) In what contingency can there be a second break-even point for the month and for the year as a whole?

(iv) *Have you any comments to offer on the above?* *(Nov 1999)*

Answer

(a) Angle of Incidence: It is the angle between total sales line and total cost line drawn in the case of break-even. It provides useful information about the rate at which profits are being made. The larger the angle, the higher the rate of profit or vice-versa.

Break-even level: It is that level of sales (or production) at which the sales revenue exactly equals total costs, both variable and fixed. In other words, it is the level of activity at which the firm neither earns a profit nor suffers a loss.

Margin of safety: It is the difference between total sales and sales at break-even point. In other words margin of safety is the amount of sales above the break-even point. If there is a fall in the sales to the extent of margin of safety, the firm will not be in the red.

Relationship between Angle of Incidence, Break-even level and Margin of Safety.

1. If the break-even point is low and angle of incidence is large. The margin of safety is large and the business enjoys financial stability. A low break-even point indicates that the business could be run profitably even if there is a fall in sales, unless the sales are very low.
2. If the break-even point is low and angle of incidence is small the conditions are the same as in 1 above except that the rate of profit earning capacity is not so high as in 1.
3. If the Break-even point is high and angle of incidence is small. The margin of safety is low. The business is very vulnerable, even a small reduction in activity may result is a loss.
4. If the break-even point is high and angle of incidence is large. This shows that the margin of safety is low; the business is likely to incur losses through a small reduction in activity. However, after the break-even point, the business makes the profit at a high rate.

(b) (i) Profit Statement of M/s Satish Enterprises for first and second year on monthly and yearly basis.

	First year		*Second Year*	
	Monthly *Rs.*	*Yearly* *Rs.*	*Monthly* *Rs.*	*Yearly* *Rs.*
Sales revenue: (A)	600	7,200	600	7,200
	(3,000 units × Rs.200)			
Material cost	180	2,160	180	2,160
	(3,000 units × Rs.60)			
Labour cost	75	900	75	900
	(3,000 units × Rs.25)			
Variable overheads	60	720	60	720
	(3,000 units × Rs.20)			
Primary packing cost	45	540	45	540
	(3,000 units × Rs.15			
Boxes cost	24	288	24	288
	$\left(\frac{\text{Rs.3,000 units}}{\text{12 months}}\right)\times 400$			
Total fixed overhead	108	1,296	110	1,320
(Refer to working note 1)	$\left(\frac{\text{Rs.1,296}}{\text{12 months}}\right)$		$\left(\frac{\text{Rs.1,320}}{\text{12 month}}\right)$	
Total cost : (B)	492	5,904	494	5,928

Profit : C = [(A)-(B)]	108	1,296	106	1,272

Working Note :

1. (i)

Fixed overhead	*First year : (Rs.)*	*Second year (Rs.)*
Depreciation $\frac{\text{Rs}, 24,00,000 + \text{Rs}.2,88,000 \text{ duty}}{3 \text{ years}}$	8,96,000	8,96,000
Other fixed overheads	4,00,000	4,24,000
Total Fixed overheads	12,96,000	13,20,000

(ii) Statement of monthly break – even units of the first year.

Levels – No. of units (Refer to working note)	1351 – 1400	1401 – 1450	1451 – 1500	1501 – 1500
	Rs.	Rs.	Rs.	Rs.
Fixed costs (A)				
Total fixed overheads per month (Refer to working note)	1,08,000	1,08,000	1,08,000	1,08,000
Semi – variable costs (Special boxes cost) – (B)	11,200	11,600	12,000	12,400
	(28 boxes × Rs.400)	(29 boxes × Rs.400)	(30 boxes × Rs.400)	(31boxes × Rs.400
Total fixed and semi variable costs : (A+B)	1,19,200	1,19,600	1,20,000	1,20,000
Break-even level of units:	1490	1495	1500	1505
$\left(\frac{\text{Total fised and semi - variable costs}}{\text{Contribution per unit}}\right)$	(Rs. 1,19,200 / Rs.80)	(Rs. 1,19,600 / Rs.80)	(Rs. 1,20,000 / Rs.80)	(Rs. 1,20,000 / Rs.80)

The first and second break-even level of unit viz. 1490 and 1495 units falls outside the range of 1351 – 1400 and 1401 – 1450 units respectively. Here a monthly break-even level of units is 1,500 units which lies in the range of 1451 – 1500 units.

Statement of yearly break-even points of the first year

Levels No. of units	17851-17900	17901-17950	17951-18000	18001-18050
	Rs.	Rs.	Rs.	Rs.
Fixed Costs (A)	12,96,000	12,96,000	12,96,000	12,96,000
Semi-variable costs (Special boxes costs): (B)	1,43,200	1,43,600	1,44,000	1,44,000
	(358 boxes × Rs.400)	(359 boxes × Rs.400)	(360 boxes × Rs.400)	(361 boxes × Rs.400)
Total fixed and semi-variable costs (A + B)	14,39,200	14,39,600	14,40,000	14,40,400
Break-even level units	17,990	17,995	18,000	18,005
	(Rs.14,39,200	(Rs.14,32,600	(Rs.14,40,000	(Rs.14,40,400

/ Rs.80) / Rs.80) / Rs.80) / Rs.80)

Have a break-even level of units (on yearly basis) is 18,000 units which lies in the range of 17,951 – 18,000 units as well. The other first two figures do not lie in the respective ranges, so they are rejected.

Working note:

		Rs.
1.	Fixed overhead in the first year	12,06,000
	Fixed overhead per month	1,08,000
	Contribution per unit (S.P. per unit – VC per unit)	80

Hence the break-even number of units will be above 1,350 units

$$\left(\frac{\text{Rs.}1{,}08{,}000}{\text{Rs.}80}\right)$$

(iii) If the number of toys goes beyond the level of 1,500 numbers, one more box will be required to accommodate each 50 additional units of toys. In that case the additional cost of a box will be Rs.400/- this amount can be recovered by the additional contribution of 5 toys. Hence, the second break-even point in such a contingency is 1,505 toys. (Refer to 1(b) (ii) last column of first statement).

(iv) Comments: Yearly break-even point of 18,000 units of toys in the first instance is equal to 12 times the monthly break-even point of 1,500 units, because the monthly and yearly figures of break-even point fell on the upper limit of the respective range.

In the second instance, it is not so because the monthly and early break-even point fell within the range of 50 toys.

Question 19

Mention any four important factors to be considered in Marginal Costing Decisions. (Nov 1999)

Answer

Important factors to be considered in “Marginal Costing Decisions” are as follows:

(i) Whether the product or production makes a contribution,

(ii) In the selection alternatives, additional fixed costs if any should be considered.

(iii) The continuity of demand after expression and its impact on selling price are to be considered.

(iv) Non-cost factors such as the need to keep labour force intact and governmental attitude are also to be taken into account.

Question 20

Briefly explain the methods of separating semi-variable costs into their fixed and variable elements. (May 2000)

Answer

Semi-variable costs as the name suggests are partly fixed and partly variable. The methods for separating the semi-variable costs into their fixed and variable elements have been discussed briefly as under:

(i) Graphical method: Under this method, a large number of observations regarding the total costs at different levels of output are plotted on a graph with the output on the

X-axis and the total cost on the Y-axis. Then, the by judgment, a line of “best fit”, which passes through all or most of the points is drawn. The point at which this line cuts the

Y-axis indicates the total fixed cost component in the total cost. If a line is drawn at this point parallel to the X-axis, this indicates the fixed cost. The variable cost at any level of output, is derived by deducting this fixed cost element from the total cost.

(ii) High points and low points method: Under this method, the difference between the total cost at highest and lowest volume is divided by the difference between the sales value at the highest and lowest volume. The quotient thus obtained gives the rate of variable cost in relation to sales value. The fixed cost is the remainder; i.e., total cost minus variable cost.

(iii) Comparison by period or level of activity method: Under this method, the variable cost per unit may be determined by comparing two levels of output with the amount of expenses at those levels. Since the fixed element does not change, therefore the variable elements of cost may be ascertained with the help of the following formula:

$$\frac{\text{Change in the amount of expenses}}{\text{Change in the quantity of output}}$$

(iv) Least squared method: This is the best method of separating semi-variable costs into their fixed and variable elements. It is a statistical method and is based on finding out a line of best fit for a number of observations. The method uses the lower equation y = mx + c; where m represents the variable element of cost per unit, V represents the total fixed cost, 'y' represents the total cost, V represents the volume of output. The total cost is thus split into fixed and variable elements by solving this equation.

(v) Analytical method: An attempt is made under this method to judge empirically the proportion of semi-variable cost and fixed cost. The degree of variability is determined for each item of semi-variable cost. Once this has been done, the method is easy to apply.

Question 21

"Cost is not the only criterion for deciding in favour of shut down" – Briefly explain. (May 2000)

Answer

Cost is not only criterion for deciding in the favour of shut down. Non-cost factors worthy of consideration in this regard are as follows:

(i) Interest of workers, if the workers are discharged, it may become difficult to get skilled workers later, on reopening of the factory. Also shut-down may create problems,

(ii) In the face of competition it may difficult to re-establish the market for the product.

(iii) Plant may become obsolete or depreciate at a faster rate or get rusted. Thus, heavy capital expenditure may have to be incurred on re-opening.

Question 22

M Company's Central Services Department is evaluating new coping machines to replace the firm's current copier, which is worn out. The analysis of alternative machines has been narrowed to three and the estimated costs of operating them are shown below:

		Cost per 100 copies	
	Machine A	*Machine B*	*Machine C*
	Rs.	*Rs.*	*Rs.*
Materials Cost	*60*	*40*	*20*
Labour Cost	*80*	*30*	*20*
Annual Lease Cost	*30,000*	*58,000*	*1,00,000*

Required:

(i) Compute the cost indifference points for the three alternatives.

(ii) What do the cost indifference points suggest as a course of action in this regard?

(iii) If the management expects to need 87,000 copies next year which copier would be most economical? (Nov 2000)

Answer

(i) Computation of Cost indifference points for the three alternatives:

Cost indifference point for two machines viz.,

A & B $= \dfrac{\text{Difference in fixed cost}}{\text{Difference in variable cost per unit}}$

$= \dfrac{\text{Rs.}58{,}000 - \text{Rs.}30{,}000}{\text{Rs.}(60+80) - \text{Rs.}(40+30)}$

$= \dfrac{\text{Rs.}28{,}000}{\text{Rs.}70 \text{ (per unit of 100 copies)}}$ = 400 Nos. (Multiple of 100 copies)

Cost indifference point for two machines viz.

B & C $= \dfrac{\text{Rs.}1{,}00{,}000 - \text{Rs.}58{,}000}{\text{Rs.}(40+30) - \text{Rs.}(20+20)}$

$= \dfrac{\text{Rs.}42{,}000}{\text{Rs.}30 \text{ (per unit of 100 copies)}}$

= 1,400 Nos. (Multiple of 100 copies)

Cost indifference point for two machines viz.

C & A $= \dfrac{\text{Rs.}1{,}00{,}000 - \text{Rs.}30{,}000}{\text{Rs.}(60+80) - \text{Rs.}(20+20)}$

= 700 Nos. (Multiple of 100 copies)

(iii) From the above computations, it is clear that at activity level below the indifference point the alternative (machine) with lower fixed cost and higher variable costs should be used. In case the activity level exceeds the indifference point, a machine with lower variable cost per unit (or higher contribution per unit) and higher fixed cost, is more profitable to operate. At the activity level equal to the indifference point both machines are on equal footing.

Hence from the above we conclude as follows:

From 0 to 400 Nos. (Multiple of 100 copies) use Machine A

From 400 to 1,400 Nos. (Multiple of 100 copies) use Machine B

Above 1,400 Nos. (Multiple of 100 copies) use Machine C.

(iv) If the management needs 87,000 copies next year, i.e. 870 Nos. (Multiple of 100 copies), it is clear that machine B would be most economical.

Question 23

Explain, how Cost Volume Profit (CVP) - based sensitivity analysis can help mangers cope with uncertainty. (Nov 2000)

Answer

Sensitivity analysis focuses on how a result will be changed if the original estimates or the underlying assumptions change.

Cost Volume Profit (CVP) – based sensitivity analysis can help mangers to provide answers to the following questions to cope with uncertainty.

1. What will be the profit if the sales mix changes from that originally predicted?
2. What will be the profit if fixed costs increase by 10% and variable costs decline by 5%.

The use of spreadsheet packages has enabled mangers to develop CVP computerised models which can answer the above questions. Managers can now consider alternative plans by keying the information into a computer, which can quickly show changes both graphically and numerically. Thus mangers can study various combinations of changes in selling prices, fixed costs, variable costs and product mix, and can react quickly without waiting for formal reports from the accountant. In this manner the use of CVP based sensitivity analysis can help mangers to cope up with uncertainty.

Question 24

Enumerate the limitations of using the marginal costing technique. *(May 2001)*

Answer

Marginal costing is defined as the ascertainment of marginal cost and of the effect on profit of changes in volume or type of output by differentiating between fixed costs and variable costs. Limitations of Marginal Costing Techniques:

The limitations of using the marginal costing technique are as follows:

1. It is difficult to classify exactly the expenses into fixed and variable category. Most of the expenses are neither totally variable nor wholly fixed.
2. Contribution itself is not a guide unless it is linked with the key factor.
3. Sales staff may mistake marginal cost for total cost and sell at a price; which will result in loss or low profits. Hence, sales staff should be cautioned while giving marginal cost.
4. Overheads of fixed nature cannot altogether be excluded particularly in large contracts, while valuing the work-in-progress. In order to show the correct position fixed overheads have to be included in work-in-progress.
5. Some of the assumptions regarding the behaviour of various costs are not necessarily true in a realistic situation. For example, the assumption that fixed cost will remain static throughout is not correct.

Question 25

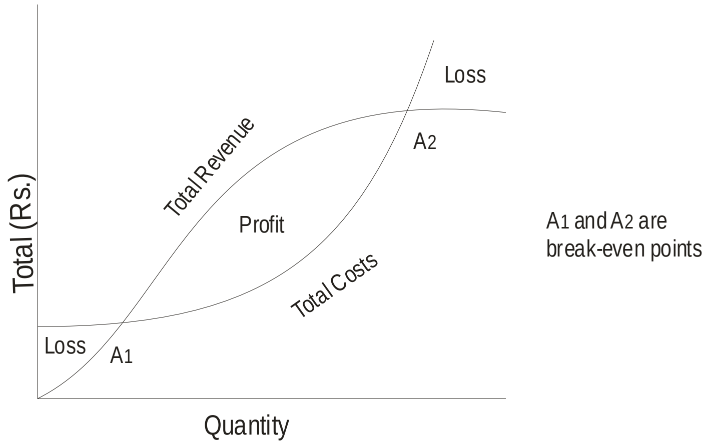
Briefly discuss on curvilinear CVP analysis. *(Nov 2001)*

Answer

In CVP analysis, the usual assumption is that the total sales line and variable cost line will have linear relationship, that is, these lines will be straight lines. However, in actual practice it is unlikely to have a linear relationship for two reasons, namely:

- after the saturation point of existing demand, the sales value may show a downward trend.
- the average unit variable cost declines initially, reflecting the fact that, as output increase the firm will be able to obtain bulk discounts on the purchase of raw materials and can also benefit from division of labour. When the plant is operated at further higher levels of output, due to bottlenecks and breakdowns the variable cost per unit will tend to increase. Thus the law of increasing costs may operate and the variable cost per unit may increase after reaching a particular level of output.

In such cases, the contribution will not increase in linear proportion i.e. based on the phenomenon of diminishing marginal productivity, the total cost lie will not be straight, as assumed but will be of curvilinear shape. This situation will give rise to two break even points. The optimum profit is earned at the point where the distance between sales and total cost is the greatest.



Question 26

A company manufactures two types of herbal product, A and B. Its budget shows profit figures after apportioning the fixed joint cost of Rs.15 lacs in the proportion of the numbers of units sold. The budget for 2002, indicates:

	A	*B*
Profit (Rs.)	*1,50,000*	*30,000*
Selling price / unit (Rs.)	*200*	*120*
P/V ratio (%)	*40*	*50*

You are required to advise on the best option among the following, if the company expects that the number of units to be sold would be equal.

(i) Due to exchange in a manufacturing process, the joint fixed cost would be reduced by 15% and the variables would be increased by 7½ %.

(ii) Price of A could be increased by 20% as it is expected that the price elasticity of demand would be unity over the range of price.

(iii) Simultaneous introduction of both the option, viz, (i) and (ii) above. *(Nov 2001)*

Answer

1. Contribution per unit of each product:

	Product	
	A	*B*
	Rs.	*Rs.*
Contribution per unit	80	60

(Sales × P/V ratio)	(Rs.20 × 40%)	(Rs.12 × 50%)

2. Number of units to be sold:

We know that:

Total contribution – Fixed cost = Profit

Let x be the number of units of each product sold, therefore:

(80x + 60x) – Rs.15,00,000 = Rs.1,50,000 + Rs.30,000

or x = 12,000 units

(i) *Option:* Increase in profit when due to change in a manufacturing process there is reduction in joint fixed cost and increase in variable costs.

		Rs.
Revised contribution from 12,000 units of A due to 7.5% increase in variable cost		8,52,000
(12,000 units (Rs.200 – Rs.129)		
Revised contribution from 12,000 units of B due to 7.5% increase in variable cost		6,66,000
12,000 units (Rs.120 – Rs.64.50)		
Total revised contribution	15,18,000	
Less: Fixed cost	12,75,000	
(Rs.15,00,000 – 15% × Rs.15,00,000)		
Revised Profit	2,43,000	
Less: Existing profit	1,80,000	
Increase in profit	63,000	

(ii) Option: Increase in profit when the price of product A increased by 20% and the price elasticity of its demand would be unity over the range of price.

	Rs.
Budgeted revenue from Product A	24,00,000
(12,000 units × Rs.200)	
Revised demand (in units)	10,000
(Rs.24,00,000 / Rs.240)	
Revised contribution (in Rs.)	12,00,000
[10,000 units × (Rs.240 – Rs.120)]	
Less: Existing contribution	9,60,000
(12,000 units × Rs.80)	
Increase in profit (contribution)	2,40,000

*Note: Since price elasticity of demand is 1, therefore the revenue in respect of products will remain same.

(iii) Option: Increase in profit on the simultaneous introduction of above two options

	Rs.
Revised contribution from Product A	11,10,000

[10,000 units (Rs.240 – Rs.129)]	
Revised contribution from Product B	6,66,000
[12,000 units (Rs.120 – Rs.64.50)]	
Total revised contribution	17,76,000
Less: Revised fixed cost	12,75,000
Revised profit	5,01,000
Less: Existing profit	1,80,000
Increase in profit	3,21,000

Advise: A comparison of increase in profit figures under above three options clearly indicates that the option (iii) is the best as it increases the profit of the concern by Rs.3,21,000.

Note: The budgeted profit/(loss) for 2002 in respect of products A and B should be Rs.2,10,000 and (Rs.30,000) respectively instead of Rs.1,50,000 and Rs.30,000.

Question 27

"Use of absorption costing method for the valuation of finished goods inventory provides incentive for over-production." Elucidate the statement. *(May 2002)*

Answer

When absorption costing method is used, production fixed overheads are charged to products and are included in product costs. Consequently, the closing stocks are valued on total cost (including fixed overheads) basis. The net effect is that the charge of fixed overheads to P/L account gets reduced, if the closing stock is greater than the opening stock. This situation has the effect of inflating the profit for the period.

Where stock levels are likely to fluctuate significantly, profits may be distorted if calculated on absorption costing basis. If marginal costing is used, since the fixed costs are charged off to P/L account as period cost, such a situation will not arise. The impact of using absorption costing on profits can be summerised as under:

- When sales are equal to production, profits will be the same under absorption costing and marginal costing.
- If production is higher than sales, the absorption costing will post higher profits that marginal costing.
- If sales are in excess of production, absorption costing will show lower profits than marginal costing.

Since profit calculation in absorption costing can produce strange result, the managers may deliberately alter the stock levels to influence the profits if absorption costing is used. Hence, it is true to say that if absorption costing method is used managers have the incentive to over produce to show better result.

Question 28

A Pharmaceutical company produces formulations having a shelf life of one year. The company has an opening stock of 30,000 boxes on 1st January, 2005 and expected to produce 1, 30,000 boxes as was in the just ended year of 2004. Expected sale would be 1, 50,000 boxes. Costing department has worked out escalation in cost by 25% on variable cost and 10% on fixed cost. Fixed cost for the year 2004 is Rs40 per unit. New price announced for 2005 is Rs100 per box. Variable cost on opening stock is Rs40 per box. You are required to compute breakeven volume for the year 2005.

Answer

Shelf life is one year hence opening stock of 30,000 boxes is to be sold first. Contribution on these boxes is 30,000(100 – 40) = Rs18,00,000.

In the question production of 2004 is same as in 2005. Hence fixed cost for the year 2004 is Rs52, 00,000 (1, 30,000×40). Therefore fixed cost for the year 2005 is Rs57, 20,000 (52, 00,000 + 10% of 52, 00,000).

Variable Cost for the year 2005 (Rs40 + 25% of Rs40) = Rs50 per Unit

Hence Contribution per unit during 2005 is Rs50 (100 – 50)

Break even volume is the volume to meet the fixed cost i.e. fixed cost equals to contribution. Therefore, remaining fixed cost of Rs39, 20,000 (57, 20,000 – 18, 00,000) to be recovered from production during 2005.

Production in 2005 to reach BEP = 3920000 / 50 = 78,400 units

Therefore BEP for the year 2005 is 1, 08,400 boxes (30000 + 78400)

Question 29

Jay Kay Limited is a single product manufacturing company. The following information relates to the months of May and June, 2003:

		May	*June*
		Rs.	*Rs.*
(i)	*Budgeted Costs and Selling prices:*		
	Variable manufacturing cost per unit	*2.00*	*2.20*
	Total fixed manufacturing cost		
	(based on budgeted output of 25,000 units per month)	*40,000*	*44,000*
	Total fixed marketing cost	*14,000*	*15,400*
	Selling price per unit	*5.00*	*5.50*
(ii)	*Actual production and sales:*		
		Units	*Units*
	Production	*24,000*	*24,000*
	Sales	*21,000*	*26,500*

(iii) There was no stock of finished goods at the beginning of May, 2003. There was no wastage or loss of finished goods during May or June, 2003.

(iv) Actual costs incurred corresponded to those budgeted for each month.

You are required to calculate the relative effects on the monthly operating profits of applying: (i) Absorption costing and (ii) Marginal costing.

Answer

(a) Quantity tally:

		May 2003	*June 2003*
Opening Stock	units	–	3,000
Production	units	24,000	24,000
Total	units	24,000	27,000
Sales	units	21,000	26,500
Closing Stock	units	3,000	500
Fixed manufacturing overheads	Rs.	40,000	44,000
Budgeted output	units	25,000	25,000
Fixed overheads absorption rate per unit	Rs.	1.60	1.76

(i) Profitability based on absorption costing:

	May 2003 Rs.	June 2003 Rs.
Sales:		
May: 21,000 units @ Rs. 5.00	1,05,000	
June: 26,500 units @ Rs. 5.50		1,45,750
Production Costs:		
Variable: May 24,000 units @ Rs. 2.00	48,000	
June 24,000 units @ Rs. 2.20		52,800
Fixed: May 24,000 units @ Rs. 1.60	38,400	
June 24,000 units @ Rs. 1.76		42,240
Total production costs	86,400	95,040
Add: Opening stock		
May Nil		
June 3,000 units @ Res. 3.60*		10,800
Total	86,400	1,05,840
Less: Closing stock		
May 3,000 units @ Rs. 3.60*	10,800	
June 500 units @ Rs. 3.96*		1,980
Production cost of goods sold	75,600	1,03,860
Marketing fixed costs	14,000	15,400
Total cost of goods sold	89,600	1,19,260
Profit (Sales – COGS)	15,400	26,490
Budgeted output		
Actual output		
Shortfall		
Under recovery of fixed overheads		
May 1,000 units @ Rs. 1.60	1,600	
June 1,000 units @ Rs. 1.76		1,760
Net profit	13,800	24,730

*Total cost =	VC + FC
May	2.00 + 1.60 = 3.60
June	2.20 + 1.76 = 3.96

(ii) Profitability based on marginal costing:

	May 2003 Rs.	June 2003 Rs.
Sales	1,05,000	1,45,750
Production cost – variable	48,000	52,800
Add: Opening stock		
May Nil		
June		6,000
Total	48,000	58,800
Less: Closing stock		

May 3,000 units @ Rs. 2.00			6,000	
June 500 units @ Rs. 2.20				1,100
Variable cost of goods sold			42,000	57,700
Contribution			63,000	88,050
Fixed costs:	May	June		
Production	40,000	44,000		
Marketing	14,000	15,400	54,000	59,400
Net profit			9,000	28,650

Question 30

X Ltd. manufactures a semiconductor for which the cost and price structure is given below:

	Rs. per unit
Selling price	*500*
Direct material	*150*
Direct labour	*100*
Variable overhead	*50*
Fixed cost = Rs. 2 lakhs.	

The product is manufactured by a machine, whose spare part costing Rs. 2,000 needs replacement after every 100 pieces of output. This is in addition to the above costs. Assume that no defectives are produced and that the spare part is readily available in the market at all times at Rs. 2,000.

(i) Prepare the profitability statement for production levels of 2,000 units and 3,000 units, when fixed cost = Rs. 1 lakhs.

(ii) What is the break-even point (BEP) for the above data?

(iii) Comment on the BEP, if the fixed cost can be reduced to Rs. 1,80,000 from the existing level of 2 lakhs.

Answer

(i) X Ltd. Profitability Statement:

	Volume Level	
Particulars	2000 units	3000 units
	Rs.'000	
Sales	1,000	1,500
Variable costs		
Direct Material	300	450
Direct Labour	200	300
Variable overhead	100	150
Part costs*	40	60
Fixed cost	100	100
Total cost	740	1,060
Profit	260	440

*Part cost: $\frac{2,000}{100} \times 2,000 = 40,000$ $\frac{3,000}{100} \times 60,000 = 2,000$

(ii) For computing the BEP: Parts cost although a step fixed cost can be considered as variable for the limited purpose of computing the range in which BEP occurs. The variable parts cost per unit is Rs. $20\left(\frac{2,000}{100}\right)$.

Range in which the BEP occur	$\frac{1,00,000}{(200-20)} = 555.55$	$\frac{2,00,000}{(200-20)} = 1,111.11$
Range	501–600	1,101–1,200
General Fixed Cost	1,00,000*	2,00,000
Parts cost	(6 × 2,000) = 12,000	(12 × 2,000) = 24,000
Total Fixed Cost	1,12,000	2,24,000
Gross Contribution/unit**	200	200
BEP	560 units	1,120 units

**Gross Contribution per unit

Sales –Direct Material – Direct Labour – Variable Overheads

Rs. 500 – Rs. 150 – Rs. 100 –Rs. 50 = Rs. 200

(iii) When fixed cost is Rs. 1,80,000. Range of BEP will be $\frac{1,80,000}{180} = 1,000\,(901-1,000)$

Since the BEP of 1,000 falls on the upper most limits in the range 901 – 1,000 there will be one more BEP in the subsequent range in 1,001 – 1,100.

Range	901 – 1,000	1,001 – 1,100
	Rs.	Rs.
Gross fixed cost	1,80,000	1,80,000
Parts cost	20,000	22,000
	10 × 2,000	11 × 2,000
Total fixed cost	2,00,000	2,02,000
Gross contribution/unit	200	200
BEP	1,000 units	1,010 units

Question 31

A company has produced 1,500 units against a budgeted quantity of 2,000 units. Actual sales were 1,300 units. The company's policy is to value stocks at standard absorption cost.

Other data are:

Direct material	*Rs. 100 per unit*
Direct labour	*Rs. 100 per unit at normal efficiency*
Variable OH	*Rs. 50 per unit*
Fixed OH at budgeted capacity	*Rs. 1,00,000*
Variable selling OH	*Rs. 26,000*
Budgeted fixed selling OH	*Rs. 30,000*
Actual fixed selling OH	*Rs. 25,000*

Selling price	*Rs. 400 per unit*

There was no opening stock.

(i) Present the profitability statement under absorption costing system.

(ii) Assuming actual labour was 25% below normal efficiency and that 100 units of production had to be scrapped after complete manufacture, compute the actual profit or loss.

(iii) Reconcile the profits under (i) and (ii) above. *(May 2007,11, Marks)*

Answer

(i & ii) Profitability under absorption costing system — Actual profit and loss account

Particulars	*Rs. 000's*	*Particulars*	*Rs. 000's*
Sales (1,300×400)	520	Sales (1,300×400)	520
Absorption costs		Closing Stock (100×300)	30
Opening Stock	Nil	Total	550
Cost of production		Cost	
1,500 units × 300	450	Direct materials (1,500×100)	150
Less: Closing stock (200×300)	60	Direct labour (1,500×100/75%)	200
Net Absorption costs	390	Variable overhead (1,500×50)	75
Add: Under-absorption (500×50)	25	Fixed manufacturing overhead	100
Total absorption costs	415	Fixed Selling overhead	25
Gross profit	105	Variable selling overhead	26
Less: Selling overhead variable	26	Total costs	576
Selling overhead fixed	25		
Profit/(loss)	54	Profit / (Loss)	(26)

Working Notes:

	Rs.		Units
Absorption cost per unit		Budgeted capacity	2,000
Direct materials	100	Production	1,500
Direct labour	100	Under-absorption	500
Variable overhead	50	Sales	1,300
Fixed Overhead (1,00,000 / 2,000)	50	Closing stock	200
Total	300		

(iii) Reconciliation

	Rs. 000's
Profit under absorption costing	54
Less: Labour inefficiency**	(50)
Less: Value of units scrapped	(30)

Actual profit / (loss)	(26)

** (1,500× (133 1/3–100)

Note: In case budgeted fixed selling overheads are considered while arriving at absorption profit a saving of Rs. 5,000 shall need to be identified as part of reconciliation.

3 & 4

DECISION MAKING

Question 1

Universe Ltd. manufactures 20,000 units of 'X' in a year at its normal production capacity. The unit cost as to variable costs and fixed costs at this level are Rs.13 and Rs.4 respectively.

Due to trade depression, it is expected that only 2,000 units of 'X' can be sold during the next year. The management plans to shut-down the plant. The fixed costs for the next year then is expected to be reduced to Rs.33,000. Additional costs of plant shut-down are expected at Rs.12,000. Should be plant be shut-down? What is the shut-down point? (May 1996)

Answer

Note: The decisions regarding the plant to shut-down and the calculation of shut-down point requires the figure of selling price per unit of the units sold. As the statement of the question fails to indicate the selling price (per unit) therefore one is free assume it.

Assumption: Let's assume the Selling Price per unit be Rs.20.

Statement of cost for taking a decision about shut-down of plant

	Plant is operated Rs.	*Plant is shut down Rs.*
Variable Cost	26,000	-
	(2,000 units × Rs.13)	
Fixed Costs	80,000	33,000
	(20,000 units × Rs.4)	(unescapable cost)
Additional shut down cost	-	12,000
Total Cost	1,06,000	45,000
State of loss:		
Sales	40,000	
	(2,000 units × Rs.20)	
Less: Total Cost	1,06,000	45,000
(as above)		
Loss	(66,000)	(45,000)
	(if continued)	(if shut-down)

Recommendation: A comparison of loss figures indicated as above points out, that loss is reduced if the plant is shut-down. In fact by doing so the concern's loss would be reduced by (Rs.21,000).

$$\text{Shut-down point} = \frac{\text{Total fixed cost} + \text{Shut down costs}}{\text{Contribution per unit}}$$

$$= \frac{\text{Rs.}80{,}000 + \text{Rs.}45{,}000}{\text{Rs.}20 - \text{Rs.}13}$$

= 5,000 units

Question 2

ZED Ltd. manufactures two products P and Q and sells them at Rs.214 and Rs.320 per unit respectively. The variable costs per unit are as under:

	Product – P (Rs.)	Product Q (Rs.)
Raw materials		
Material – X	*22.00*	*28.00*
Material – Y	*8.00*	*32.00*
Direct wages (Rs.6 per labour hour):		
Department – A	*36.00*	*54.00*
Department – B	*18.00*	*36.00*
Department – C	*54.00*	*-*
Department – D	*-*	*72.00*
Variable overheads	*23.00*	*14.30*

The company procures raw materials against import licence. The company operates at single shift a day of 8 ours for 300 days in a year. The number of workmen engaged are 30, 16, 18 and 24 in departments A, B, C and D respectively. Neither the workers are subject to transfer from one department to another nor any new recruitment is possible at present. Fixed costs are Rs.12,000 per month.

You are required to find out the following:

(a) The product-mix to yield maximum profit.

(b) The most profitable product if only one product is to be manufactured. Whether the answer will differ if licence to import raw materials is released only Rs.1,80,000. *(Nov 1996)*

Answer

Working Notes:

1. Computation of total labour hours available

Department	*No. of workmen*	*Days*	*Hrs./day*	*Total hours*
(a)	*(b)*	*(c)*	*(d)*	*(e)=(b)×(c)×(d)*
A	30	300	8	72,000
B	16	300	8	38,400
C	18	300	8	43,200
D	24	300	8	57,600

2. Computation of hours required per unit of each product

Department		*Product P*			*Product Q*	
	Wages	*Wage/hr.*	*Hrs.*	*Wages*	*Wage/hr.*	*Hrs.*
	Rs.	*Rs.*		*Rs.*	*Rs.*	
	(a)	*(b)*	*(c)=(a)/(b)*	*(d)*	*(e)*	*(f)=(d)(e)*
A	36	6	6	54	6	9
B	18	6	3	36	6	6
C	54	6	9	-	-	-
D	-	-	-	72	6	12
	Total hours per unit:		18			27

3. Statement showing maximum output permissible

Departments Hours	*Product P*	*Product Q*

	available	Hrs. required / unit	Maximum output in Units	Hrs. required / unit	Maximum output in Units
	(a)	(b)	(c) = (a) / (b)	(d)	(e) = (a) / (d)
A	72,000	6	12,000	9	8,000
B	38,400	3	12,800	6	6,400
C	43,200	9	4,800*	-	-
D	57,600	-		12	4,800*
Total hours p.u.:		18		27	

* This shows that either 4,800 units of product P or Q can be obtained by utilising the available hours in the four departments.

4. Productwise contribution per hour

	Product P	Product Q
	Rs.	Rs.
Selling price p.u. (A)	215	320
Total raw material cost p.u.		
(Rs.28 + Rs.32)	30	60
Total wages per unit		
(Rs.36 + Rs.18 + Rs.54)		
(Rs.54 + Rs.36 + Rs.72)	108	162
Variable overheads p.u.	23	14.30
Total variable cost p.u. (B)	161	236.30
Contribution p.u. [(A)-(B)]	54	83.70
Labour hours p.u.	18	27
Contribution per labour hour	3	3.10
	(Rs.54/18 hrs)	Rs.83.70/27 hrs)

(a) Though the contribution per labour hour of Product Q is better but there is a constraint viz., the numbers of workers in each department can neither be interchanged nor newly recruited, hence due to this following two alternatives would arise which may help in deciding about the product mix to yield maximum profit.

Alternative I: Producing 4,800 units of Product Q and utilising the remaining available hours of labour for making units of Product P.

Alternative II: Producing 4,800 units of product P and utilising the remaining available hours of labour for making units of Product Q.

Statement of Product mix under Alternative I

Department	Available hours	Hours required for 4,800 unit of Q	Remaining Hours	Hrs./Unit of Product P	Units of Product P
	(a)	(b)	(c)=(a)-(b)	(d)	(e)=(c)/(d)
A	72,000	43,200	28,800	6	4,800
B	38,400	28,800	9,600	3	3,200
C	43,200	-	43,200	9	4,800
D	57,600	57,600	Nil	-	-

The above table shows that out of the available hours under Alternative I; 4,800 units of Product Q and 3,200 units of Product P can be made.

Department	*Available hours*	*Hours required for 4,800 unit of Q*	*Remaining Hours*	*Hrs./Unit of Product P*	*Units of Product*
	(a)	*(b)*	*(c)=(a)-(b)*	*(d)*	*(e)=(c)/(d)*
A	72,000	28,800	43,200	9	4,800
B	38,400	14,400	24,000	6	4,000
C	43,200	43,200	-	-	-
D	57,600	-	57.600	12	4,800

The above table shows that out of the available hours under Alternative II; 4,800 units of Product P and 4,000 units of Product Q can be made.

Profit Statement under above Alternatives

Products	*First Alternative*			*Second Alternative*		
	Units	*Contribution p.u. (Rs.)*	*Amount (Rs.)*	*Units*	*Contribution p.u. (Rs.)*	*Amount (Rs.)*
P	3,200	54.00	1,72,800	4,800	54.00	2,59,200
Q	4,800	83.70	4,01,760	4,000	83.70	3,34,800
Total Contribution:			5,74,560			5,94,000
Less: Fixed cost p.a.			1,44,000			1,44,000
Profit			4,30,560			4,50,000

Second alternative is the most profitable product mix.

(b) Statement of most profitable product if only one product is to be manufactured.

Products	*P*	*Q*
Contribution per unit (Rs.) : (A)	54.00	83.70
Maximum possible output (in units): (B)	4,800	4,800
Total Contribution: (A) × (B)	2,59,200	4,01,760

Total Q is to be preferred.

Statement of most profitable product if only one product is to be manufactured and licence to import the raw material is only for materials worth Rs.1,80,000

Products	*P*	*Q*
Raw material required p.u. (Rs.)	30	60
Permissible output in units out of imported material of Rs.1,80,000	6,000	3,000
Maximum output possible in the available hours	4,800	4,800
Output possible keeping in view the availability of imported material and labour hours (units)	4,800	3,000
Contribution per unit (Rs.)	54	83.70
Total contribution (Rs.)	2,59,200	2,51,100

	(4,800 units × Rs.54)	(3,000 units × Rs.83.70)

Product P is to be preferred (i.e. answer fifers) because of imported licence restriction which in only available for purchasing material worth only Rs.1,80,000.

Question 3

Universe Ltd. manufactures two products X and Y. It is facing severe competition in the market. The monthly sales potential in units at different selling prices as anticipated by the Sales Manager are as under:

Product – X		*Product – Y*	
Selling price per unit (Rs.)	*Sales potential (in units)*	*Selling price per unit (Rs.)*	*Sales potential (in units)*
110	*5,000*	*78*	*30,000*
108	*7,500*	*77*	*32,000*
107	*8,000*	*75*	*35,000*
103	*8,400*	*72*	*40,000*
96	*9,000*	*69*	*45,000*

The total cost as disclosed by the budgets of the company are as follows:

	Product X		*Product Y*	
Output and sales per month (units)	*5,000*	*9,000*	*30,000*	*45,000*
Total costs per month (Rs. in lacs)	*5*	*6.6*	*18*	*25.5*
Labour hours needed per month	*20,000*	*36,000*	*60,000*	*90,000*

You are required to find out the selling price and units to be sold to earn maximum profit where (a) labour hours are available without any restriction and (b) only 95,000 hours are available.

(May 1997)

Answer

Working Notes:

1. Computation of variable cost p.u and fixed cost (p.m.) of two products 'X' and 'Y' of Universe Ltd.

Products	*X*	*Y*
	Rs.	*Rs.*
Variable cost per unit	40	50
$\left(\frac{\text{Change in total cost of a product}}{\text{Change in the output of the product}}\right)$	$\left(\frac{\text{Rs.1,60,000}}{\text{4,000 units}}\right)$	$\left(\frac{\text{Rs.7,50,000}}{\text{15,000 units}}\right)$
Fixed cost	3,00,000	3,00,000
(Total cost – variable cost)	(Rs.5,00,000 – Rs.2,00,000)	(Rs.18,00,000 – Rs.15,00,000)

2. Selling price and sales level of maximum contribution

Product X				*Product Y*			
Selling price p.u. Rs.	*Contribution per unit Rs.*	*Units*	*Total Contribution (Rs. in lacs)*	*Selling price p.u. Rs.*	*Contribution (S.P.V.C.) Rs.*	*Units*	*Total Contribution (Rs. in lacs)*

110	70	5,000	3.5	78	28	30,000	8.4
108	68	7,500	5.1	77	27	32,000	8.64
107	67	8,000	5.36	75	25	35,000	8.75
103	63	8,400	5.292	72	22	40,000	8.80
96	56	9,000	5.04	69	19	45,000	8.55

Maximum contribution of two products X and Y are Rs.5.36 (Lakhs) and 8.80 (Lakhs) at selling prices Rs.107 and Rs.72 respectively.

3. Incremental contribution per labour hour of Products X and Y (Refer to Working Note 2)

Product X				*Product Y*			
Selling price p.u. Rs.	*Incremental Contribution (Rs .in lacs)*	*Incremental labour hours (units × 4 hrs.)*	*Contribution per hour Rs.*	*Selling price p.u. Rs.*	*Incremental Contribution (Rs .in lacs)*	*Incremental labour hours (units × 2 hrs.)*	*Contribution per hour Rs.*
(1)	(2)	(3)	(4)=(2)/(3)	(5)	(6)	(7)	(8)=((6)/(7)
110	3.5	20,000	17.50	78	8.40	60,000	14.00
108	1.6	10,000	16.00	77	0.24	4,000	6.00
107	0.26	2,000	13.00	75	0.11	6,000	1.83
103	(40.068)	1,600	(-4.25)	72	0.05	10,000	0.50
96	(-0.252)	2,400	(-10.50)	69	(-0.25)	10,000	(2.50)

4. Ranking of Products X and Y based on the incremental Contribution per hour as per Working Note 3.

S. No.	*Selling price Rs.*	*Incremental Contribution per hour Rs.*	*Product*	*Ranking*
1.	110	17.50	X	I
2.	108	16.00	X	II
3.	78	14.00	Y	III
4.	107	13.00	X	IV
5.	77	6.00	Y	V
6.	75	1.83	Y	VI
7.	72	0.50	Y	VII

(a) Statement of selling price and units to earn maximum profit (No restriction on the availability of labour hours)

Product		*X*	*Y*	*Total*
Output and sales (in units) of optimum Contribution per month	(1)	8,000	40,000	
(Refer to Working Note 2)				
Selling price p.u. (Rs.)		107	72	
Contribution (Rs. / Unit)	(2)	67	22	
(Refer to Working Note 2)				
Total contribution (Rs.)	(1)×(2)	5,36,000	8,80,000	14,16,000

Less: Fixed Cost (Rs.)	3,00,000	3,00,000	6,00,000
(Refer to Working Note 1)			
Profit			8,16,000

(b) Statement of selling price and units to earn maximum profit when only 95,000 labour hours available (Refer to Working Note 4)

Products	*Selling Price*	*Incremental Contribution per hour*	*Incremental Units*	*Labour hours*	*Total Contribution*
	Rs.	*Rs.*			*(Rs. in lacs)*
X	110	17.50	5,000	20,000	3.50
X	108	16.00	2,500	10,000	1.60
Y	78	14.00	30,000	60,000	8.40
X	107	13.00	500	2,000	0.6
Y	77	6.00	1,500	3,000	0.18
				95,000	13.94
Less: Fixed costs					6.00
Profit					7.94

* Balancing figure

Question 4

A machine manufactures 10,000 units of a part, at a total cost of Rs.21 of which Rs.18 is variable. This part is readily available in the market at Rs.19 per unit.

If the part is purchased from the market then the machine can either be utilised to manufacture a component in same quantity contributing Rs.2 per component or it can be hired out at Rs.21,000.

Recommend which of the alternative is profitable? (May 1997)

Answer

1st Alternative:

(10,000 units of the part are manufactured internally)

Variable cost of 10,000 units

@ Rs.18/- p.u. (Rs.)1,80,000

2nd Alternative:

(10,000 units of the part are purchased from the market and the machine is utilized to manufacture 10,000 units of a component contributing Rs.2/- per unit)

Purchase cost of 10,000 units

@ Rs.19/- p.u. (Rs.)1,90,000

Less: Contribution received on the utilization of machine time

10,000 units × Rs.2 = 20,000

1,70,000

3rd Alternative:

(10,000 units of the part are purchased from outside and the machine time is hired out at Rs.21,000).

Purchase cost of 10,000 units.	
@ Rs.19/- p.u. (Rs.)1,90,000	
Less: Rent received on hiring out the machine	21,000
	1,69,000

Important Note

In this problem fixed cost is not relevant for decision making, therefore it has been ignored.

Recommendation:

Out of the above three alternative, 3rd Alternative is the best, as the cost of 10,000 required units under it is the lowest.

Question 5

X Ltd. has two factories, one at Lucknow and another at Pune producing 7,200 tonnes and 10,800 tonnes of a product against the maximum production capacity of 9,000 and 11,880 tonnes respectively at Lucknow and Pune.

10% of the raw material introduced is lost in the production process. The maximum quantity of raw material, available locally is 6,000 and 13,000 tonnes at Rs.720 and Rs.729 per tonne at Lucknow and Pune respectively. For the additional needs a supplier of Bhopal is ready to supply raw material at our factory site at Rs.792 per tonne.

Other variable costs of the production process are Rs.22.32 lacks and Rs.32.94 lacs and fixed costs are Rs.18 lacs and Rs.24.84 lacs respectively for Lucknow and Pune factory.

The output is sold at a selling price of Rs.1,450 and Rs.1,460 per tonne by Lucknow and Pune factory respectively.

You are required to compute the cost per tonne and net profit earned in respect of each factory.

Can you suggest any other alternative production plan for both the factories without any change in present total output of 18,000 tonnes whereby the company may earn optimum profit? *(Nov 1997)*

Answer

Statement of cost per tonne and net profit earned in respect of each factory

	Lucknow	*Pune*
Present production tonnes: (A)	7,200	10,800
	Rs.	Rs.
Cost of raw material (Rs. in lacs)	59.04	87.48
(Refer to working note 1)		
Other variable costs (Rs. in lacs)	22.32	32.94
Fixed cost (Rs. in lacs)	18.00	24.84
Total cost (Rs. in lacs): (B)	99.36	145.26
Cost per tonne (Rs) : (C) = [(B) / (A)]	1,380	1,345
Selling price (Rs. Per tonne: (D)	1,450	1,460
Net profit per tonne (Rs.) : [(D) – (C)]	70	115
Total net profit (Rs. in lacs)	5.04	12.42
	(Rs.70 ×7,200 tonnes)	(Rs.115×10,800 tonnes)

Total profit of the company = Rs.15.46 lacs

(Rs.5.04 lacs + Rs.12.42 lacs)

Alternative production plan to earn optimum

	Lucknow	*Pune*
Maximum production capacity (tonnes)	9,000	11,880
Present production (tonnes)	7,200	10,800
	Rs.	Rs.
Cost per tonne of output:	800	810
Cost per tonne of output manufactured from locally purchased raw material: (A)		
(Refer to working note 2)		
Cost per tonne of output manufactured from material purchased from Bhopal : (B)	880	880
(Return to working note 3)		
Other variable cost (Rs.) : (C)	310	305
	$\left(\frac{\text{Rs.22.32 Lacs}}{\text{7,200 tonnes}}\right)$	$\left(\frac{\text{Rs.32.94 Lacs}}{\text{10,800 tonnes}}\right)$
Selling price per tonne (Rs.) : (D)	1,450	1,460
Contribution per tonne of Output : [(D)–{(A)+(C)}]	340	345
Contribution per tonne of Output : [(D) – {(B)+(C)}]	260	275
(When material was purchased from Bhopal)		

The priority to produce 18,000 tonnes of total output is as below as apparent from the above data:

	Priority
Pune factory (Local purchase of raw material)	1st
Lucknow factory (local) purchase of raw material)	2nd
Pune factory (raw material purchased from Bhopal)	3rd
Lucknow factory (raw material purchased from Bhopal)	4th

Suggested alternative production plan :

	Production priority	*Raw Material*	*Output (in tonnes)*		
		Input(in tonnes)	*Lucknow*	*Pune*	*Total*
I	11,700 tonnes	13,000	--	11,700	11,700
II	5,400 tonnes	6,000	5,400	--	5,400
III	(11,880 – 11,700) = 180 tonnes	200	--	180	180
IV	720 tonnes balancing figure (18,000 – 17,280 tonnes)	800	720	--	720
		20,000	6,120	11,880	18,000

Working Notes:

		Lucknow	*Pune*
1.	Present production output (tonnes)	7,200	10,800
	Total raw material required for present production (tonnes)	8,000	12,000
		$\left(7{,}200 \times \frac{100}{90}\right)$	$\left(10{,}800 \times \frac{100}{90}\right)$

	Raw material produced locally (tonnes)	6,000	12,000
	Raw material product from Bhopal	2,000	--
	Cost of raw material purchased locally	59.04	87.48
	and from Bhopal (Rs. in lacs)	(Rs.720×6,000+ Rs.792 × 2,000)	(12,000 × Rs.729)
2.	Cost per tone of output manufactured from locally purchased raw material	800	810
	(in Rs.)	$\left(720 \times \frac{100}{90}\right)$	$\left(729 \times \frac{100}{90}\right)$
3.	Cost per tonne of output manufactured from material purchased from Bhopal	880	880
	(in Rs.)	$\left(792 \times \frac{100}{90}\right)$	

Question 6

A Company can produce and sell at its maximum capacity 20,000 units of a product. The sale price is Rs.100. the present sales is 15,000 units. To produce over 20,000 units and upto another 10,000 units some balancing equipments are to be installed at a cost of Rs.10 lakhs and the same will have a life span of 10 year.

The current cost structure is as under:

Direct material	*30% of the sale value*
Direct labour	*20% of sale value*
Variable Overheads	*Rs.20 per unit*
Profit	*Rs.15 per unit*

The present cost is estimated to go up due to price escalation as under:

10% in Direct Material from present level of 30%

25% in Direct Labour from present level of 20%

Rs.50,000 in Fixed overheads per year.

There is a concrete proposal from a party to take 10,000 units additionally over the present level of output on a long-term basis at a unit price of Rs.90. Apart from the investment of Rs.10 lakhs, as shown above, the fixed overheads will increase by Rs.50,000 due to additional Administrative expenses.

The Company is in a dilemma as to whether to accept the order for 10,000 units or to use the present unused capacity of 5,000 units for which there will be additional selling expenditure or Rs.50,000.

Ignore financing charges and give your recommendation. *(Nov 1998)*

Answer

Working Note:

Fixed overheads	Rs.
Present sale value: (A)	15,00,000
(15,000 units ×Rs.100)	
Direct materials	4,50,000
(30% of sale value)	

Direct labour	3,00,000
(20% of the value)	
Variable overheads	3,00,000
(Rs.20 per unit)	..
Total variable costs (B)	10,50,000
Contribution: (C) = (A) – (B)	4,50,000
Profit : (D)	2,25,000
(15,000 units × Rs.15)	.
Fixed overheads: (C) – (D)	2,25,000
(current level)	
Add: Additional fixed overheads due to price escalation	50,000
Total fixed overheads:	2,75,000

Statement of profitability for various alternatives

Alternatives	*I*	*II*	*III*	*IV*
	Rejecting the proposal for the purchase of 10,000 units and continuing with present level of sales only	Rejecting the proposal for the purchase of 10,000 units from a party and attaining the maximum capacity by incurring additional selling expenditure	Accepting the proposal of the party to take 10,000 units @ Rs.90 per units by installing a balancing equipment and continuing with present level of sales	Accepting the proposal of the party to take 10,000 units @ Rs.90 per cent by installing a balancing equipment and attaining sale of maximum available capacity by incurring additional selling expenditure
Sale (units)	15,000	20,000	25,000	30,000
	Rs.	Rs.	Rs.	Rs.
Sales Value: (A)	15,00,000 (15,000 × Rs.100)	20,00,000 (20,000 × Rs.100)	24,00,000 (15,000 × Rs.100+10,000 × Rs.90	29,00,000 (20,00,000 × Rs.100 + 10,000 × Rs.90)
Variable costs				
Direct material	4,95,000	6,60,000	8,25,000*	9,90,000*
(33% of sales value)				
Direct Labour	3,75,000	5,00,000	6,25,000*	9,90,000*
Variable overheads	3,00,000	4,00,000	5,00,000	6,00,000
(@Rs.20 per unit)				
Total variable costs: (B)	11,70,000	15,60,000	19,50,000	23,40,000

Fixed costs				
Fixed overheads	2,75,000	2,75,000	2,75,000	2,75,000
(Refer to working note)				
Additional selling expenditure	-	50,000	-	50,000
Depreciation for balancing equipment	-	-	1,00,000	1,00,000
Additional administrative expenses	-	-	50,000	50,000
Total fixed cost : (C)	2,75,000	3,25,000	4,25,000	4,75,000
Total cost D: [(B)+(C)]	14,45,000	18,85,000	23,75,000	28,15,000
Profit: (A)-(D)	55,000	1,15,000	25,000	85,000

Note: For computing the material and labour cost under alternative III & IV the notional sale price of Rs.100 is taken for additional 10,000 units.

Recommendation: Alternative II is the best as it gives maximum profit.

Question 7

A firm needs a component in an assembly operation. If it wants to do the manufacturing itself, it would need to buy a machine for Rs.4 lakhs which will last for 4 years with no salvage value. Manufacturing costs in each of the 4 years would be Rs.6 lakhs, Rs.7 lakhs, Rs.8 lakhs and Rs.10 lakhs respectively. If the firm had to buy the components from a supplier, the cost would be Rs.9 lakhs, Rs.10 lakhs, 11 lakhs and Rs.14 lakhs respectively in each of the four years. However, the machine would occupy floor space which would have been used for another machine. This later machine would be hired at no cost to manufacture an item, the sale of which would produce net cash flows in each of the four years of Rs.2 lakhs. It is impossible to find room for both the machines and there are no other external effects. The cost of capital is 10% and the present value factor for each of the four years in 0.909, 0.826 0.751 and 0.683 respectively.

Should the firm make the components or buy from outside? *(May 1999)*

Answer

Evaluation of Make or Buy proposal

(All figures are in lakhs in rupees)

Year	*P.V. factors at 10%*	*When the component is manufactured*		*When the component is bought from an outside supplier*	
		Cash outflow (Capital cost + manufacturing cost + opportunity cost)	*Present Value*	*Cash outflow (Buying cost)*	*Present Value*
		Rs.	*Rs.*	*Rs.*	*Rs.*
(a)	(b)	(c)	(d)=(b)×(c)	(e)	(f)=(b)×(e)

0	1.000	4	4.000	-	-
1	0.909	6+2	7.272	9	8.181
2	0.826	7+2	7.434	10	8.260
3	0.751	8+2	7.510	11	8.261
4	0.683	10+2	8.196	14	9.562
Total			34.412		24.264

Saving in cash outflow (when brought from outside) = [total present value of cash outflow, when the component is manufactured internally] − [Total present value of cash outflow, when the component is bought from outside.]

= Rs.24.412 – Rs.34.264

= Rs.0.148 (lakhs)

Conclusion: Since there is a saving of Rs.0.148 (lakhs) in buying the component from outside, therefore, we should stick to this decision.

Note: The loss of Rs.2 lakhs cash inflow for each of the four years due to the inability of the firm to operate another machine if it manufactures the component has been treated as an opportunity cost.

Question 8

Veejay Ltd., makes and sells two products, Vee and Jay. The budgeted selling price of Vee is Rs.1,800 and that of Jay is Rs.2,160. Variable costs associated with producing and selling the Vee are Rs.900 and with Jay Rs.1,800. Annual fixed production and selling costs of Veejay Ltd. are Rs.88,000.

The company has two production/sales options. The Vee and Jay can be sold either in the ratio of one Vees to three Jays or in the ratio of one Vee to two Jays.

What will be the optimal mix and why? *(Nov 1999)*

Answer

Statement of best optimal mix B

	Rs.	Rs.
Budgeted selling price p.u.	1,800	2,160
Less: Variable cost p.u.	900	1,800
Contribution p.u.	900	360

(I) Production / Sales option : (2 units of Vee and 3 units of Jays)

Total contribution under 1st option

= (2 units × Rs.900 + 3 units × Rs.360)

= Rs.1,800 + Rs.1,080 = Rs.2,880

Break-even point $= \dfrac{\text{Annual fixed Production \& Selling costs}}{\text{Total Contribution under 1st option}}$

$= \dfrac{\text{Rs.88,000}}{\text{Rs.2,880}}$ = 30.56 (sets of 5 units each)

Products

Vee	*Jay*	*Total*

Break-even point (units)	30.56 × 2 units	30.56 × 3 units	
	= 61.12 units	= 91.68 units	
	= 61 (units approx.)	= 92 (units approx)	
Break-even sales (Rs.)	= 1,09,800	= 1,98,720	3,08,520
	(61 units × Rs.1,800)	(92 units × Rs.2,160)	

(II) Production / Sales option: (1 unit of Vee and 2 units of Jays)

Total contribution under IInd option

= (1 unit × Rs.900 + 2 units × Rs.360)

= Rs.900 + Rs.720 = Rs.1,620

Break-even point

$= \frac{\text{Rs.}88{,}000}{\text{Rs.}1{,}620}$ = 54.32 (set of 3 units each)

	Products		
	Vee	*Jay*	*Total*
Break-even point (Units)	54.32 × 1 unit	54.32 × 2 units	
	= 54 (units approx.)	= 109 (units approx.)	
Break-even sales (Rs.)	= 97,200	= 2,35,440	32,32,640
	(54 units × Rs.1,800)	(109 units × Rs.2,160)	

Note :

The given amount of annual fixed production and selling cost is such that it fails to determine the exact figure of break-even point under two given sales options. The approximations made in the above solutions under option 1, at break-even sales level over recovers Rs.20; whereas under option II of the solution there is an under recovery of fixed cost to the extent of Rs.150.

Decision and reasoning:

Option I is preferred over option II, as it results in a lower level of sales to reach break-even (because of higher average contribution per unit sold). The average contribution per unit (under option I) is Rs.576 (Rs.2,880/5 units) and (under option II) it is Rs.540 (Rs.1,620/3 units). Option I contains a higher percentage (40% as against 33 1/3%) of more profitable products.

Question 9

(a) *Product 'A' takes five hours to produce on a particular machine and it has a selling price of Rs.50 and a marginal cost of Rs.35.*

On the same machine, another product 'B' can be made at two hours at a marginal cost of Rs.5 per unit.

Supplier's price of product 'B' is Rs.10 per unit.

Assuming that machine hour is the key factor, advise whether product 'B' could be bought out or manufactured.

(b) *R Ltd. will produce 3,00,000 kgs. Of S and 6,00,000 kgs. Of Y from an input of 9,00,000 kgs. of raw material Z.*

The selling price of S is Rs.8 per kg and that of Y is Rs.6 per kg.

Processing costs amount to Rs.54 lacs per month as under:

Raw material Z 9,00,000 kgs. at Rs.3 per kg.	*Rs.27,00,000*

Variable processing costs	*Rs.18,00,000*
Fixed processing costs	*Rs.9,00,000*
Total	*Rs.54,00,000*

There is an offer to purchase 60,000 kgs. of Y additionally at a price of Rs.4 per kg. The existing market for Y will not be affected by accepting the offer. But the price of S is likely to be decreased uniformly on all sales.

Find the minimum reduced average price for S to sustain the increased sales. (Nov 1999)

Answer

(a)

	Rs.
Selling price per unit of product 'A'	50
Less: marginal cost per unit	35
Contribution per unit	15
Contribution per hour of product 'A'	3

Since one unit of product 'B' needs 2 hours, therefore if a unit of B is produced, then the contribution lost by not producing 'A' = 2 hours × Rs.3 = Rs.6

Real cost of producing one unit of product 'B'

	Rs.
Marginal cost per unit	5
Add: Contribution lost per unit	6
Total cost of producing a unit of Product 'B'	11

As the suppliers price per unit of product 'B' is Rs.10 and that of producing in the factory is Rs.11, therefore it is suggested that it is better to buy product 'B' from outside.

(b) Since S and Y are produced simultaneously from an input of raw material Z, therefore when additional 60,000 kgs. of Y will be produced then 30,000 of S will also be produced simultaneously. The input of material Z required for these additional 60,000 kgs. of Y and 30,000 kgs. of S will be 90,000 kgs. of material Z. Hence the cost of processing 90,000 kgs. of material will be as follows:

	Rs.
Cost of Raw material Z	2,70,000
(90,000 kgs. × Rs.3)	
Variable processing cost	1,80,000
(90,000 kgs. × Rs.2)	
Total cost of processing	4,50,000
Less: Sales revenue from 60,000 kgs. of Y	2,40,000
(60,000 kgs. × Rs.8)	
Balance cost to be recovered	2,10,000
Current sales revenue from the sale of 3,00,000 kgs. of S	24,00,000
(3,00,000 kgs. × Rs.8)	
Total sales revenue to be earned from the Sale of S	26,10,000

(3,00,000 kgs. + 30,000 kgs.)	
Hence minimum reduced price per kg. of S to recover Rs.26.10,000 from the sale of 3,30,000 kgs. of S (Rs.26,10,000 / 3,30,000 kgs.)	7.91

Question 10

GG Ltd. manufactures and sells an equipment called water purifier. The cost data for each batch often numbers of water purifier is as follow:

Components	*A*	*B*	*C*	*D*	*E*
Machine Hours	*20*	*28*	*24*	*-*	*-*
Labour Hours	*-*	*-*	*-*	*4*	*2*
	Rs.	*Rs.*	*Rs.*	*Rs.*	*Rs.*
Variable Costs	*64*	*108*	*116*	*24*	*8*
Fixed costs as Apportioned	*36*	*52*	*64*	*26*	*22*

Assembly costs (all variable) Rs.50 per batch.

Selling price Rs.800 per batch.

Maximum available machine capacity for making components A, B and C is 10,800, hours and it cannot be increased further. Labour is available for making components D and E and for assembling the product.

Estimated increase in demand next year is 50% and fixed costs in general may increase Rs.10,000.

In order to increase production capacity to meet increased market demand, the company decided to purchase one of the machine made components.

Quote Ltd. is the only supplier of components A, B and C. Because of incomplete records it is unable to quote single figure prices. It is quotation is as follows:

Component	*Pessimistic view Rs.*	*Probability*	*Most Likely view Rs.*	*Probability*	*Optimistic view Rs.*	*Probability*
A	*120*	*0.25*	*110*	*0.5*	*80*	*0.25*
B	*200*	*0.25*	*130*	*0.5*	*140*	*0.25*
C	*160*	*0.25*	*140*	*0.5*	*120*	*0.25*

It is agreed between the companies that the price of each of the components will be determined on an overall basis based on information found in the quotation.

You are required to:

(i) Indicate, in the context of key factor, the maximum number of batches that could be produced, if each of the three alternatives namely buying A or B or C is considered.

(ii) Analyse the financial implication of purchase and advise which component is to be bought keeping in view the fact that production capacity will be limited to a 50% increase.

(iii) Prepare a profit Statement for the period assuming that the component chosen by you is bought out and extra production is made and sold. *(May 2000)*

Answer

Working Notes:

1. Present demand of components (in batches) from 10,800 (maximum) available machine hours and projected estimates of components demand (in batches) in the next year.

Maximum available machine hours			10,800
Machine hours needed to manufacture components. A, B and C (Per batch of ten numbers) of water purifier			
Components			Total
A	20	Machine hours	
B	28	Machine hours	
C	24	Machine	72 hours
Present demand (in batches) of components A, B and C (10,800 hours/ 72 hours)			150
Projected estimate of demand of components A, B and C (add 50% increase) in the next year			225

2. Present and future fixed costs:

Present fixed cost of 150 batches @ Rs.200/- per batch	30,000
Add: Increase in fixed cost to meet 50% increase in demand	10,000
Total future fixed cost for 225 batches	40,000

3. Expected purchase cost of components

View point	*Probability*	*Component*		
		A	*B*	*C*
		Expected price Rs.	*Expected Price Rs.*	*Expected Price Rs.*
Pessimistic	0.25	30 (Rs.120×0.25)	50 (Rs.200×0.25)	40 (Rs.160×0.25)
Most likely	0.50	55 (Rs.110×0.50)	65 (Rs.130×0.50)	70 (Rs.140×0.50)
Optimistic	0.25	20 (Rs.80×0.25)	35 (Rs.140×0.25)	30 (Rs.120×0.25)
Total		105	150	140

4. Present contribution (per batch)

	Rs.	*Rs.*
Selling price (per batch)		800
Less: Variable production cost	320	
Less: Variable assembly cost	50	370
Contribution (per batch)		430
Total Present contribution on 150 batches		64,500

(i) Maximum number of batches that could be produced in 10,800 machine hours each of the three alternatives namely buying A or B or C is considered respectively.

(a) Buy component A (from outside) No machine hour required

Make component B 28 Machine hours required

Make component	C	<u>24</u>	Machine hours required
	Total	<u>52</u>	

Number of batches that could be produced internally 207.69 batches

(10,800 hours/52 hours)

(b)	Buy component	B (from outside)		No machine hour required
	Make component	A	20	Machine hours required
	Make component	C	<u>24</u>	Machine hours required
		Total	<u>44</u>	

Number of batches that could be produced internally 245.45 batches

(10,800 hours/744 hours)

But in view of projected (expected) market demand of 225 batches, production would be restricted to 225 batches only.

(c)	Buy component	C (from outside)		No machine hours required
	Make component	A	20	Machine hours required
	Make component	B	28	Machine hours required
		Total	48	

Number of batches that could be produced internally 225 batches

(10,800 machine hours 748 hours)

(ii) Statement of financial implication when purchases of component A, B and C are made from outside

(in view of the fact that production capacity will be limited to 50% increase)

Component bought	*A*	*B*	*C*
	Rs.	*Rs.*	*Rs.*
Total variable cost per batch (I)	64	108	116
Expected purchase cost (II)	<u>105</u>	<u>150</u>	<u>140</u>
(Refer to working note 3)			
Increase I variable cost per batch (III) = (II – I)	41	42	24
Present contribution per batch (IV)	430	430	430
(Refer to working note 4)			
Revised contribution per batch (V) = (IV – III)	389	388	406
Total revised contribution	80,791	87,300	91,330
	(207.69 batches × Rs.389)	(225 batches × Rs.388)	(225 batches × Rs.406)

Advise: Purchase component C from outside as it gives maximum contribution on manufacturing A and B internally.

(iii) Profit Statement

(When C is bought from outside and A, B were manufactured internally and extra production is made and sold)

	Per Batch Rs.	*Total (for 225 batches)*

			Rs.
Sales revenue: (I)		800.00	1,80,000 (225 batches × Rs.800)
Less: Variable costs (Rs. (Per batch) : (II)			
Production cost of A	Rs.64		
Production cost of B	Rs.108		
Production cost of D	Rs.24		
Production cost of E	Rs.8		
Production cost of C	Rs.140		
(Refer to working note 3)			
Rs.344			
Assembly cost	Rs.50	394.00	88.650 (225 batches × Rs.394)
Contribution : (III) – (-II)		406.00	91,350
Less: Fixed costs		177.78	40,000
(Rs.40,000 / 225 batches)			
(Refer to working note 2)			
Profit		228.22	51.350

Question 11

Unique Products manufactures and sells in a year 20,000 units of a particular product to definite customers at a price of Rs.100 per unit. The concern has a capacity to produce 25,000 unit of the product per annum. To produce beyond 25,000 units per annum, the concern will have to install a new equipment at a cost of Rs.15 lakhs. The equipment will have a life span of 10 years and will have no residual value. There is an offer from a client to purchase 10,000 units of the product regularly at a price of Rs.90 per unit. The order accepted, will have to be over and above the existing level of production of 20,000 units.

The cost structure is as under:

	Per Unit
Direct Material	*30*
Direct Labour	*20*
Variable Overhead	*10*
Profit	*20*

During the coming year, it has been estimated that the cost of direct material, as company the current year will increase by 10%. Because of certain wage agreement direct labour will increase by 25%. Fixed overheads will increase by 10%. If the new order for 10,000 is accepted, fixed overheads will increase further by Rs.60,000 due to increased administrative charges.

You are required to analyse whether the concern should accept the order or instead of that try to secure order for the balance unused capacity, as available now, through some sales promotion expenses which will be Rs.50,000 per annum. Ignore financial charges for the new investment.

(May2000)

Answer

Comparative profit Statement (based on Revised Cost Structure)

	Proposal 1	*Proposal 2*	*Proposal 3*
	Sell 20,000 units only	Secure orders for 5,000 additional units (unused capacity) and sell 25,000 units	Accept the new order for 10,000 additional units and sell 30,000 units
	Rs.	Rs.	Rs.
Total sales revenue (A)	20,00,000	25,00,000	29,00,000
	(Rs.20,000 units × Rs.100)	25,000 units × Rs.100)	(30,000 units + Rs.33)
Director Labour	5,00,000	6,25,000	7,50,000
	(20,000 units × Rs.25)	(Rs.25,000 units × Rs.10)	(30,000 units + Rs.10)
Variable overhead	2,00,000	2,50,000	3,00,000
	(20,000 units × Rs.10)	(25,000 units × Rs.10)	(30,000 units + Rs.10)
Fixed overheads	4,40,000	4,40,000	4,40,000
	(Rs.4,00,000 + Rs.40,000)		
Add: Administrative charges	-	-	60,000
Add: Sales promotion expenses	-	50,000	-
Depreciation (New equipment)			1,50,000
Total cots (B)	18,00,000	21,90,000	26,90,000
Profit (C) = [(A) – (B)]	2,00,000	3,10,000	2,10,000

Analysis

An analysis of the profit figures of M/s Unique products under three proposals clearly shows that it is maximum under proposal 2. Therefore, it is advisable for the concern to produce and sell 25,000 units @ Rs.100/- per unit and utilise its full production capacity.

Question 12

A firm furnishes the following information:

Capacity in Units	*Unit Cost*	*Unit Price*
	Rs.	*Rs.*
2,000	*40*	*100*
3,000	*35*	*95*
4,000	*34*	*94*
5,000	*32*	*-*
6,000	*31*	*-*

At present the firm is operating at 4,000 units capacity and has received an order for 2,000 units from an export market at Rs.28 per unit. Should the order be accepted? (May 2000)

Answer

Statement of Increment Cost and Incremental Revenue

Capacity in units	Unit cost Rs.	Total cost Rs.	Incremental cost Rs.	Unit price Rs.	Total price Rs.	Incremental revenue Rs.
(a)	(b)	(c)=(a)×(b)	(d)	(e)	(f)=(a)×(e)	(g)
200	40	80,000	-	100	2,00,000	-
3000	35	1,05,000 (Rs.1,05,000 – Rs.80,000)	25,000	95	2,85,000	85,00,000 (Rs.2,85,000 - Rs.2,00,000)
4000	34	1,36,000 Rs.1,36,000 – 1,05,000)	31,000	94	3,76,000	91,000 (Rs.3,76,000 – Rs.2,85,000)
5,000	32	1,60,000	24,000 (Rs.1,60,000 – Rs.1,36,000)	-	-	-
6,000	31	1,86,000	26,000 (Rs.1,86,000 – Rs.1,60,000)	-	-	-

Decision:

At 4,000 units capacity told sales revenue is Rs.3,76,000 and the total cost is Rs.1,36,000 leaving a profit of Rs.2,40,000. The profit figure at this level clearly shows that the fixed expenses stand fully recovered. Hence, we have to take incremental cost for further level levels of output. For an additional sales of 2,000 units incremental cost is Rs.50,000 (Rs.1,86,000 – Rs.1,36,000) and the cost per unit is Rs.25 $\left(\frac{\text{Rs.50,000}}{\text{2,000 units}}\right)$

Since the price quoted per unit is Rs.28, which is more than Rs.25, therefore, the order should be accepted.

Question 13

A Co. Ltd. manufactures several different styles of jewellery cases. Management estimates that during the third quarter, the company will be operating at 80 percent of the normal capacity. Because the company desires a higher utilisation of plant capacity, the company will consider a special order.

The company has received special order inquiries from two companies. The first order is from JCP Co. Ltd., which would like to market a jewellery case similar to one of A Co. Ltd.'s jewellery cases. JCP jewellery case would be marketed under JCP's own label. JCP Co. Ltd. has offered A Co. Ltd. Rs.57.50 per jewellery case for 20,000 cases to be shipped by the last date of the quarter. The cost data for A Co. Ltd. jewellery case that would be similar to the specifications of JCP special order are as follows:

	Rs.
Regular selling price per unit	*90*
Cost per unit	

Raw Materials	*25*
Direct Labour 0.5 hour @ Rs.60	*30*
Overhead 9.25 machine hour @ Rs.40	*10*
Total Costs	*65*

According to the specifications provided by JCP Co., the special order case requires less expensive raw materials. Consequently the raw materials will only cost Rs.22.50 per case. Management has estimated that the remaining costs, labour time and machine time will be the same as for A Co. Ltd. jewellery case.

The second special order was submitted by K Co. Ltd. for 7,500 jewellery cases at Rs.75 per case. These jewellery cases, like the JCP cases, would be marketed under K label and have to be shipped by the last date of the quarter. However, the K Jewellery case is different from any jewellery case in the A Co. Ltd. line. The estimated per unit cost of this case are as follows:

	Rs.
Raw Materials	*32.50*
Direct Labour 0.5 hour @ Rs.60	*30.00*
Overhead 0.5 machine hour @ Rs.40	*20*
Total Costs	*92.50*

In addition, A Co. Ltd will incur Rs.15,000 in additional setup costs and will have to purchase a Rs.25,000 special device to manufacture these cases, this device will be discarded once the special order is completed.

The A Co. Ltd.'s manufacturing capabilities are limited to the total machine hours available. The plant capacity under normal operations is 90,000 machine hours per year or 7,500 machine hours per month. The budgeted fixed overhead for the Current year amounts to Rs.21,60,000. All manufacturing overhead costs are applied to production on the basis of machine hours at Rs.40 per hour.

A Co. Ltd. will have the entire quarter to work on the special orders. Management does not expect any repeat sales to be generated from either special order. Company practice precludes from subcontracting any portion of an order, when special orders are not expected to generate repeat sales.

Required: Should A Co. Ltd. accept either special order? Justify your answer and show the calculations.

(Nov 2000)

Answer

Statement showing profits on the acceptance of special orders in 4,500 unutilised hours (Refer to working note 1)

Alternatives	*I*	*II*
	JCP Co. Ltd.	K. Co. Ltd.
Units made	18,000	7,500
	Rs.	Rs.
Selling price per unit	57.50	75.00
Less: Cost per unit	56.50	70.50
(Refer to working note 2)		
Profit per unit	1.00	4.50
Total profit	18,000	33,750
	(18,000 units × Re.1)	(7,500 units × Rs.4.50)

Less: Costs of set up and special device	NIL	40,000
Net Profit / (Loss)	18,000	(6,250)

Note: For special orders allocation of fixed overhead costs are not relevant.

Decision:

(i) If special order o JCP Co. Ltd. can be bifurcated, the company can supply 18,000 units of jewellery cases and can earn additional profit of Rs.18,000. The remaining 2,000 units of order cannot be met due to capacity constraint.

(ii) The special order from K. Co. Ltd. is not acceptable as it results into loss to the extent of Rs.6,250.

Working Notes:

1. Total unutilized hours during the third quarter

Total hours of third quarter	22,500
(7,500 hours × 3 months)	
Hours utilized for 80% operating level	16,000
(22,500 hours × 80%)	
Total unutilized hours during the third quarter	4,500

2. Computation of fixed and variable overhead rate

Fixed overheads per annum (Rs.)	21,60,000
Normal capacity hours	90,000
Fixed overheads rate per hour (Rs.)	24
(Rs.21,60,000 / 90,000 hours)	
Manufacturing overhead application rate per hour (Rs.)	40
Therefore, variable overhead rate per hour Rs.	16
(Rs.40 – Rs.24)	

3. Cost per unit of the order form JCP Col Ltd. and K. Co. Ltd.

	JCP Co. Ltd.	*K. Co. Ltd.*
	Rs.	*Rs.*
Raw materials cost per unit	22.50	32.50
Direct Labour	30.00	30.00
Variable overheads	4.00	8.00
	(0.25 hours × Rs.16)	(0.5 hours × Rs.16)
Total cost per unit	56.50	70.50

Question 14

State the non-cost factors to be considered in make/buy decisions. *(May 2001)*

Answer

Non-cast factors in make / buy decisions:

(i) Possible use of released production capacity and facility as a result of buying instead of making.

(ii) Sources of supply should be reliable and they are capable of meeting un-interruptedly the requirement of the concern.

(iii) Assurance about the quality of goods supplied by outside supplier.

(iv) Reasonable certainty, from the side of supplier about, meeting the delivery dates.

(v) The decision of buying the product / component from outside suppliers should be discouraged, if the technical know how used is highly secretive.

(vi) The decision of buying from outside sources should not result in the laying off of workers and create industrial relation problems. In fact, on buying from outside the resources freed should be better utilised else where in the concern.

(vii) The decision of manufacturing product / component should not adversely affect the concern's relationship with suppliers.

(viii) Ensure that more than one supplier of product/component is available to reduce the risk of outside buying.

(ix) In case the necessary technical expertise is not available internally then it is better to buy the requirements from outside.

Question 15

A company manufactures two products P and Q. Both the products pass through the company's two departments, A and B. The market demand for a month is 2,500 units of P and 2,000 units of Q. The company has a normal capacity of 600 hours in department A and 520 hours in department B per month. Overtime is acceptable upto 50% of normal hours in each department. The details relating to the products are as under:

			Products	
			P	*Q*
Direct material cost per unit		*Rs.*	*10*	*5*
Fixed overheads per month		*Rs.*	*18,000*	*6,400*
			Department	
			A	*B*
Direct labour time per unit (Minutes)				
Product	*P*		*6*	*12*
	Q		*18*	*12*
Direct wage rate per hour				
	Normal Time	*Rs.*	*10*	*12*
	Overtime	*Rs.*	*15*	*18*

In the event of the company not being able to fulfil the demand for want of capacity, the balance quantity of the products can be sold by buying from a sub-contractor, who has agreed to supply product P at Rs.18 and product Q at Rs.12 per unit.

Required:

(i) Calculate the quantity of each product to be manufactured and / or to be subcontracted in a most economical way of fulfilling the market demand.

(ii) Present a statement showing the total costs involved in your solution in (i) above. (May 2001)

Answer

Working notes:

1.

(a) Total normal and overtime hours available.

	Department A	Department B
Normal capacity hours	600	520
Overtime hours	300	260
(50% of normal hours in each department)		
Total available hours	900	780

(b) Total hours required to meet fully the market demand of 2,500 units of P and 2,000 units of Q.

	Department A	Department B
Hours required for manufacturing P 2,500 units of Product	250	500
	(2,500 Units × 0.1 hour)	(2,500 Units × 0.2 hour)
Hours required for manufacturing Q 2,000 units of Product	600	400
	(2,000 Units × 0.3 hour)	(2,000 Units × 0.2 hour)
Total hours required	850	900

2. Sub-contracting should be resorted:

   To meet the market demand of 2,500 units of product P and 2,000 units of product 850 and 900 hours [Refer to working note 1(b)] are required in departments A and B respectively. In department B only 780 hours are available and thus does not meet fully the requirement of 900 hours. Hence, sub-contracting should be resorted to meet the market demand fully.

3. (i) Contribution per unit;

Product	*P*		*Q*	
	Normal hours	*Overtime hours*	*Normal hours*	*Overtime hours*
Director material cost (Rs.)	10.00	10.00	5.00	5.00
Direct labour cost Dept. A (Rs.)	1.00	1.50	3.00	4.50
	(Rs.10 × 0.1 hr.)	(Rs.15 × 0.2 hrs.)	(Rs.10 × 0.3 hrs.)	(Rs.15 × 0.3 hrs.)
Dept. B: (Rs.)	2.40	3.60	2.40	3.60
	(Rs.12 × 0.2 hrs.)	(Rs.18 × 02 hrs.)	(Rs.12 × 0.2 hrs.)	(Rs.18 × 0.2 hrs.)
Total variable cost per unit (Rs.) : (A)	13.40	15.10	10.40	13.10
Sub-contract price per unit (Rs.) : (B)	18.00	18.00	12.00	12.00
Contribution / cost saving / (Loss per unit (Rs.)	4.60	2.90	1.60	1.10
(C) = [(B) – (A)]				

(ii) Contribution per hour

Hours required per unit				
Dept. A	0.1	0.1	0.3	0.3
Dept. B	0.2	0.2	0.2	0.2
Contribution per hour				
Dept. A (Rs.)	46	29	5.33	Loss
	(Rs.4.60/0.1 hrs.)	(Rs.2.90/0.1 hr.)	(Rs.1.60/0.3 hrs.)	--
Dept. B (Rs.)	23	14.50	8.0	Loss
	(Rs.4.60/0.2 hrs.)	(Rs.2.90/0.2 hr.)	(Rs.1.60/02. Hrs.)	--

4. Utilization of normal and overtime available hors to meet fully monthly market demand of 2,500 units of P and 2,000 of Q.

   (i) An analysis of contribution statement (Refer to working note 3) clearly shows that 2,500 units of the product P should be manufactured by utilising the normal capacity hours of departments A and B. The manufacturing of 2,500 units of P will consume 250 normal hours of department A and 500 hours of department B (Refer to working note 1(b).

   (ii) For manufacturing 2,000 units of product Q, it is beneficial to utilise the remaining normal available hours of departments A and B. The normal available hours in the department B are only 20 hours, [520 hours – 500 hours] and in department A 350 hours [600 hours – 250 hours]. 100 units of product Q can be manufactured by utilising the normal available hours of departments A and B. The manufacturing of 100 units of Q in normal available hours will utilise 30 hours in department A and 20 hours in department B.

   (iii) Now for manufacturing the remaining 1,900 units of product Q, we have 320 normal hours plus 300 overtime hours in department A and 260 overtime hours in the department B. The manufacturing cost per unit of product Q comes to Rs.11.60 when normal hours of department A and overtime hours of department B are utilized.

   {Rs.5 (Material Cost) + Rs.3 (Direct Labour in Department A) + Rs.3.60 (Direct Labour in Department B)}

   On comparing Rs.11.60 with sub-contracting price of Rs.12 per unit, we arrive at a contribution of 0.40 per unit. Hence maximum number of units of product Q should be manufactured by using normal hours of department A and overtime hours of department B. since 0.3 and 0.2 hours are required respectively for manufacturing one unit of product Q in the two departments, therefore, utilising 320 normal hours and 213 overtime hours in departments A and B respectively, 1066.66 units (or say 1,067 units) of product Q are manufactured.

   (iv) Finally, to manufacture remaining 833 units of Q, the available time is 300 overtime hours and 47 overtime hours in department A and B respectively. According to (working note 1) the available time in department B is short by 120 hours (900 required hours – 780 available hours) therefore 833 units of Q cannot be made internally. But few units can be made by utilising the available overtime hours in departments A and B. The manufacturing cost of 1 unit of Q by utilizing overtime hours in departments A and B comes to Rs.13.10 (Refer to working note 3) which on comparison with subcontract price of Rs.12 gives rise to a situation of loss of Rs.1.10 per unit {Rs.13.10 – Rs.12}. Hence it is advisable not to manufacture the remaining 833 units internally. These 833 units should be sub-contracted at a price of Rs.12/- per unit.

(i) Statement of quantity of each product to be manufactured / or to be sub-contracted for fulfilling the market demand in most economical way.

	Departments			
	A		*B*	
	Normal time hours	*Overtime hours*	*Normal time hours*	*Overtime hours*
Available hours (Refer to working note 1(i)	600	300	520	260
Production 2,500 units of P	250	--	500	--
(Refer to working note 4 (i))	(2,500 units × 0.1 hrs.)		(2,500 units × 0.2 hrs.)	
100 units of Q	30	--	20	--
(Refer to working note 4 (ii)	(100 units × 0.3 hrs.)		(100 units × 0.2 hrs.)	
1067 units of Q	320	--	--	213
(Refer to working note 4(iii))	(1,067 units × 0.3 hrs.)		(1,067 units × 0.2 hrs.)	

(ii) Statement Showing Total Cost

(Based on the solution in (i) above)

	Products			
Particulars	*P*	*Q*	*Sub contract price*	*Total*
	Rs.	*Rs.*	*Rs.*	*Rs.*
Direct Material Cost	25,000	5,835	-	30,855
	(2,500 units × Rs.10)	(1,167 units × Rs.5)		
Direct Wages:				
Dept. A	2,500	3,500	--	6,000
	(250 hours × Rs.10)	(350 hours × Rs.10)		
Dept. B	6,000	4,074	--	10,075
	(500 hours × Rs.12)	(20 hours × Rs.12 + 213 hours × Rs.18		
Fixed overhead	18,000	6,400	-	24,400
Cost of 833 units @ Rs.12 per unit on sub-contracting	--	--	9,996	9,996
Total Cost	51,500	19,809	9,996	81,305

Question 16

Enumerate the factors involved in decisions relating to expansion of capacity *(May 2001)*

Answer

The factors involved in decisions relating to expansion of capacity are enumerated as below:

(i) Additional fixed overheads involved should be considered.

(ii) Possible decrease in selling price due to increased production capacity.

(iii) Whether the demand id sufficient to absorb the increased production.

Question 17

In 19×1, the turnover of a company, which operated at a margin of safety of 25% amounted to Rs.9,00,000 and its profit volume ratio was 33-1%. During 19×2, the company estimated that although the same volume of sales as in 19×1 would be maintained, the sales value would go down due to decrease in selling price. There will be o change in variable costs. The company proposes to reduce its fixed costs through an intensive cost reduction programme. These changes will alter the profit volume ratio and margin of safety to 30% and 40% respectively in 19×2.

Even if the company closed down its operations in 19×2, it would incur a minimum fixed cost of Rs.50,000.

Required:

(i) Present a comparative statement indicating the sales, variable costs, fixed costs and profit for 19×1 and 19×2.

(ii) At what minimum sales will the company be better off by locking up in business in 19×2?

(May 2001)

Answer

(i) Comparative Statement (indicating sales, variable costs, fixed costs and profit)

Year	*19×(Refer to working note 1)*	*19×(Refer to working note2)*
	Rs.	*Rs.*
Sales	9,00,000	8,57,143
Variable costs	6,00,000	6,00,000
Fixed costs	2,25,000	1,54,286
Profit	75,000	1,02,857

(ii) Minimum sales at which the company will be better off if it locks up minimum fixed cost of Rs.50,000 when company closed down its operation in 19×2.

Relevant fixed production costs in the year 19×2	Rs.1,04,286
(Rs.1,54,286 – Rs.50,000)	
Minimum sales required to recover the relevant fixed cost is	Rs.3,47,620
(Contribution / P/V ratio) or (Rs.10,04,286 / 30%)	

Working Notes:

1. Year 19×1

	Rs.
Sales: (A)	9,00,000
Variable cost: (B)	6,00,000
(66 – 2/3% of sales)	
Contribution: C = {(A) – (B)}	2.00,000
Break even sales	6,75,000
(75% of sales is break even sales as margin of safety is 25%)	
Fixed cost: (D)	2,25,000
(B.E.S. × P/V ratio)	

(Rs.6,75,000 × 33 – 1/3%)

Profit : {(C) – (D)}	75,000

2. (a) Year 19×2

Sales (A)	
Variable costs : (A)	6,00,000
(as it remains same and equals that of year 19×1)	
Contribution : (C) = (A – V)	(x – 6,00,000)

Since P/V ratio = $\frac{\text{Contribution}}{\text{Sales}}$

$\therefore \frac{30x}{100} = (x - 6,00,000)$

On solving above relations:

x (sales) = Rs.8,57,143 (approx)

(b)

Sales (A)	8,57,143
Variable costs : (B)	6,00,000
Contribution : C = (A – B)	2,57,143
Break even sales	5,14,286
(60% of sales)	
Fixed costs: (D)	1,54,286
(B.E.S. × P/V ratio)	
Profit (C – D)	1,02,857)

Question 18

X Ltd. has incurred losses during the past five years. Its projection for the year 2002 is also not very encouraging. The management is seriously considering the closure of the only manufacturing unit. However, it is quite open to getting the products o a sub-contracting basis and to continue its administrative and marketing functions. Currently, four products are being manufactured and sold by catering do different markets. The management is also willing to sacrifice any of these products to ensure survival.

The projections for the four products for 2002 are:

(Rs. in crores)

	A (Rs.)	*B (Rs.)*	*C (Rs.)*	*D (Rs.)*
Sales	*72.0*	*54.0*	*84.0*	*60.0*
Costs:				
Material	*48.0*	*30.0*	*54.0*	*36.0*
Labour	*18.0*	*12.0*	*30.0*	*30.0*
Allocated Overheads:				
Manufacturing	*6.0*	*4.8*	*7.2*	*4.8*
Admin. & Selling	*2.4*	*1.2*	*3.6*	*2.4*
Total Cost	*74.4*	*48.0*	*94.8*	*73.2*
Profit / Loss)	*(2.4)*	*6.0*	*(10.8)*	*(13.2)*

The projected volume and sub-contracting chares are:

	A	B	C	D
Volume ('000 nos.)	*2,000*	*1,500*	*3,000*	*2,000*
Sub-contracting charges / unit (Rs.)	*80*	*70*	*90*	*130*

Manufacturing, administrative and selling overheads consists of staff salaries, rent, essential maintenance and tax payable to the local authorities.

In case the management decides to discontinue the manufacturing operations a minimum notice period of 3 months will be required to be given to the staff as well as to the landlords of the manufacturing unit and offices. You may assume that both the manufacturing as well as the administrative and selling overheads are fixed in nature, and that in the notice period mentioned above, these expenses would continue to be incurred.

- *Assume that labour costs are related to the volume of operations and do not involve any notice period for discontinuance;*
- *Assume that the costs are incurred and revenues earned evenly in each of the calendar months.*

Based on the above, you are required to advise the management on the best option out of the options under its consideration, viz.:

(i) Issue notices to the staff, the landlords of manufacturing unit and offices on the first day of the year and discontinue all the operations on that very day.

(ii) Issue notices as above on the first day of the year and continue the operations till the end of the notice period (only profitable products need to be continued).

(iii) Issues notices to the staff and the landlord, only in the manufacturing unit, resort to sub-contracting and to continue the administrative and marketing functions. (Sub-contracting is needed to be done on profitable products only). *(Nov 2001)*

Answer

(i) Option

Statement of Profit (Loss)

(if the firm discontinue all the operations during notice period of 3 months)

(Rs. Crores)

Products	*A*	*B*	*C*	*D*	*Total*
Sales*	-	-	-	-	-
Costs:					
Material & Labour	-	-	-	-	-
Allocated overheads:					
Manufacturing	1.5	1.2	1.8	1.2	5.7
Admin. & Selling	0.6	0.3	0.9	0.6	2.4
Total allocated overheads during notice period of 3 months	2.1	1.5	2.7	1.8	8.1
Profit / (Loss)	(2.1)	(1.5)	(2.7)	(1.8)	(8.1)

*The option (i) would not yield any revenue.

Conclusion: The option (i) will result in a loss of Rs.8.1 crores due to the committed costs account of 3 months notice period.

(ii) Option

Working note:

Ascertaining profitable products (if their production is continued during 3 months of notice period)

				(Rs. Crores)
Products	*A*	*B*	*C*	*D*
Sales (X)	18	13.5	21	15
Variable cost:				
Materials	12.0	7.5	13.5	9.0
Labour	4.5	3.0	7.5	7.5
Total variable costs: (Y)	16.5	10.5	21.0	16.5
Contribution: (X – Y)	1.5	3.0	-	(1.5)

A review of contribution figures in the above statement of four products A, B, C and D clearly reveals that products A and B are only profitable.

Statement of Profit (Loss)

(If the firm continues the operations of profitable products A and B during 3 months of notice period)

			(Rs. Crores)
Products	*A*	*B*	*Total*
Contribution (Refer to above working note)	1.5	3.0	4.5
Less: total manufacturing administrative & selling overheads (Refer to part (i) above)			8.1
Profit / (Loss)			(3.6)

Conclusion: Under this option the total loss is (Rs.3.6) crores which is less than the loss of option (i).

(iii) Option

Working Note:

Ascertaining profitable products (when notices are issued to the staff and the landlord – only in the manufacturing unit, resort to subcontracting only on profitable products)

				(Rs. Crores)
Products	*A*	*B*	*C*	*D*
Sales: (X)	72.0	54.0	84.0	60.0
Variable Cost:				
Materials	48.0	30.0	54.0	36.0
Sub-contracting charges	16.0	10.5	27.0	26.0
	(20 lacs × Rs.80)	(15 lacs × Rs.70)	(30 lacs × Rs.90)	(20 lacs × Rs.130)
Total variable costs : (Y)	64.0	40.5	81.0	62.0
Contribution: (X – Y)	8.0	13.5	3.0	(2.0)

A review of contribution figures in the above statement clearly shows that products A, Band C are only profitable.

Statement of Profit / (Loss)

(If the firm resorts to manufacturing of profitable products by sub-contracting)

(Rs. Crores)

	Product			*Total*
	A	*B*	*C*	
Contribution: (X)	8.0	13.5	3.0	24.5
(Refer to above working note)				
Total manufacturing overheads of 3 months notice period : (Y)				5.7
(Refer to option (i) above)				
Total administrative & Selling overheads: (Z)				9.6
Profit/(Loss): {X – (Y+Z)}				9.2

Decision:

Out of the three options the option (iii) is the most viable one. Not only it will help the company with a turn around, but from the year 2002, the company can look forward to even higher profitability, since the manufacturing overhead would no longer be incurred thereafter.

Question 19

(a) *Discuss the role of costs in product-mix decisions.* *(Nov 2001)*

(b) *P Ltd. manufactures plastic cans of a standard size. The variable cost per can is Rs.4 and the selling price is Rs.10 each. The factory of the company has eight machines of identical size. Any individual machine can produce 30 cans per hour. The factory works on 300 days per annum basic and the actual available hour per machine per day is 7.5. The company has an order of 4,20,000 cans from an oil company, to supply. The yearly fixed cost of the company is Rs.20 lacs. P Ltd has received an order from another firm for supplying 60,000 nos. of plastic moulded toys. The price of the toys is Rs.60 each and the variable cost is Rs.50 each. While this order would be acceptable for supplying for total quantities only, on acceptance, a special mould costing Rs.2,25,000 would required to be acquired to manufacture the toys. The time study exercise has revealed that 15 nos. of toys can be produced per hour by any of the machines;*

Advise the company, with reasons in the following situations:

(i) *Whether to accept the order of manufacturing moulded toys, in addition to supplying 4,20,000 nos. of cans or not;*

(ii) *Whether to accept the order of manufacturing moulded toys, if the order of cans increases to 5,40,000 nos. or not;*

(iii) *While a sub-contractor is willing to supply the toys, either while or part of the required quantities at an all inclusive rate of Rs.57.50 each, what would be the minimum excess capacity needed to justify the manufacturing of any portion of the toys order, instead of sub-contracting?*

(iv) *The company had an understanding that the orders of the cans will be increased during the year on negotiation, and planned and manufactured 4,50,000 cans during the year. For utilizing the excess capacity, they also accepted the toys order and sub-contracted only 15,000 nos. of toys. At the year's end, however, it was revealed that the order of the cans could be for 4,80,000 nos., if it was properly negotiated. How much loss has been suffered by the company due to improper prediction of demand and negotiation?*

(Nov 2001)

Answer

(a) Role of costs in product mix decisions: All types of cost involved in cost accounting system are useful in decision making. The cost which plays a major role in product mix decision is the relevant cost. Costs to be relevant should meet the following criteria:

(i) The costs should be expected as future costs.

(ii) The costs differ among the alternatives course of action.

While making decision about product mix using the facilities and other available resources, the end results should always aim at profit minimisation. Variable costs are relevant costs in product mix decisions and consequently contribution plays a major role in minimisation of profit. In addition to the relevancy of costs, the other factors and costs that should be taken into account at the time of deciding the products mix are:

(i) The available production capacity

(ii) The limiting factor (s)

(iii) Contribution per unit of the limiting factor

(iv) Market demand for the products.

(v) Opportunity costs

(b) (i)

Statement showing Profit / Loss of company

(If it accepts the order of manufacturing moulded toys)

Total available machine hours: (A)	18,000
(8 machine × 7.5 hours / day × 300 days)	
Machine hours required for producing	
4,20,000 cans: (B)	14,000
(4,20,000 cans /30 cans)	
Balance machine hours: {(A) – (B)]	4,000
Total number of production of moulded toys in balance hours	60,000
(4,000 hours × 15 toys / hour)	
Total contribution on 60,000 moulded toys (Rs.)	6,00,000
(60,000 × Rs.10)	
Less: Fixed expenses of mould (Rs.)	2,25,000
Net profit	(Rs.) 3,75,000

Decision: It is advisable for the company to accept the order of 60,000 moulded toys as it will increase its profit by Rs.3,75,000.

(ii) Statement showing Profit / Loss

(If the order of manufacture of cans increase to 5,40,000)

If 5,40,000 cans are produced, no machine hours would be available for manufacturing toys

	Rs. (Lacs)
Total contribution on 5,40,000 cans	32.40
5,40,000 cans × Rs.6)	
Less: Fixed cost	20.00
Profit	12.40

Alternatively, the production would be 4,20,000 cans and 60,000 moulded toys

Rs. (lacs)

A.	Profit from 4,20,000 cans:	
	Contribution	25.20
	(4,20,000 cans × Rs.6)	
	Less: Fixed cost	20.00
	Profit	5.20
B.	Profit from 60,000 moulded toys	3.75
	(Refer to (i) above)	
	Total profit: (A + B)	8.95

Decisions: The production of 1,20,000 additional cans instead of 60,000 moulded toys will result an additional profit of Rs.3.45 lacs (Rs.12.40 lacs – Rs.8.95 lacs). Therefore, the company is advised not to accept the order of manufacturing moulded toys.

(iii) Let the minimum excess capacity needed to justify the manufacturing of any portion of the moulded toys order be x.

If toys are manufactured, the profit is	= (Rs.60 – Rs.50) x – Rs.2,25,000
and, if toys are sub-contracted, the profit is	= (Rs.60 – Rs.57.50) x
Indifference point would be 10x – Rs.2,25,000	= 2.5x
or x	= 30,000 moulded toys
Toys produced per hour	=15 toys

Therefore, 2,000 (30,000 toys / 15 toys) excess machine hours are required to justify manufacturing of toys by the company, instead of sub-contracting.

(iv) Profit under existing production plan:

	(Rs. Lacs)
Contribution from 4,50,000 cans	27.00
(4,50,000 × Rs.6)	
Contribution from 45,000 toys	4.50
(45,000 × Rs.10)	
Total contribution	31.50
Less: Fixed cost	22.25
(20 lacs + 2.25 lacs)	
Profit	9.25
Profit from 15,000 sub-contracted toys	0.375
(15,000 × Rs.2.50)	
Total profit	9.625

If demand was accurately forecasted & 4,80,000 cans were manufactured, excess machine hour capacity available was 2,000 hrs, such excess being the pint of indifference i.e. profit from toys order would be the same by either manufacturing 30,000 toys or sub-contracting them along with the rest of 30,000 toys.

(v) Profit under properly negotiated production plan:

(Rs. Lacs)

Contribution from 4,80,000 cans	28.80
(4,80,000 × Rs.6)	
Less: Fixed cost	20.00
Profit	8.80
Profit from Toys	1.50
60,000 Nos. sub-contracted	
(60,000 × Rs.2.5)	
Total profit	10.30

Therefore, the loss for improper prediction and negotiation is Rs.10,30,000 – Rs.9,62,500 or Rs.67,500.

Question 20

A company has two plants – one at Sambalpur and the other at Bilaspur, where production of goods takes place.

The basic raw material requirement is 80% of the finished product, by weight. Such materials are available locally, but are limited to 6,000 M.T. at Rs.1,800 per M.T. at Sambalpur and 16,000 M.T. at Rs.2,000 per M.T. at Bilaspur. Any extra requirements will have to be procured from Jamshedpur at Rs.2,500 per M.T. Other details are as under:

	For unit at Sambalpur	*For unit at Bilaspur*
Annual output (M.T.)	*12,000*	*15,000*
Capacity utilisation (%)	*80*	*60*
Other variables (Rs. lacs)	*156*	*192*
Fixed cost (Rs. lacs)	*108*	*120*

You are required to determine:

(i) The cost break-up of each unit per M.T. of output;

(ii) The quantity of production at each unit from the availability of local supplies of basic raw material only, by keeping the same total production of the company, as a whole;

(iii) Cost savings, if any, as per the revised schedule of production. *(Nov 2001)*

Answer

(i) Statement of Cost break-up

	Sambalpur		*Bilaspur*	
	Total cost (Rs. Lacs)	*Cost per M.T. of output (Rs.)*	*Total cost (Rs. Lacs)*	*Cost per M.T. output (Rs.)*
Material cost	198	1,650	240	1,600
(Refer to working note)	(6,000 M. T. × Rs.1,800 + 3,600 M. T. × Rs.2,500)	(Rs.198 lacs/ 12,000 M. T.)	(12,000 M. T. × Rs.12,000)	(Rs. 240 lacs/ 15,000 M. T.)
Other variables	156	1,300	192	1,280
		(156 lacs/ 12,000 M. T.)		(192 lacs/ 15,000 M. T.)
Fixed Cost	108	900	120	800
		(108 lacs/ 12,000 M. T.)		(120 lacs/ 15,000 M. T.)

Total Cost	462	3,850	552	3,680

Working Note:

	Sambalpur	Bilaspur
Annual output (M. T.)	12,000	15,000
Maximum possible output (M. T.)	15,000	25,000
	(12,000/80%)	(15,000/60%)
Basic raw material requirement (M. T.)	9,600	12,000
	(12,000 × 80%)	(15,000 × 80%)
Material available locally (M. T.)	6,000	16,000
Possible output from local material (M. T.)	7,500	20,000
	(6,000 / 80%)	(16,000 / 80%)

(ii) Quantity of production at each unit from the availability of local supplies of basic raw material:

	Sambalpur	Bilaspur
Maximum output/ possible (M. T.)	15,000	25,000
(Refer to above working note)		
Material cost/ M. T. of output from locals (Rs.)	1,440 (6,000 × Rs.1,800) / 7,500 M T.	1,600
Other variables / M. T. of output from locals (Rs.)	1,300	1,280
[Refer to part (i)]		
Total variable cost / M. T. of output	2,740	2,880
Possible output (M. T.) from local supplies of basic raw material	7,500	19,500
		(Balancing Figure)

(iii) Cost saving as per revised schedule of production :

	Sambalpur *(Rs. lacs)*	*Bilaspur* *(Rs. lacs)*	*Total* *(Rs. lacs)*
Total variable cost of output	205.5	561.6	767.1
(Refer to part ii)	(7,500 M. T. × Rs.2,740)	(19,500 M. T. × Rs.2,880)	
Fixed Cost	108.0	120.0	228.0
Total cost: (A)	313.5	681.6	995.1
Previous total cost: (B)	462.0	552.0	1014.0
[as per (i) above]			
Cost savings: {(B) – (A)}	148.5	(129.6)	18.9

Question 21

State the relative economics of the "makes vs. buy" decision in management control. *(Nov 2001)*

Answer

The relative economics of the "make vs. buy" decision is management control:

Generally for taking a make vs. buy decision comparison is made between the supplier's price and the marginal cost of making plus the opportunity cost. Make vs. buy decision is a strategic decision, and, therefore, both short-term as well as well as long-term thinking about various cost and other aspects needs to be done.

A company generally buy a component instead of making it under following situations:

1. If it costs less to buy rather than to manufacture it internally;
2. If the return on the necessary investment to be made to manufacture is not attractive enough;
3. If the company does not have the requisite skilled manpower to make;
4. If the concern feels that manufacturing internally will mean additional labour problem;
5. If adequate managerial manpower is not available to take charge of the extra work of manufacturing;
6. If the component shows much seasonal demand resulting in a considerable risk of maintaining inventories;
7. If transport and other infrastructure facilities are adequately available;
8. If the process of making is confidential or patented;
9. If there is risk of technological obsolescence for the component such that it does not encourage capital investment in the component.

Question 22

XYZ Limited is currently manufacturing 5,000 units of the product 'XY 100' annually, making full use of its machine capacity. The selling price and total costs per unit associated with 'XY 100' are as follows:

	Rs.	Rs.
Selling price per unit		*900*
Costs per unit:		
Direct materials	*200*	
Variable machine operating costs	*150*	
(Rs.100 per machine hour)		
Manufacturing overhead costs	*180*	
Marketing and administrative costs	*200*	*730*
Operating income per unit of 'XY 100'		*170*

XYZ Limited can sell additional 3,000 units of 'XY 100', if it can outsource those additional units.

ABC Limited, a supplier of quality products, ahs agreed to supply upto 6,000 units of 'XY 100' per year at a price of Rs.650 per unit delivered at XYZ's factory.

XYZ Limited can use its facility to produce an alternative product 'XY 200'. It can sell up to 12,000 units of 'XY 200' annually. Estimated selling price and total costs per unit to manufacture and sell 12,000 units of 'XY 200' are as follows:

	Rs.	Rs.
Selling price per unit		*600*
Costs per unit:		
Direct materials	*200*	
Variable machine operating costs	*50*	

(Rs.100 per machine hour)		
Manufacturing overhead costs	*60*	
Marketing and administrative costs	*110*	*420*
Operating income per unit of 'XY 100'		*180*

Other information pertaining to the operation of XYZ Limited is as follows:

(a) XYZ Limited use machine hour as the basis for assigning fixed manufacturing overhead. The fixed manufacturing overhead for the current year is Rs.3,00,000. These costs will not be affected by the product-mix decision.

(b) Variable marketing and administrative costs per unit for various products are as follows:

Manufactured	*'XY 100'*	*Rs.80*
Purchased	*'XY 100'*	*Rs.40*
Manufactured	*'XY 200'*	*Rs.60*

Fixed marketing and administrative costs for the current year is Rs.6,00,000. These costs will not be affected by the product-mix decision.

Calculated the quantity of each product that XYZ Limited should manufacture and/or purchase to maximize operating income.

Sow your calculations. *(May 2002)*

Answer

Working Notes:

1. (i) Fixed manufacturing overhead per unit

"XY 100"; Rs.3,00,000 / 5,000 units or Rs.60

"XY 200"; Rs.3,00,000 / 12,000 units or Rs.25

(ii) Variable manufacturing overhead per unit

"XY 100"; (Rs.180 – Rs.60) or Rs.120

"XY 200"; (Rs.60 – Rs.25) or Rs.35

2. Variable costs of production of "XY 100" and "XY 200"

Product	*Per unit*	
	'XY 100'	*'XY 200'*
	Rs.	*Rs.*
Direct material	200	200
Variable machine operating costs	150	50
Variable manufacturing overheads	120	35
Total variable costs per unit	470	285

3. (i) machine hours for the production of one unit of each of the two products.

"XY 100"; Rs.150/-Rs.100 per hour = 1.5 hours.

"XY 200"; Rs.50/- Rs.100 per hour = 0.50 hours.

(ii) Total machine hours available

5,000 units × 1.5 hours = 7,500 hours

Ranking between manufactured “XY 100” and manufactured “XY 200”

	Manufactured “XY 100”	*Manufactured “XY 200”*
	Rs.	*Rs.*
Variable cost of production (Refer to working note 2)	470	285
Variable marketing and administrative cost	80	60
Total variable cost per unit: (A)	350	345
Selling price per unit: (B)	900	600
Contribution per unit: [(B) – (A)]	350	255
Contribution per hour	233	510
[Refer to working note 3(i)]	(Rs.3.50/1.5 hrs)	(Rs.255/0.5 hrs)
Ranking	II	I

Ranking between manufactured “XY 100” and purchased “XY 100”

	Manufactured “XY 100”	*Manufactured “XY 200”*
	Rs.	*Rs.*
Variable cost of production (Refer to working note 2)	470	--
Purchase price	--	650
Variable marketing and administrative cost	80	40
Total variable cost per unit: (A)	550	690
Selling price per unit: (B)	900	900
Contribution per unit: [(B) – (A)]	350	310
Ranking	II	I

“XY 200”: 12,000 units × 0.50 hours or 6,000 hours

“XY 100”: (7,500 – 6,000) hours = 1,500 hours

Quantity of each product that XYZ Limited should manufacture and / or purchase to maximise operating income

Manufactured “XY 200”	12,000 units
Manufactured “XY 100”: 1,500 hours / 1.5 hours	1,000
Purchased “XY 100”	6,000
Maximum number of units Which ABC can supply.	

Question 23

A Limited has been offered a contract that, if accepted, would significantly increase next year's activity level. The contract requires the production of 20,000 kgs. of product X and specifies a contract price of Rs.1,000 per kg. The resources required in the production of each kg. of X include the following:

	Resources per kg. of X
Labour:	
Grade 1	*2 hours*
Grade 2	*6 hours*
Materials:	
A	*2 units*
B	*1 Litre*

Grade 1 labour is highly skilled and although currently under-utilized in the firm, it is A's policy to continue to pay Grade 1 labour in full. Acceptance of the contract would reduce the idle time of Grade 1 labour. Idle time payments are treated as non-production overheads. Grade 2 is unskilled with a high turnover, and may be considered a variable cost.

The cost to A for each type of labour are:

Grade 1 Rs.40 per hour; Grade 2 Rs.20 per hour.

The materials required to fulfil the contract would be drawn from the materials already in stock Material A is widely used within the firm and any usage for the contract will necessitate replacement. Material B was purchased to fulfil an expected order that was not received. If material B is not used for the contract, it will be sold.

For accounting purposes FIFO is used. The various values and costs for A and B are as follows:

	A	B
	Per unit (Rs.)	Per unit (Rs.)
Book value	8	300
Replacement cost	100	320
Net realizable value	90	250

A single recovery rate for fixed factory overheads is used throughout the firm, even though some of these costs could be attributed to a particular product or department. The overhead is recovered by applying a pre-determined rate per productive labour hour. Initial estimates of next year's activity, which exclude the current contract, show fixed production overhead of Rs.60,00,000 and production labour hours of 3,00,000. Acceptance of the contract would increase fixed production overheads by Rs.22,80,000.

Variable production overheads are accurately estimated at Rs.30 per productive labour hour.

Acceptance of the contract would encroach on the resources used to produce and sale another product Y, which is also made by A Limited. It is estimated that the sale of Y would then decrease by 5,000 units in the next year only. However, this reduction in sale of Y would enable attributable fixed factory over head of Rs.5,80,000 to be avoided. Information on Y is as follows:

	Per unit
Selling price	Rs.700
Labour Grade 2	4 hours
Materials relevant variable costs	Rs.120

Required

Advise A Limited on the desirability of the acceptance of the contract purely on economic consideration. Show your calculations. *(May 2002)*

Answer

Working Notes:

1. Relevant cost of labour

Grade	:	Nil, labour cost for Grade 1 labour as it will not be affected by the decision.
Grade 2	:	Rs.20 per hour

2. Relevant cost of material

Material A	:	Rs.100 per unit, the replacement cost because the material is widely used.
Material B	:	Rs.250 per unit, the net realisable value, being the opportunity cost.

3. Statement of loss of contribution from the reduction in the sale of product Y.

	Rs.	*Rs.*
Sales revenue per unit: (A)		700
Variable cost per unit		
Grade 2 labour: (4 hour × Rs.20)	80	
Materials relevant variable costs	120	
Variable production overheads: (B)	120	320
(4 hours × Rs.30)		
Contribution per unit: [(A) – (B)]		380
Loss of contribution from the reduction in sale of 5,000 units		19,00,000
(5,000 units × Rs.380)		
Less: Avoidable fixed factory overhead cost		5,90,000
Net Loss		13,20,000

Relevant costs and benefit analysis from the acceptance of the contract.

		(Rs.'000)
Sales revenue: (1)		20,000
(20,000 kgs. × Rs.1,000)		
Relevant costs:		
Labour:		
Grade 1	NIL	
Grade 2	2,400	
(20,000 kgs. × 6 hours × 20)		
Material A (20,000 × 2 units × Rs.1,000)	4,000	

Material B (20,000 kgs. × 1 litre × Rs.250)	5,000
Variable production overhead (20,000 kgs. × 8 hours × Rs.30)	4,800
Total variable cost	16,200
Incremental fixed costs	2,280
	18,480
Add: Loss of contribution on product Y	
(Refer to working note 3)	
Total relevant cost: (ii)	19,800
Excess of relevant revenue over relevant cost:	200

Advice to A Limited: to accept the contract, as it will enhance the pre-tax operating income by Rs.2,00,000.

Question 24

Panchwati Cement Ltd. produces '43 grade' cement for which the company has an assured market. The output for 2004 has been budgeted at 1,80,000 units at 90% capacity utilisation. The cost sheet based on output (per unit) is as follows: (16 Marks)

	Rs.
Selling price	*130*
Direct material	*30*
Component 'EH'	*9.40*
Direct wages @ Rs. 7 per hour	*28*
Factory overhead (50% fixed)`	*24*
Selling and distribution overheads (75% variable)	*16*
Administrative overhead (fixed)	*5*

The factory overheads are applied on the basis of direct labour hours.

To utilise the idle capacity and to improve the profitability of the company, the following proposals were put up before the Board of Directors for consideration:

(i) An order has been received from abroad for 500 units of product '53 grade' cement per month at Rs. 175 per unit. The cost data are:

Direct material Rs. 56 per unit, direct labour 10 hours per unit, selling and distribution overhead applicable to this product order is Rs. 14 per unit and variable factory overhead are chargeable on the basis of direct labour hours.

(ii) The company at present manufactures component 'EH', one unit of which is required for each unit of product '43 grade'. The cost details for 15,000 units of component 'EH' are as follows:

	Rs.
Direct materials	*30,000*
Direct labour	*52,500*
Variable overheads	*25,500*
Fixed overheads	*33,000*
Total	*1,41,000*

The component 'EH' however is available for purchase at the market at Rs. 7.90 per unit.

(iii) In the event of company deciding to purchase the component 'EH' from market, the company has two alternatives for the use of the capacity so released, which are as under:

(a) Rent out the released capacity at Re. 1 per hour.

(b) Manufacture component 'GYP' which can be sold at Rs. 8 per unit. The cost data of this component for 15,000 units are:

	Rs.
Direct materials	*42,000*
Direct labour	*31,500*
Factory variable overheads	*13,500*
Other variable overheads	*25,500*
Total	*1,12,500*

Required:

(i) Prepare a statement showing profitability of the company envisaged in the budget.

(ii) Evaluate the export order and state whether it is acceptable or not.

(iii) Make an appraisal of proposal to manufacture component 'EH' and state whether the component 'EH' should be manufactured in the factory or purchased from the market. Assume that no alternative use of spare capacity is available.

(iv) Evaluate the alternative use of the spare capacity and state whether to manufacture or buy the component 'EH' and if you decision is to buy the component 'EH', which of the two alternatives for the use of spare capacity will you prefer ?

Answer

(i) Profitability as per original Budget

		Rs ('000s)	Rs('000s)
Sales(1,80,000 units × Rs 130)	(A)		23,400
Direct Material (1,80,000 units × Rs 30)		5,400	
Component 'EH' (variable cost = Rs 7.20 per unit)		1,296	
Direct wages (1,80,000 units × Rs 28)		5,040	
Variable factory overheads (1,80,000 units × Rs 24 × 50%)		2,160	
Variable selling & distribution (1,80,000 units × Rs 24 × 50%)		2,160	
Total variable cost	(B)		16,056
Contribution	(A – B)		7,344
Fixed factory overheads		2,160	
Fixed selling & distribution overheads		720	
Component 'EH' @2.20		396	
Administrative overhead		900	4,176
Profit			3,168

(ii) Export order

	Rs per Unit	Rs per Unit
Direct material	56	
Direct labour (10 hours × Rs 7 per hour)	70	
Variable factory overhead (Rs 3 × 10 labour hours)	30	
Selling and distribution overheads	14	

Total variable cost	170
Selling price (export)	175
Contribution	5

Since the product earns contribution of Rs.5 per unit, it should be accepted.

Total units 500(per month) = 6000 units(per annum)

Therefore additional contribution (6000 units $\times$ Rs 5) = Rs.30,000

Total hours on product '43 grade' (1,80,000 units $\times$ 4) = 7,20,000 Hrs

Total hours on component 'EH' (1,80,000 units $\times$ 0.5*) = 90,000 Hrs

$$* \frac{\text{Direct Labour cost}}{\text{No of units produced} \times \text{Labour rate per hour}} = \frac{\text{Rs } 52{,}500}{15{,}000 \text{ units} \times \text{Rs } 7 \text{ per hour}} =$$

0.5 Hrs

Total hours utilised at 90% capacity = 7,20,000 hours + 90,000 hours = 8,10,000 hours

$$100\% \text{ capacity hours} = \frac{8{,}10{,}000 \text{ hours} \times 100}{90} = 9{,}00{,}000 \text{ Hrs}$$

Balance hours available = 90,000 hours p.a

Hours required for export order 60,000 hours.

Both contribution per unit of export order and availability of capacity confirm its acceptance.

(iii) Component 'EH' make or buy

(per 15,000 units)	Make (Rs.)	Buy (Rs.)
Direct material	30,000	
Direct labour	52,500	
Variable factory overhead	25,500	
Total	1,08,000	1,18,500
Per unit	7.20	7.90

If the company makes the component the out of pocket cost is Rs.7.20 per unit whereas if the component is bought , the out of pocket cost is Rs.7.90.

Decision : If the capacity remains idle it is profitable to make.

(iv) Alternative use of the spare capacity

Units required = 1,80,000 units and hours required = 1,80,000 $\times$ 0 .5 = 90,000 Hrs

Cost of buying component 'EH' = (1,80,000 units $\times$ Rs 7.90) =Rs 14,22,000

Cost of making component 'EH' = (1,80,000 units $\times$ Rs 7.20) = Rs 12,96,000

Hence , excess cost of buying = Rs.1,26,000

Rent income (90,000 hours $\times$ Re1) = Rs.90,000

Contribution per unit from making component 'GYP' = Rs 8 - $\frac{\text{Rs } 1{,}12{,}500}{15{,}000 \text{ Units}}$ = Rs 0.5 per unit.

Direct labour cost per unit of 'GYP' = $\frac{\text{Rs } 31{,}500}{15{,}000 \text{ Units}}$ = Rs. 2.10 per unit.

No. of labour hours required for one unit of 'GYP' = $\frac{\text{Rs } 2.10}{\text{Rs } 7}$ = 0.3 Hrs

No. of units of 'GYP' in 90,000 hours = $\frac{90{,}000 \text{ hours}}{0.3 \text{ hours}}$ =3,00,000

Contribution from component 'GYP' = 3,00,000 × Rs 0.50 = Rs 1,50,000

Since the contribution from 'GYP' is greater than the extra variable cost of buying component 'EH' , component 'GYP' should be manufactured and component 'EH' should be purchased.

Question 25

R Ltd. has spare capacity in two of its manufacturing departments – Department 4 and Department 5. A five-day week of 40 hours is worked, but there is only enough internal work for 3 days per week so that 2 days per week (16 hours) could be available in each department. R Ltd. has sold this time to another manufacturer, but there is some concern about the profitability of this work.

The accountant has prepared a table giving the hourly operating cost in each department. The summarised figures are as follows:

	Department 4	*Department 5*
	Rs.	*Rs.*
Power costs	*40*	*60*
Labour costs	*40*	*20*
Overhead costs	*40*	*40*
	120	*120*

The labour is paid on a time basis and there is no charge in the weekly wage bill whether or not the plant is working at full capacity. The overhead figures are based on firm's current overhead absorption rates (fixed and variable) when the departments are operating at 90% of full capacity (assume a 50 week year). The budgeted fixed overhead attributed to department 4 is Rs. 36,000 p.a. and that for Deptt. 5 Rs. 50,400 p.a.

As a short term measure the company has been selling processing time to another manufacturer @ Rs. 70 per hour in either departments. The customer is willing to continue this arrangement and to purchase any spare time available, but R Ltd. is considering the introduction of a new product on a minor scale to absorb the spare capacity.

Each unit of the new product would require 45 minutes in Deptt. 4 and 20 minutes in Deptt. 5. The variable cost of the required input material is Rs. 10 per unit. The market study indicated as follows:

(i) with a selling price of Rs. 100, the demand would be 1,500 units p.a.

(ii) with a selling price of Rs. 110, the demand would be 1,000 units p.a.

(iii) with a selling price of Rs. 120, the demand would be 500 units p.a.

You are required to calculate the best weekly programme for the spare time in the two manufacturing departments, to determine the best price to charge for the new product and to quantity the weekly gain that this programme and price should yield.

Answer

The relevant cost of producing the new product is the variable cost plus the lost contribution from selling the processing time to another manufacturer. It is given that, the main product will absorb 3 days per week.

Calculation of variable overhead rates

	Dept. 4	Dept. 5
Normal Hrs.per annum (0.9×40 hr×50 wks)	1,800 hrs	1,800hrs
Fixed O.H. rate/hr. (Rs.)	20 (36,000/1,800)	28(50,400/1800)
Total O.H. rate/hr (given) (Rs.)	40	40
Thus variable OH rate/hr (Rs.)	20	12

The variable costs per hour are:

Department 4 : Power Cost Rs 40 + Variable Cost Rs 20 = Rs 60

Department 5 : Power Cost Rs 60 + Variable Cost Rs 12 = Rs 72

Note: labour costs are fixed (given).

If the new product is not developed, dept. 4 shall sell unused processing time at Rs. 70 per hour. It is not profitable for Dept. 5 to sell processing time at Rs. 70 per hour since the variable costs is more at Rs. 72. Therefore the relevant cost per processing hour are

Dept. 4 Rs. 70 (Rs. 60 variable cost + Rs. 10 lost contribution for selling processing time)

Dept. 5 Rs. 72

Relevant cost for producing the new product

	Rs
Direct Material (Given)	10.00
Dept. 4, variable operating cost (0.75 hr ×Rs. 70)	52.50
Dept. 5 variable operating cost (0.33 hr. × Rs. 72)	24.00
Relevant cost	86.50

Additional contribution for various selling prices/demand levels

	Rs.	*Rs.*	*Rs.*
Selling price per unit	100	110	120
Restricted demand (Units)	* 1067	1000	500
Relevant cost (Rs)	86.50	86.50	86.50
Contribution (Rs)	13.50	23.50	33.50
Total Contribution (Rs)	14,404.50	23,500	16,750

* Dept 4 (800 Hrs × $\frac{4}{3}$) = 1,067 units

* Dept. 5 (800 Hrs × 3) = 2400 units

Hence selling 1000 units @ Rs. 110 per unit will achieve optimum contribution.

Computation of spare time for production of 1,000 units pa

	Department 4	*Department 5*
Time required per unit (Hours)	$\frac{3}{4}$	$\frac{1}{3}$
Total time for producing 1,000 units (Hours)	750	334
Time available (Hours)	800	800
Spare time (Hours)	50	466
Spare time per week (Hours)	1	9.32

Therefore Dept 4 can sell 1 hr. per week at Rs. 70 per hour.

It is not profitable to sell spare capacity of 9.32 hrs. / week at the existing rate of Rs. 70 per hour.

Weekly gain from this programme

	Rs.
Selling price	110

Variable cost	
Direct materials	10
Dept. 4 variable operating cost 0.75×60	45
Dept. 5 variable operating cost 0.33×72	24
	79
Contribution / unit	31
Weekly sale	20 units
Additional contribution / week	620
Plus contribution of selling 1 hr (selling price – variable cost = 70-60)	10
Total contribution	630
Without the new product the weekly contribution 16 hours × Rs. 10 per hr	160
Additional gain for introducing the new product	470

Question 26

Zilmil Ltd. makes two products 'Brightly; and 'Lightly'. Both the products use the same labour force, the size of which is restricted to 78,000 hours per month. Brightly needs 2 hours per unit to make whereas lightly needs one hour. The estimated production and sales, manufacturing and selling expenses per month are as follows:

	Brightly		*Lightly*	
Production and Sales (in Nos.)	*12,000*	*16,000*	*40,000*	*48,000*
Cost per month (Rs.)	*34,00,000*	*38,00,000*	*62,00,000*	*66,80,000*

The Company is considering pricing option in a highly competitive market. It has estimated sales demand at various selling prices:

Brightly:						
Selling Price per unit (Rs.)	*276*	*272*	*268*	*264*	*260*	*254*
Sales demand per month	*12,000*	*14,000*	*16,000*	*18,000*	*20,000*	*22,000*
Lightly:						
Selling Price per unit (Rs.)	*163*	*162*	*161*	*160*	*156*	*152*
Sales demand per month	*40,000*	*42,000*	*44,000*	*46,000*	*48,000*	*50,000*

You are required to compute profit maximizing price and quantity for each product.

Answer

Brightly

Unit price Rs.	*Contribution per unit Rs.*	***Volume** Units*	*Total contribution (Rs. in 000)*	*Incremental contribution (Rs. 000)*	*Labour hours*	*Incremental labour hours*	*Incremental contribution per labour hour Rs.*	*Rank*
276	176	12000	2112	2112	24000	24000	88	2
272	172	14000	2408	296	28000	4000	74	6
268	168	16000	2688	280	32000	4000	70	7
264	164	18000	2952	264	36000	4000	66	8
260	160	20000	3200	248	40000	4000	62	9
254	154	22000	3388	188	44000	4000	47	10

Lightly

Unit price	*Contribution per unit*	*Volume*	*Total contribution (Rs. in 000)*	*Incremental contribution (Rs. 000)*	*Labour hours*	*Incremental labour hours*	*Incremental contribution per labour hour*	*Rank*
163	103	40,000	4120	4,120	40,000	40,000	103	1

162	102	42,000	4284	164	42,000	2,000	82	3
161	101	44,000	4444	160	44,000	2,000	80	4
160	100	46,000	4600	156	46,000	2,000	78	5
156	96	48,000	4608	8	48,000	2,000	4	11
152	92	50,000	4600	(8)	50,000	2,000	(4)	Loss

As the labour time is scarce source (time available 78,000 hours), the decision has to be taken on the basis of ranks based upon incremental contribution per labour hour.

Product	*Price*	*Incremental volume*	*Incremental labour hours*	*Balance hours*	*Incremental Contribution (in 000 Rs.)*
Lightly	163	40,000	40,000	38,000	4120
Brightly	276	12,000	24,000	14,000	2112
Lightly	162	2,000	2,000	12,000	164
Lightly	161	2,000	2,000	10,000	160
Lightly	160	2,000	2,000	8,000	156
Brightly	272	2,000	4,000	4,000	296
Brightly	268	2,000	4,000		280
Total					7,288

Hence product mix is Brightly – 16,000 units and Lightly 46,000 units

Optimal contribution per month	Rs. 72,88,000
Fixed costs per month	Rs. 60,00,000
Optimal profit per month	Rs. 12,88,000

Working Notes:

	Brightly	*Lightly*
Variable cost (p.u.)	$\frac{(38,00,000-34,00,000)}{(16,000-12,000)} = \text{Rs.}100$	$\frac{(66,80,000-62,00,000)}{(48,000-40,000)} = \text{Rs.}60$
Fixed cost (Rs.)	22,00,000	38,00,000

Contribution = Unit selling price less variable cost per unit.

Question 27

"The use of Absorption costing method in decision-making process leads to anomalies." Discuss.

Answer

In absorption costing, fixed overheads are assigned to products by establishing overhead absorption rates based on budgeted or normal output. By using absorption costing principles, it is possible for profit to decline when sales volume increases. If the stock levels fluctuate significantly, profits may be distorted because stock changes will significantly affect the amount of fixed overheads allocated to a period. If profits are measured on monthly or quarterly or on periodical basis, seasonal variations in sales may cause significant fluctuations in profits.

Internal profit statements on monthly or quarterly basis are used for measuring the managerial performance. In the circumstances, managers may deliberately alter inventory levels to influence profit, if absorption costing is used. When sales are less and the closing inventory increases, a part of the fixed overheads contained in the value of the closing stock is reduced from the fixed costs allocated to production for the period. Thus, if sales are reduced, inventories will increase and absorption cost will post higher profits. Similarly, if sales are increased as compared to production, inventories will be reduced and absorption costing will return lower profits.

Question 28

A Company manufactures two products 'X' and 'Y'. Company's fixed cost per annum is Rs. 5 lacs. These products are sold for Rs. 288 per unit of 'X' and Rs. 432 per unit of 'Y'. Standard cost data are:

	Product 'X'	Product 'Y'
	Rs.	Rs.
Direct Raw Material	40	80
Direct wages Rs. 8 per hour in Departments:		
1	48	72
2	24	48
3	72	–
4	–	96
Variable overhead	32	28

The Company operates 8 hours shift for 300 days in a year. Number of workers engaged by each department is given below:

Department	1	2	3	4
No. of Workers	45	24	27	36

Required:

(a) How many units of each product should be manufactured and what is the resultant maximum profit, if numbers of employees cannot be increased or transferred?

(b) If only one product is to be manufactured by the Company, which of the products would give the maximum profit and what is the amount of such profit?

Answer

Contribution analysis:

	Product X	Product Y
	Rs.	Rs.
Selling price	288	432
Variable costs:		
Direct materials	40	80
Direct Labour:	48	72
	24	48
	72	–
	–	96
Variable overheads	32	28
Total variable costs	216	324
Contribution per unit	72	108

The direct labour hours required to manufacture the two products in each of the four departments at the wage rate of Rs. 8 per hour are as under:

Department	Product X		Product Y	
	Wage cost	*Hours/unit*	*Wage cost*	*Hours/unit*
1	48	6	72	9
2	24	3	48	6
3	72	9	–	–
4	–	–	96	12

Department 3 is used only for product X and department 4 is used only for product Y. Hence, these two departments will determine the maximum production of these two products as under:

Department 3 : Maximum available hours:

Workers	×	Hours/day	×	Days/year		
27	×	8	×	300	=	64,800 hours

Maximum possible production of product X: $\frac{64{,}800}{9 \text{ hrs per unit}}$ = 7,200 units

Department 4 : Maximum available hours:

Workers	×	Hours/day	×	Days/year		
36	×	8	×	300	=	86,400 hours

Maximum possible production of product Y: $\frac{86{,}400}{12 \text{ hrs per unit}}$ = 7,200 units

The company can produce 7,200 units each of products X and Y provided departments 1 and 2 have capacity to process this quantity of output.

We can check the capacity of departments 1and 2 as under:

Department 1: Maximum available hours:

Workers	×	Hours/day	×	days/year		
45	×	8	×	300	=	1,08,000 hours

Hours required to produce 7,200 units each of X and Y:

Product X	7,200 × 6 hours	=	43,200 hours
Product Y	7,200 × 9 hours	=	64,800 hours
Total		=	1,08,000 hours

Department 1 has capacity to produce 7,200 units each of products X and Y.

Department 2 : Maximum available hours:

Workers	×	Hours/day	×	days/year		
24	×	8	×	300	=	57,600 hours

Hours required to produce 7,200 units each of X and Y:

Product X	7,200 ×3 hours	=	21,600 hours
Product Y	7,200 × 6 hours	=	43,200 hours

Total = 64,800 hours

Department 2 has scarce capacity.

Since department 2 capacity is scarce, link the contribution to the key factor of department 2 hours as under:

		Product X	Product Y
Contribution per unit		72	108
Department 2 hours per unit Hours		3	6
Contribution per hour of Department 2	Rs.	24	18
Rank		1	2

Optimal product mix:

Product	Max. units	Lab. Hours/unit	Prod. units	Hours used	Balance hours	Cont./unit	Total cont.
						Rs.	*Rs.*
X	7,200	3	7,200	21,600	36,000	72	5,18,400
Y	7,200	6	6,000	36,000	–	108	6,48,000
Total optimal contribution							11,66,400
Fixed costs							5,00,000
Optimal profit							6,66,400

Alternative Solution:

The maximum possible production of product X is 7,200 units and that of product Y is 7,200 units. The following two methods shall be used to determine the optimal profit:

(a) Produce 7,200 units of product X and use the balance capacity to produce product Y.

(b) Produce 7,200 units of product Y and use the balance capacity to produce product X.

Profitability based on (a):

Direct labour hours are scarce in Department 2.

Maximum available hours in Department 2	57,600
Product X requires 7,200×3=	21,600 hours
Balance hours on Y	36,000
Production of Y 36,000 ÷ 6=	6,000 units

Contribution:	X 7,200 units @ Rs. 72	Rs. 5,18,400
	Y 6,000 units @ Rs. 108	Rs. 6,48,000
	Total	Rs. 11,66,400
	Fixed costs	Rs. 5,00,000
	Profit	Rs. 6,66,400

Profitability based on (b):

Maximum available hours in Department 2	57,600
Product Y requires 7,200×6=	43,200 hours

Balance hours on X	14,400	
Production of X 14,400 ÷ 3=	4,800 units	
Contribution:	X 4,800 × 72	Rs. 3,45,600
	Y 7,200 × 108	Rs. 7,77,600
	Total	Rs. 11,23,200
	Fixed costs	Rs. 5,00,000
	Profit	Rs. 6,23,200

Profitability of (a) is better.

Question 30

Division Z is a profit center which produces four products A, B, C and D. Each product is sold in the external market also. Data for the period is:

	A	*B*	*C*	*D*
Market price per unit (Rs.)	*150*	*146*	*140*	*130*
Variable cost of pdn. Per unit (Rs.)	*130*	*100*	*90*	*85*
Labour hours required per unit	*3*	*4*	*2*	*3*

Product D can be transferred to division Y, but the maximum quantity that may be required for transfer is 2,500 units of D.

The maximum sales in the external market are:

A	*2,800 units*
B	*2,500 units*
C	*2,300 units*
D	*1,600 units*

Division Y can purchase the same product at a price of Rs. 125 per unit from outside instead of receiving transfer of product D from Division Z.

What should be the transfer price for each unit for 2,500 units of D, if the total labour hours available in division Z are 20,000 hours?

Answer

Ranking of products when availability of time is the key factor

Products	A	B	C	D
Market price	150	146	140	130
Less: Variable cost	130	100	90	85
Contribution p.u. (Rs.)	20	46	50	45
Labour hours p.u.	3	4	2	3
Contribution/labour hour	6.66	11.5	25	15
Ranking	IV	III	I	II
Maximum demand (units)	2,800	2,500	2,300	1,600
Total No of hours	8,400	10,000	4,600	4,800
Allocation of 20,000 hours on the basis of ranking	600*	10,000	4,600	4,800

*Balancing figure

Note: Time required meeting the demand of 2,500 units of product D for division Y is 7,500 hours. This requirement of time viz, 7,500 hours for providing 2,500 units of product D for division Y can be met by sacrificing 600 hours of Product A (200 units) and 6,900 hours of Product B (1,725 units)

Transfer Price = Variable cost + Opportunity cost

Or $$\frac{\text{Rs}85 + (\text{Rs}6{,}900 \times 11.5 + 600 \times 6.66)}{2{,}500} = \frac{\text{Rs}85 + (79350 + 4000)}{2500}$$

= Rs (85 + 33.34) = Rs 118.3

5

STANDARD COSTING AND VARIANCE ANALYSIS

Question 1

Which accounting plan of standard costing helps to convert standards into actual by using the ratios? (May 1996)

Answer

Dual plan.

Question 2

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 (May 1997)

Answer

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

(i) The formulation/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.

(ii) 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.

(iii) 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.

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

(v) Sharp rises in prices will raise questions as to whether unadjusted standards can be used in the decision making process (eg. Pricing decisions).

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

Question 3

Super Computers manufactures and sells three related PC models:

(1) PC = Sold mostly to college students.

(2) Portable PC = Smaller version of PC positioned as home computer

(3) Super PC = Sold mostly to business executives.

Budgeted and actual data for 1995 is as follows:

Budget for 1995

	Selling Price per Unit	*Variable Cost per Unit*	*Contribution margin per Unit*	*Sales Volume in Units*
	Rs.	*Rs.*	*Rs.*	*Rs.*

PC	*24,000*	*14,000*	*10,000*	*7,000*
Portable PC	*16,000*	*10,000*	*6,000*	*1,000*
Super PC	*1,00,000*	*60,000*	*40,000*	*2,000*
				10,000

Actual for 1995

	Selling Price per Unit	*Variable Cost per Unit*	*Contribution margin per Unit*	*Sales Volume in Units*
	Rs.	*Rs.*	*Rs.*	*Rs.*
PC	*22,000*	*10,000*	*12,000*	*8,250*
Portable PC	*13,000*	*8,000*	*5,000*	*1,650*
Super PC	*70,000*	*50,000*	*20,000*	*1,100*
				11,000

Super computers derived its total unit sales budget for 1995 from the internal management estimate of a 20% market share and an industry sales forecast by computer manufactures association of 50,000 units. At the end of the year the association reported actual industry sales of 68,750 units.

Required:

(i) Compute the individual product and total sales volume variance.

(ii) Compute total sales quantity variance.

(iii) Compute the market size and market share variance.

(iv) Compute individual product and total sales mix variances.

(v) Comment on your results. *(May 1996)*

Answer

Working Notes:

1. Statement of budgeted average contribution margin per unit for the year 1995:

Product different PC models	*Budgeted contribution margin per unit of each product*	*Budgeted sales volume*	*Total budgeted contribution margin*
	(Rs.)	*(Units)*	*(Rs.)*
PC	10,000	7,000	7,00,00,000
Portable PC	6,000	1,000	60,00,000
Super PC	40,000	2,000	8,00,00,000
		10,000	15,60,00,000

Budgeted average contribution margin per unit $= \dfrac{\text{Rs.}15{,}60{,}00{,}000}{10{,}000 \text{ units}}$

$= \text{Rs.}15{,}600$

2. Actual market share percentage $= \dfrac{\text{Actual sales of - 3 PC models}}{\text{Actual industry sales}} \times 100$

$= \dfrac{11{,}000 \text{ units}}{68{,}750 \text{ units}} \times 100$

$$= 16$$

3. Actual sales mix percentage of product = $\dfrac{\text{Actual sales of Product}}{\text{Total Actual sale of 3 PC models}} \times 100$

Actual sales mix percentage of product PC $= \dfrac{8{,}250 \text{ units}}{11{,}000 \text{ units}} \times 100 = 75$

Actual sales mix %age of product Portable PC $= \dfrac{1{,}650 \text{ units}}{11{,}000 \text{ units}} \times 100 = 15$

Actual sales mix %age of product Super PC $= \dfrac{1{,}100 \text{ units}}{11{,}000 \text{ units}} \times 100 = 10$

(i) Computation of individual product and total sales volume variance

$$\text{Sales} = \begin{bmatrix} \text{Actual} & & \text{Budgeted} \\ \text{Sales} & - & \text{Sales} \\ \text{Volume} & & \text{Volume} \\ \text{in units} & & \text{in units} \end{bmatrix} \times \begin{matrix} \text{Budgeted} \\ \text{contribution} \\ \text{margin per} \\ \text{unit} \end{matrix}$$

Individual product sales volume variance:

PC = (8,250 units – 7,000 units) × Rs.10,000 = Rs.1,25,00,000 (Fav.)

Portable PC = (1,650 units – 1,000 units) × Rs.6,000 = Rs.39,00,000 (Fav.)

Super PC = (1,100 units – 2,000 units) × Rs.40,000 = Rs.2,60,00,000 (Adv.)

Total Sales Volume Variance = Rs.1,96,00,000 (Adv.)

(ii) Computation of total sales quantity variance:

$$\text{Total sales quantity variance} = \begin{bmatrix} \text{Total actual} & - & \text{Total Budgeted} \\ \text{sales Unit} & & \text{Sales units} \end{bmatrix} \times \begin{matrix} \text{Budgeted average} \\ \text{contribution margin} \\ \text{per unit} \end{matrix}$$

= (11,000 units – 10,000 units) × Rs.15,600 = Rs.1,56,00,000 (Fav.)

(iii) Computation of the market size and market share variance

1. Market size variance:

   Budgeted market Share %age =

$$\begin{bmatrix} \text{Actual Industry} & - & \text{Budgeted Industry} \\ \text{Sales in units} & & \text{Sales in units} \end{bmatrix} \times \begin{matrix} \text{Budgeted average} \\ \text{contribution margin} \\ \text{per unit} \end{matrix}$$

   = 0.20 (68,750 units – 50,000 units) × Rs.15,600

   = Rs.5,85,00,000 (Fav.)

2. Market share variance:

$$= \begin{bmatrix} \text{Actual market} & - & \text{Budgeted market} \\ \text{share percentage} & & \text{share percentage} \end{bmatrix} \begin{bmatrix} \text{Actual Total} \\ \text{Sales Volume} \\ \text{in units} \end{bmatrix} \times \begin{bmatrix} \text{Budgeted average} \\ \text{Contribution margin} \\ \text{per unit} \end{bmatrix}$$

= (0.16 – 0.20) × 68,750 units × Rs.15,600

= Rs.4,29,00,000 (Adv.)

(iv) Computation of individual product and total sales mix variances

1. Individual product and total sales mix variance:

Sales mix variance:

$$\begin{bmatrix}\text{Actual sales} & \text{Budgeted sales} \\ \text{mix \%age of} & -\text{mix \%age of} \\ \text{product} & \text{product}\end{bmatrix} \times \begin{bmatrix}\text{Actual Total} \\ \text{Sales Volume} \\ \text{in units}\end{bmatrix} \times \begin{bmatrix}\text{Budgeted} & \\ \text{Individual} & \text{Budgeted average} \\ \text{Contribution} & -\text{contribution} \\ \text{margin} & \text{margin}\end{bmatrix}$$

PC*** = (0.75 – 0.70) × 11,000 units × (Rs.10,000 – Rs.15,600)

= Rs.30,80,000 (Adv.)

Super PC****= (0.10 – 0.20) × 11,000 units × (Rs.40,000 – Rs.15,600)

= Rs.2,68,40,000 (Adv.)

2. Total sales mix variance = rs.3,52,00,000 (Adv.)

* Refer to working note 1.

** Refer to working note 2.

*** Refer to working note 3.

Note: Sales variances can also be calculated by using sales value approach.

(v) Comment on above results:

1. Favourable sales quantity variance of Rs.1.56 crores was because of growth in industry as a whole. However the firm could not retain the budgeted market share of 20%. As a result the benefit of increased market size i.e. Rs.5.85 crores is partly offset by loss due to fall in market share i.e. Rs.4.29 crores.
2. Increase in the percentage sale of computers below-average budgeted margins and a decrease in the percentage sale of computers above-average budgeted margins had resulted in the reduction of operating profit by Rs.3.52 crores.
3. As a result of above, the operating profit of 'Super Computers' had been adversely affected by Rs.1.96 crores due to sales variances.

Question 4

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 following:

(1) The standard costs of sales target in respect of A, B, C and D are Rs.5,00,000, Rs.3,75,000, Rs.4,00,000 and Rs.4,25,000 respectively.

(2) A, B, C and D respectively earned Rs.29,900, Rs.23,500, Rs.24,500 and Rs.25,800 as commission at 5% on actual sales effected by them during the previous year.

(3) The relevant variances as computed by a qualified cost accountant are as follows:

	A	*B*	*C*	*D*
	Rs.	*Rs.*	*Rs.*	*Rs.*
Sales price variance	*4,000 (F)*	*6,000 (A)*	*5,000 (A)*	*2,000 (A)*
Sales volume variance	*6,000 (A)*	*26,000 (F)*	*15,000 (F)*	*8,000 (F)*

Sales margin mix variance	*14,000 (A)*	*8,000 (F)*	*17,000 (F)*	*3,000 (A)*

(A) = Adverse variance and (F) = Fabourable variance.

You are required to:

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

(2) Evaluate the overall performance of these zonal sales officers taking three relevant base factors and then recommend whose performance is the best. *(Nov. 1996)*

Answer

(1) Statement showing the amount of sales target fixed and the actual amount of contribution earned. *(Rs.'000)*

Zonal Sales Officers	*A*	*B*	*C*	*D*
Commission earned	29.9	23.5	24.5	25.8
Actual sales:				
(Commission earned / 5%)	598	470	490	516
Sales price variance	4 (F)	6 (A)	5 (A)	2 (A)
Sales volume variance	6 (A)	26 (F)	15 (F)	8 (F)
Sales target / Budgeted sales	600	450	480	510
Standard cost of sales target	500	375	400	425
Standard margin/ Budgeted margin	100	75	80	85
Sales margin mix variance	14 (A)	8 (F)	17 (F)	3 (A)
Sales price variance	4 (F)	6 (A)	5 (A)	2 (A)
Actual margin	90	77	92	80

Note: As there is no information about sales margin quantity variances, therefore for calculating actual contribution the same has been assumed to be zero.

(2) Statement to evaluate the performance of zonal sales officers

S. No.	*Base factor to evaluate performance*	*Zonal Sales Officers* *A*	*B*	*C*	*D*
	Efficiency towards the target sales:				
1.	(a) Whether target achieved	No	Yes	Yes	Yes
	(b) Actual sales to Target sales ratio (Actual / target) (%)	99.67 $\left(\frac{598 \times 100}{600}\right)$	104.44 $\left(\frac{470 \times 100}{450}\right)$	102.98 $\left(\frac{490 \times 100}{480}\right)$	101.18 $\left(\frac{516 \times 100}{510}\right)$
	(c) Ranking	IV	I	II	III
2.	(a) Contribution earned (in Rs.'000)	90	77	92	80
	(b) Ranking	II	IV	I	III
3..	(a) Standard margin/	16.67	16.67	16.67	16.67

sales target ratio				
(b) Actual margin / Actual sales ratio (%)	15.05	16.38	18.78	15.50
(c) Ranking	IV	II	I	III

Recommendation:

A review of performance of four officers based on three based factors, shows that the performance of officer C is the best.

Question 5

Describe the role of cost accountant in the area of operating efficiency. *(May 1997)*

Answer

Role of Cost Accountant in the area of operating efficiency: Operating efficiency relates to the efficient use of various resources, viz material, labour, machines etc. The cost accountant can contribute towards efficient and effective use of man, material and machine by introducing control and accounting procedures.

In the area of labour efficiency, the role of cost accountant includes reporting efficiency variances and evaluating wage incentive schemes. In the case of material, efficiency can be increased by introducing effective material control and accounting procedures and computing material usage variance. In the area of machine efficiency, his objective would be to ensure optimum utilization of machine time. He may also give his advice based on his information and analysis, to the management, towards the replacement of old machine with the latest one. The efficiency of operating procedures will be monitored by industrial engineers and organization & methods specialists but the cost accountant may be required to calculate the net savings to be expected from the procedural change.

Question 6

The following information is available in respect of Y Ltd. for a week:

(a) 400 kg of raw material were actually used in producing product 'EXE'. The purchase cost thereof being Rs.24,800. The standard price per kg of raw material is Rs.60. The expected output is 12 units of product 'EXE' from each kg of raw material. Raw material price variance and usage variance as computed by cost accountant are Rs.800 (adverse) and Rs.600 (adverse) respectively.

(b) The week is of 40 hours. The standard time to produce one unit of 'EXE' is 30 minutes. The standard wage rate is Rs.5 per labour hour. The company employs 60 workers who have been paid hourly wage rate as under:

Number of workers	*6*	*8*	*46*
Hourly Wage Rate (Rs.)	*4.80*	*5.20*	*5.00*

(c) Budgeted overheads for a four-weekly period is Rs.81,600. The actual fixed overheads spent during the said week are Rs.19,800.

(d) Entire output of 'EXE' has been sold at its standard selling price of Rs.15 per unit.

You are required to:

(i) Compute the variances relating to labour and overheads.

(ii) Prepare a statement showing total standard costs, standard profit, and actual profit for the week.
(May 1997)

Answer

(i) Working Notes:

1. Standard quantity and cost of raw material required for actual output

Actual output of EXE (units)

Standard output per kg. of raw material (units)

Standard quantity of raw material required for actual output (kgs.)

(4,680 units / 12 units)

Standard cost of 390 kgs. of raw material at Rs.60 per kg. (Rs.)

2. Basic data for the computation of labour variances:

	Standard labour data for actual output			*Actual data*		
Std. Time hours	*Rate p.h.*	*Amount*	*Standard cost of actual hours*	*Actual cost hours*	*Rate p.h.*	*Amount*
2,340	5	11,700	12,000	240	4.80	1,152
(4,680 units ×½ hr.)				320	5.20	1,664
				1,840	5.00	9,200
2,340		11,700	12,000	2,400		12,016

3. Basic data for the computation of fixed overhead variances:

Budgeted / Std. data		*Actual data*	
Budgeted fixed overhead (Rs.) (for 1 week)	24,400	Actual fixed overhead (Rs.)	19,800
Budgeted hours	2,400	Actual labour hours	2,400
(60 workers×40 hrs. per week)		Actual output (units)	4,680
Budgeted output (units)	4,800		
Std. rate p.h. (Rs.)	8.50		
Std. rate p.u. (Rs.)	4.25		

(i) Computation of labour and overhead (variances):

Labour cost variance: (Refer to working Note 2)

= (Std. cost of labour – Actual cost of labour)

= Rs.11,700 – Rs.12,016 = Rs.316 (Adverse)

Labour rate variance:

= Actual hours (Std. rate – Actual rate)

= Rs.12,000 – Rs.12,016

= Rs.16 (Adv.)

Labour efficiency variance:

= Standard rate per hr. (Std. hours – Actual hours paid)

= (Rs.11,700 – Rs.12,000) = Rs.300 (Adv.)

= Total fixed overhead cost variance:

= (Fixed overhead absorbed – Actual fixed overhead)

= [(4,680 units × Rs.4.25) – Rs.19,800]

= Rs.19,890 – Rs.19,800 = Rs.90 (Fav.)

Fixed overhead volume variance:

= Std. fixed overhead rate per unit [Actual output – Budgeted output]

= Rs.4.25 (4,680 units – 4,800units)

= Rs.510 (Adv.)

Fixed overhead expenditure variance:

= [Budgeted fixed overhead – Actual fixed overhead]

= [Rs.20,400 – Rs.19,800] – Rs.600 (Fav.)

(ii) Statement showing total standard cost, standard profit and actual profit for the week.

Sales	*Rs.*	*Rs.*
4,680 units × Rs.15		70,200
Less: Standard cost of :		
Direct material	23,400	
Direct labour	11,700	
Overheads	19,890	54,990
(4,680 × Rs.4.25)		
(Refer to working notes 1 to 3)		
Standard Profit		15,210
Less: Adjustment for variance:		
Raw Material:		
Price variance : 800 (A)		
Usage variance : 600 (A)	1,400 (A)	
Labour:		
Rate Variance : 16 (A)		
Efficiency variance : 300 (A)	316 (A)	
Overhead:		
Expenditure variance: 600 (F)		
Volume variance: 510 (F)	90 (F)	1,626
Actual Profit		13,584

Question 7

What are the basic differences between Standard Costing and Budgetary Control? (Nov 1997)

Answer

Basic differences between Standard Costing and Budgetary Control are as follows:

(i) Standard costs are ascertained for material labour and overheads Here the control of each elements of cost is effected by comparing actual costs with standard costs of actual output. Whereas budgets are prepared for different functions like sales, production capital assets etc. of business. Budgetary control here is concerned with the overall profitability and financial position of the business.

(ii) Range of standard costing is narrow as it is mainly confined to the control of production costs. But the range of budgeting is wider than that of standard costing. It in fact covers sales, capital and financial expenses as well.

(iii) Standard costing is confined of the projection of cost accounts only whereas budgetary control includes projection of financial accounts as well.

(iv) For exercising control, variances are computed in standard costing as well as budgetary control. But these variances are normally recorded in different cost accounts under standard costing whereas they are not revealed under budgets.

(v) Under standard costing various causes of variances in respect of each cost element can be analysed in minute detail and corrective action taken accordingly.

Whereas budgetary control system deals with total expenses and revenues based on estimates.

Question 8

The Standard Cost of producing one unit of Item 'Q' is as under:

Direct Material --	*A – 12 Kg. @ Rs.10/-*	*= Rs.120*
	B – 5 kg. @ Rs.6/-	*= Rs.30*
Direct Wages --	*5 hrs. @ Rs.3/-*	*= Rs.15*
Fixed Production Overheads		*= Rs.35*
Total Standard Cost:		*= Rs.200*
Standard Gross Profit		*= Rs.50*
Standard Sale Price		*= Rs.250*

Fixed Production overhead is absorbed on expected annual output of 13,200 units.

Actual result for the month of September, 1997 are under:

Actual Production:	*1,000 units*	
		Rs.
Sales	*1,000 Units @ Rs.250*	*= 2,50,000*
Direct Material --	*A – 11,000 kg.*	*= 1,21,000*
	B – 5,200 kg.	*= 28,600*
Direct wages	*5,500 hrs.*	*= 17,500*
Fixed Overheads		*= 39,000*
		= 2,06,100
	Gross profit	*= 43,900*

You are required to calculate all variances. Material price variance is taken out at the time of receipt of Material. Material purchases were:

12,000 kg. 'A' @ Rs.11 & 5,000 kg. of 'B' @ Rs.5.50 *(Nov 1997)*

Answer

Basic Data:

(1) Statement showing standard and actual costs of material for 1,000 units of output and standard cost of actual input

Standard Cost	*Actual cost*	*Standard cost of actual input = (Actual quantity × Standard price)*

Ma	*Qty.*	*Price*	*Amount*	*Qty.*	*Price*	*Amount*	*Actual Qty.*	*Standard Price/kg*	*Amount*
	Kg.	Rs.	Rs.	Kg.	Rs.	Rs.	Kg.	Rs.	Rs.
A	12,000	10	1,20,000	11,000	11	1,21,000	11,000	10	1,10,000
B	5,000	6	30,000	5,200	5.50	28,600	5,200	6	31,200
			1,50,000			1,49,600			1,41,200

Standard yield (units) = $\frac{1{,}000 \text{ units}}{17{,}000 \text{ Kg.}} \times 16{,}200$ kg. = 952.941764 units approx.

(2) Statement showing standard and actual labour cost of 1,000 units produced and standard cost of actual labour hrs.

Hours	*Rate p.h.*	*Amount*	*Hours*	*Rate p.h.*	*Amount*	*Hours*	*Rate p.h.*	*Amount*
	Rs.	*Rs.*		*Rs.*	*Rs.*		*Rs.*	*Rs.*
5,000	3	15,000	5,500	3.1818	17,500	5,500	3	17,500

(3) Overheads

Fixed overheads (Rs.)	*Budgeted*	*Actual*
Hours	38,500	39,000
Output	5,500	5,500
Standard time p.u. (hrs.)	1,100	1,000
Standard fixed overheads p.u. (Rs.)	5	
Standard fixed overhead rate p.h. (Rs.)	35	
Computation of material variances (Refer to Basic data 1):	7	

Computation of material variances (Refer to Basic data (1):

Material cost variance = Standard cost – Actual cost

= Rs.1,50,000 – Rs.1,49,600 = Rs.400 (Fav.)

Material price variance = Actual quantity (Std. price – Actual price)

= 11,000 kg (Rs.10 – Rs.11) + 5,200 kg (Rs.6 – Rs.5.50)

= Rs.11,000 (Adv.) + Rs.2,600 (Fav.)

= Rs.8,400 (Adv.)

Material usage variance = Standard price (Standard quantity – Actual quantity)

= Rs.10 (12,000 kg – 11,000 kg) + Rs.6(5,000 kg–5,200 kg)

= Rs.10,000 (Fav.) + Rs.1,200 (Adv.)

= Rs.8,800 (Fav.)

Material mix variance = Total actual quantity $\left\{\frac{\text{Std. price of}}{\text{Std. mix per kg}} - \frac{\text{Std. price of}}{16{,}200 \text{ kg}}\right\}$

$= 16{,}200 \text{ kg} \left\{\frac{\text{Rs.}1{,}50{,}000}{17{,}000 \text{ kg}} - \frac{\text{Rs.}1{,}41{,}200}{16{,}200 \text{ kg}}\right\}$

= Rs.1,741.18 (Fav.)

Material yield variance = Std. Rate (Actual yield – Std. Yield

= Rs.150 (1,000 units – 952.9411764 units)

= Rs.7058.82

Material purchase price variance:

= Actual quantity of material purchased (Std. Price per kg. – Actual price per kg)

= 12,000 kg (Rs.10 – Rs.11) + 5,000 kg (Rs.6 – Rs.5.50)

= Rs.12,000 (Adv.) + Rs.2,500 (Fav.)

= Rs.9,500 (Adv.)

Computation of labour variances (Refer to basic data 2):

Labour cost variance = (Standard cost – Actual cost)

= Rs.15,000 – Rs.17,500 = Rs.2,500 (Adv.)

Labour rate variance = Actual hrs. (Std. Rate – Actual rate)

= 5,500 (Rs.3 – Rs.3.1818)

= Rs.1,000 (Adv.)

Labour efficiency variance = Std. rate p.h. (Std. Hours – Actual hours)

= Rs.3 (5,000 hrs. – 5,500 hrs.)

= Rs.1,500 (Adv.)

Computation of fixed overhead variance:

Total fixed overhead variance:

= Fixed overhead absorbed – Actual fixed overhead

= 1,000 units × Rs.35 – Rs.39,000

= Rs.35,000 – Rs.39,000 = Rs.4,000 (Adv.)

Fixed overhead expenditure variance:

= Budgeted fixed overhead – Actual fixed overhead

= Rs.38,500 – Rs.39,000 = Rs.500 (Adv.)

Fixed overhead volume variance:

= Std. Fixed overhead rate per unit (Actual output – Budgeted output)

= Rs.35 (1,000 units – 1,000 units) = Rs.3,500 (Adv.)

Efficiency variance:

= Std. fixed overhead rate per unit (Actual output – Budgeted output)

= Rs.35 (1,000 units – 1,000 units) = Rs.3,500 (Adv.)

Question 9

On 1st April, 1998, ZED Company began the manufacture of a new electronic gadget. The company installed a standard costing system to account for manufacturing costs.

The standard costs for a unit of the product are as under:

	Rs.
Direct Material (3 kg at Rs.5 per kg.)	*15.00*

Direct Labour (0.5 hour at Rs.20 per hour)	*10.00*
Manufacturing Overhead (75% of direct labour cost)	*7.50*
Total Cost	*32.50*

The following data was obtained from ZED Company's records for April 1998:

	Debit	*Credit*
	Rs.	*Rs.*
Sales	*--*	*1,25,000*
Sundry Creditors (for purchase of direct materials in April 1998)	*68,250*	*--*
Direct Material Price Variance	*3,250*	*--*
Direct Labour Rate Variance	*2,500*	*--*
Direct Labour Rate Variance	*1,900*	*--*
Direct Labour Efficiency Variance	*--*	*2,000*

The Actual Production in April 1998 was 4,000 units of the gadget and the actual sales for the month was 2,500 units.

The amount shown above for direct materials price variance applies to materials purchase during April, 1998. There was no opening stock of raw materials on 1st April, 1998.

Required:

Calculate for April, 1998 the following:

(i) Standard direct labour hours allowed for the actual output achieved.

(ii) Actual direct labour hours worked.

(iii) Actual direct labour rate.

(iv) Standard quantity of direct materials allowed (in kgs.)

(v) Actual quantity of direct materials used (in kgs.)

(vi) Actual quantity of direct materials purchased (in kgs.)

(vii) Actual direct materials price per kg. *(May 1998)*

Answer

(i) Standard direct labour hours allowed for the actual output achieved:

= Actual number of units produced × Standard direct labour hours per unit

= 4,000 units × 0.5 hrs = 2,000 hous.

(ii) Actual direct labour hour worked:

Direct labour efficiency variance

= Std. rate per hour (Std. hrs. for actual output – Actual direct labour hours worked)

or Rs.2,000 (Fav.) = Rs.20 (2,000 hrs. – Actual direct labour hours worked)

or Actual direct lbaour hours worked = 1,900 hours.

(iii) Actual direct labour rate:

Direct labour rate variance

= Actual hours (Std. rate per labour hour – Actual direct labour rate per hour)

or Rs.1,900 (Adv.) = 1,900 hours (Rs.20 – Actual direct labour rate per hour) or Actual direct labour rate per hour = Rs.21

(iv) Standard quantity of direct materials allowed (in kgs.)

= Actual number of units produced × Std. quantity of direct material required per unit (in kgs.) = 4,000units × 3 Kgs. = 12,000 Kgs.

(v) Actual quantity of direct materials used (in Kgs.)

Direct material usage variance:

=	Standard price per kg. of direct material	Standard qty. of direct material for actual output	Actual qty. of direct materials used for actual output

or Rs.2,500 (Adv.) = Rs.5 (4,000 units × 3 Kgs. – Actual qty. of direct materials used for actual output)

or 5 Actual qty. of direct material used for actual output = 60,000 + 62,500 kgs.

or Actual qty. of direct materials used for actual output = 12,500 Kgs.

(vi) Actual quantity of direct materials purchased (in Kgs.)

Material purchase price variance:

= Actual qty. of direct materials purchased (Std. Price per kg. – Actual price per kg.)

Rs.3,250 (Adv.) = Actual qty. of direct materials purchased × Rs.5 – Actual qty. of direct materials purchased × Actual price per kg.

= Rs.5 × Actual qty. of direct materials purchased – Rs.68,250

or Rs.68,250 – Rs.3,250 = Rs.5 × Actual qty. of direct material purchased

or Rs.5 × Actual qty. of direct materials purchased = Rs.65,000

or Actual qty. of direct materials purchased = Rs.13,000 Kgs.

(vii) Actual direct materials price per Kg.

Rs.3,250 (Adv.) = 13,000 Kgs. (lts.5 – Actual direct materials price per Kg.)

or Rs.65,000 + 3,250 = 13,000 kgs. × Actual direct materials price per kg.

or 13,000 Kgs. × Actual direct, materials price per Kg. = Rs.68,250

or Actual direct materials price per Kg. = Rs.5.25

Question 10

How are cost variances disposed off in a standard costing system? Explain. *(Nov 1998)*

Answer

There is no unanimity of opinion among Cost Accountants regarding the disposition of variances. The following are commonly used methods for their disposition.

1. Transfer all variances to Profit and Loss Account. Under this method, stock of work-in-progress, finished stock and cost of sales are maintained at standard cost and variances arising are transferred to profit and loss account.
2. Distributing variances on pro-rata basis over the cost of sales, work-in-progress and finished goods stocks by using suitable basis.
3. Write off quantity variance to profit and loss account and spread price variance over to cost of sales, work in progress and finished goods. The reason behind apportioning variance to inventories and cost of sales is that they represent costs although they are derived as variances.

Question 11

"Calculation of variances in standard costing is not an end in itself, but a means to an end." Discuss.
(May 1999)

Answer

The crux of standard costing lies in variance analysis. Standard costing is the technique whereby standard costs are predetermined and subsequently compared with the recorded actual costs. It is a technique of cost ascertainment and cost control. It establishes predetermined estimates of the cost of products and services based on management's standards of efficient operation. It thus lays emphasis on "what the cost should be". These should be costs are when compared with the actual costs. The difference between standard cost and actual cost of actual output is defined as the variance.

The variance in other words in the difference between the actual performance and the standard performance. The calculations of variances are simple. A variance may be favourable or unfavourable. If the actual cost is less than the standard cost, the variance is favourarable but if the actual cost is more than the standard cost, the variance will be unfavourable. They are easily expressible and do not provide detailed analysis to enable management of exercise control over them. It is not enough to know the figures of these variances from month to month. We infact are required to trace their origin and causes of occurrence for taking necessary remedial steps to reduce / eliminate them.

A detailed probe into the variance particularly the controllable variances helps the management to ascertain:

(i) the amount of variance

(ii) the factors or causes of their occurrence

(iii) the responsibility to be laid on executives and departments and

(iv) corrective actions which should be taken to obviate or reduce the variances.

Mere calculation and analysis of variances is of no use. The success of variance analysis depends upon how quickly and effectively the corrective actions can be taken on the analysed variances. In fact variance gives information. The manager needs to act on the information provided for taking corrective action. Information is the means and action taken on it is the end. In other words, the calculation of variances in standard costing is not an end in itself, but a means to an end.

Question 12

Despite the increase in the Sales price of its sole product to the extent of 20%, a company finds that it has incurred a loss during the year 1998-99 to the extent of Rs.4 lakhs as against a profit of Rs.5 lakhs made in 1997-98. This adverse situation is attributed mainly to the increase in prices of materials and overheads, the increase over the previous year being, on the average, 15% and 10% respectively.

The following figures are extracted from the books of the company.

	31..03.98	*31.03.99*
	Rs.	*Rs.*
Sales	*1,20,00,000*	*1,29,60,000*
Cost of Sales:		
Material	*80,00,000*	*91,10,000*
Variable Overhead	*20,00,000*	*24,00,000*
Fixed Overhead	*15,00,000*	*18,50,000*

Required:

Analyse the variances over the year in order to bring out the reasons for the full in profit (May 1999

Answer

Statement of figures extracted from the books of the company

Year	*1997-98*	*1998-99 (based on 1997-98 prices)*	*Difference*
	Rs.	*Rs.*	*Rs.*
(a)	*(b)*	*(c)*	*(b)-(c)*
Sales	120	*108.00	12
(Refer to working note 1)			
Cost of sales:			
Material	80	79.22	
(Refer to working note 2)			
Variable overhead	20	21.82	
(Refer to working note 3)			
Fixed overhead	15	16.82	
(Refer to working note 4)			

* Decrease in sales = Rs.120 – Rs.108 = Rs.12 lakhs or 10% of 1997-98

Sales figure at 1997-98 rate

Contribution to sales ratio during 1997-98 $= \dfrac{\text{Sales - Variable costs}}{\text{Sales}}$

$= \dfrac{\text{Rs.}120 - \text{Rs.}100}{\text{Rs.}120}$ or (1/6)of per rupee sale

Loss of combination during 1998-99 on the sale of 12 lakhs – Rs.12 lakhs × 1/6 = Rs.2 lakhs.

Sales price variance = Actual sales – Standard sales

= Rs.129.60 – 108 = Rs.21.60 (Lakhs) (Fav.)

Material price variance = Standard cost of actual quantity – Actual cost

= Rs.79.22 – Rs.91.10 = 11.88 (Lakhs) (Adv.)

Variable overhead expenditure variance = $\begin{pmatrix} \text{Budgeted variable} & & \text{Actual} \\ \text{overhead for} & - & \text{Variable} \\ \text{actual hours} & & \text{overhead} \end{pmatrix}$

= (Rs.21.82 – Rs.24) = Rs.2.18 (Lakhs) (Adv.)

Variable overhead efficiency variance = $\begin{pmatrix} \text{Standard variable} & & \text{Standard variable} \\ \text{overhead for} & - & \text{overhead for} \\ \text{Standard hours} & & \text{actual hour} \end{pmatrix}$

= (Rs.18 – Rs.21.62) = Rs.3.62 (Lakhs) (Adv.)

* Variable overhead in 1997-98 was Rs.20 lakhs. Since there was a decrease in sales in 1998-99 to the extent of 10% of 1997-98 sales figure (based o 1997-98 prices). Therefore, the standard variable overhead for standard hours at this reduced sales in 1998-99 would be equal to (Rs.20 lakhs minus 10% of 20 lakhs) i.e. (Rs.20 lakhs – Rs.2 lakhs) = Rs.18 lakhs).

Fixed overhead expenditure variance = Budgeted fixed overhead – Actual fixed overhead.

= Rs.16.82 – Rs.18.50 = Rs.1.68 (Lakhs) (Adv.)

$$\text{Fixed overhead volume variance} = \begin{pmatrix} \text{Standard variable} & & \text{Standard fixed} \\ \text{overhead for} & - & \text{overhead for} \\ \text{Actual hours} & & \text{budgeted output} \end{pmatrix}$$

= (16,82 – 15) Rs.1.82 (Lakhs) (Adv.)

Reconciliation statement

		Rs.	*Rs.*
Profit during 1997-98			5,00,000
Add: Net increase in profit due to the sales of 1998-99			19,60,000
[After taking into account increase in sales price but decrease in contribution margin due to decrease in quantum (Vol. of Sales)]			
(Refer to working note 5)			
Total			24,60,000
Less: Usage / Efficiency variance			
	Material	7,22,000	
	Variable overhead	3,82,000	
	Fixed overhead volume variance	1,82,000	12,86,000
Less:	Price variances		
	Material price variance	11,88,000	
	Variable overhead expenditure variance	2,18,000	
	Fixed overhead expenditure variance	1,68,000	15,74,000
Loss during 1998-00			4,00,000
(Difference figure)			

Conclusion

The reasons for the decrease in the total profit figure of the year 1998-99 (inspite of the increase in sales price) are due to adverse – (i) usage / efficiency variances to the extent of Rs.12,86,000 and (ii) price variances to the extent of Rs.15,74,000.

Working notes:

1. Sales during 1998-99 at 1997-98 price level = $\frac{\text{Rs.129.60}}{\text{Rs.120}} \times 100$ = Rs.108 (Lakhs)

2. Material cost of 1998-99 at 1997-98 price level = $\frac{91.10}{115} \times 100$ = Rs.79.22 (Lakhs)

3. Variable overhead of 1998-99 at 1997-98 price level = $\frac{24}{110} \times 100$ = Rs.21.82 (Lakhs)

4. Fixed overhead of 1998-99 at 1997-98 price level = $\frac{18.50}{110} \times 100$ = Rs.16.82 (Lakhs)

5. Net increase in profit due to rise of 20% of S.P. = (Rs.129.6 Lakhs – Rs.108 – Rs.2 lakhs)

   And reduction in contribution due to

   Reduction in sales = Rs.19.6 (Lakhs)

Question 13

(a) Mention the causes that give rise to labour rate variance.

(b) Following the standard cost card of a component:

Materials	*2 units at Rs.15*	*Rs.30*
Labour	*3 Hours at Rs.20*	*Rs.60*
Total overheads	*3 Hours at Rs.10*	*Rs.30*

During a particular month 10,000 units of the component were produced and the same was found to be at 60% capacity of the budget. In preparing the variance report for the month, the cost accountant gathered the following information:

Labour	*Rs.6,50,000*
Variable overheads	*Rs.2,00,000*
Fixed overheads	*Rs.3,00,000*
Material price variance	*Rs.70,000 (A)*
Material cost variance	*Rs.50,000 (A)*
Labour rate variance	*Rs.50,000 (F)*
Fixed overhead expenditure variance	*Rs.50,000 (A)*

You are required to prepare from the above details:

(1) Actual material cost incurred

(2) Standard cost of materials actually consumed

(3) Labour efficiency variance

(4) Variable OH efficiency variance

(5) Variance OH expenditure variance

(6) Fixed OH efficiency variance

(7) Fixed OH capacity variance

(8) Fixed OH volume variance *(Nov 1999)*

Answer

(a) Causes for the occurrence of labour rate variance: This variance arises due to the difference between standard labour hour rate specified and the actual labour hour rate paid. It is computed by multiplying the actual hours taken by workers on a job by the difference between the standard and actual wage rate per hour. Main cause which contribute for the occurrence of labour rate variance are as below:

(i) Increase in actual wage rate per hour paid to workers.

(ii) Use of wrong type of labour i.e. for a job requiring the use of non-skilled labour uses skilled labour.

(iii) Since the wages of skilled labour are more than that of non-skilled labour therefore this increased wage rate per hour of skilled labour force accounts for the occurrence of labour rate variance.

(iv) Payment of special increments or allowances to workers.

(v) Non-anticipated wage increase at the time of setting standards,

(vi) Using a gang or mix different from that used for setting labour standard.

(vii) Resorting to excessive overtime.

(b) (1) Actual material cost incurred

Material cost variance = Standard cost of material of actual output – Actual material cost incurred

Or Actual material cost incurred $= \begin{pmatrix} \text{Standard variable of material} & - & \text{Material cost} \\ \text{of actual output} & & \text{variacne} \end{pmatrix}$

= (10,000 units × 2 units× Rs.15 + Rs.50,000)

= Rs.3,00,000 + Rs.50,000

(2) Standard cost of materials actually consumed

Material price variance = (Standard cost – Actual cost) Actual quantity consumed

Or Standard cost of materials actually consumed =

$$\begin{pmatrix} \text{Actual material} & + & \text{Material price} \\ \text{cost incurred} & & \text{variacne} \end{pmatrix}$$

= Rs.3,50,000 – Rs.70,000 = Rs.2,80,000

(3) Labour efficiency variance (Refer to working note 1)

$$= \begin{pmatrix} \text{Standard hours for} & - & \text{Actual hours} \\ \text{actual output} & & \text{worked} \end{pmatrix} \begin{matrix} \text{Standard rate} \\ \text{per hour} \end{matrix}$$

= (10,000 units × 3 hours – 35,000 hours) Rs.20

= (Rs.6,00,000 – Rs.7,00,000) = Rs.1,00,000 (Adv.)

(4) Variable OH efficiency variance (Refer to working note 2)

$$= \begin{matrix} \text{Standard variable overhead} \\ \text{rate per hour} \end{matrix} \begin{pmatrix} \text{Standard} & - & \text{Actual} \\ \text{hours} & & \text{hours} \end{pmatrix}$$

= Rs.5 (30,000 hours – 35,000 hours) – Rs.25,000 (Adv.)

(5) Variable OH expenditure variance (Refer to working note 1)

$$= \begin{pmatrix} \text{Budgeted variable overhead} & - & \text{Actual variable} \\ \text{for actual hours} & & \text{overhead} \end{pmatrix}$$

= (Rs.5 × 35,000 hours – Rs.2,00,000) – Rs.25,000 (Adv.)

(6) Fixed OH efficiency variance (Refer to working notes 1 & 2)

$$= \begin{bmatrix} \text{Standard fixed overhead} \\ \text{rate per hour} \end{bmatrix} - \begin{bmatrix} \text{Standard hour for} & - & \text{Actual} \\ \text{actual ouput} & & \text{hours} \end{bmatrix}$$

= Rs.5 (30,000 hours – 35,000 hours) = Rs.25,000 (Adv.)

Fixed OH capacity variance (Refer to working notes 1 & 2)

$$= \begin{bmatrix} \text{Standard variable overhead} \\ \text{rate per hour} \end{bmatrix} - \begin{bmatrix} \text{Actual capacity} & - & \text{Budgeted} \\ \text{hours} & & \text{capacity hours} \end{bmatrix}$$

= Rs.5 (35,000 hours – 50,000 hours) = Rs.75,000 (Adv.)

(7) Fixed OH volume variance (Refer to working note 3)

$$= \begin{array}{l}\text{Standard variable overhead}\\ \text{rate per hour}\end{array} \begin{pmatrix}\text{Actual} & - & \text{Budgeted}\\ \text{output} & & \text{output}\end{pmatrix}$$

$$= \text{Rs.}15 \left(10{,}000 \text{ units} - \frac{50{,}000 \text{ hours}}{3 \text{ hours}}\right)$$

= Rs.1,50,000 – Rs.2,50,000 = Rs.1,00,000 (Adv.)

Working notes:

1. Labour rate variance:

   = (Standard rate per hour – Actual rate per hour) Actual hours (x)

   Or Rs.50,000 = 20x – Rs.6,50,000

   Or x = 35,000 hours

2. Standard hours = 10,000 units × 2 hours = 30,000 hours

   $$\text{Budgeted hours} = \left(\frac{30{,}000 \text{ hours} \times 100}{60}\right) = 50{,}000 \text{ hours}$$

   Budgeted fixed overhead = Actual fixed overhead + Expenditure variance

   = Rs.3,00,000 – Rs.50,000 = Rs.2,50,000

   $$\begin{bmatrix}\text{Standard fixed overhead}\\ \text{recovery rate per hour}\end{bmatrix} = \frac{\text{Rs.}2{,}50{,}000}{50{,}000 \text{ hours}} = \text{Rs.}5 \text{ per hour}$$

   Total overhead rate per hour = Rs.10

   Variable overhead rate per hour = Rs.5

   (Rs.10 – Rs.5)

3. Standard fixed overhead per unit = Rs.15

   (3 hours × Rs.5/-)

Question 14

Describe three distinct groups of variances that arise in standard costing. *(May 2000)*

Answer

The three distinct groups of variances that arise in standard costing are:

The three distinct groups of variances that arise in standard costing are:

(i) Variances of efficiency. These are the variance, which arise due to efficiency or inefficiency in use of material, labour etc.

(ii) Variances of prices and rates: These are the variances, which arise due to changes in procurement price and standard price.

(iii) Variances due to volume: These represent the effect of difference between actual activity and standard level of activity. These can be summarized as under:

Element of cost	*Variance of Efficiency*	*Variance of price*	*Variance of volume*
Material	Usage, Mixture, Yield	Price	Revision
Labour	Efficiency, idle time	Rate of pay	--

- Variable	Efficiency	Expenditure	Revision
- Fixed	Efficiency	Expenditure	Revision
			Capacity
			Calendar

Question 15

The working results of a company for two corresponding years are shown below:

	Year 1	*Year 2*
	Rs. in lacs	*Rs. in lacs*
Sales	*1,200*	*1,540*
Direct Material	*600*	*648*
Direct Wages and Variable Overheads	*360*	*412*
Fixed overheads	*160*	*300*
	1,120	*1,360*
	80	*180*

Profit

In year 2, there has been an increase in the selling price by 10%. Following are the details of material consumption and utilization of direct labour hours during the two years.

	Year 1	*Year 2*
Direct material consumption in m/t	*5,00,000*	*5,40,000*
Direct Labour Hours	*75,00,000*	*80,00,000*

(i) Keeping year 1 as base year, analyse the results of year 2 and work out the amount which each factor has contributed to change in profit.

(ii) Find out the break even sales for both years.

(iii) Calculate the percentage increase in selling price that would be needed over the sale value of year 2 to earn a margin of safety of 45%. (May 2000)

Answer

(i) Reconciliation Statement showing which factor has contributed to change in profit

	Favourable in Rs. (lakhs)	*Adverse in Rs. (lakhs)*
Increase in contribution due to increase in volume (Rs. 280 lakhs – Rs.240 lakhs)	40	
(Refer to working note 3)		
Sales price variance	140	
(Refer to working note 3)		
Material usage variance	52	
(Refer to working note)		
Material price variance		0
(Refer to working note 4)		

Direct Labour rate variance	--	28
(Refer to working note 4)		
Direct labour efficiency variance	36	--
(Refer to working note 4)		
Fixed overhead expenditure variance	--	140
(Refer to Working note 3)		
	268	168
Total change in profit	100	168

(ii)

Break-even sales (year 1) (Refer to working note 3) $= \dfrac{\text{Fixed costs}}{\text{P/V ratio}}$

$$= \frac{\text{Rs.160 lakhs}}{\left(\dfrac{\text{Rs.240 lakhs}}{\text{Rs.1,200 lakhs}}\right)} = \text{Rs.800 lakhs}$$

Break even sales (year 2) (Refer to working note 3) $= \dfrac{\text{Rs.1300 lakhs}}{\left(\dfrac{\text{Rs.480 lakhs}}{\text{Rs.1,540 lakhs}}\right)} = \text{Rs.962.50}$

(iii) Percentage increase in selling price needed over the sale value of year 2 to earn a margin of safety of 45% in year 2.

P/V ratio = (Rs.480 lakh / Rs.1,540 lakhs × 100 = 31.169%

Break even sales $= \dfrac{\text{Rs.962.50 lakhs}}{\text{Rs.1,540}} \times 100 - 62.5\%$

= (5,83,333 – 5,40,000) Rs.120 – Rs.52 lakhs (Fav.)

If Margin of safety to be earned is 45% then Break-even point should be 55%.

Contribution increase required $= \dfrac{62.5 \times 31.169}{55} \times 100 = 35.4193\%55$

Revised contribution = 1,540 lakhs ×35.4193%

= Rs.545.45 lakhs

Present contribution = Rs.480 lakhs

Increase in selling price required = Rs.65.45 lakhs (Rs.545.45 lakhs – Rs.480 lakhs)

Percentage increase in selling price

Over the sales value of year 2 $= \dfrac{\text{Rs.65.45 lakhs}}{\text{Rs.1,540 Lakhs}} \times 100 = 4.25\%$

Working notes:

1. Budgeted sales in year 2

   If actual sales in year 2 is Rs.110 then budgeted sales is Rs.100

   If actual sales in year 2 is Re1 then budged sales $= \dfrac{\text{Rs.100}}{\text{Rs.110}}$

   If actual sales in year 2 is Rs.15,40,00,000 then budged sales are

$$= \frac{Rs.100}{Rs.110} \times Rs.15{,}40{,}00{,}000$$

= Rs.1,400 lakhs

2. Budged figures of direct material; direct wages; and variable overhead worked out on the basis of % of sales in year 2:

$$\text{Direct material \% to sale (in year 1)} = \frac{\text{Direct material cost}}{\text{Sales}} \times 100$$

$$= \frac{600}{1{,}200} \times 100 = 50\%$$

Budgeted figure of direct Material (in year 2)

= 50% ×Rs.1,400 lakhs = Rs.700 lakhs

Direct wages and variable overhead

$$\text{\% to sales (in year 1)} = \frac{\text{Direct wages and variable overhead}}{\text{Sales}} \times 100$$

$$= \frac{300}{1{,}200} \times 100 = 30\%$$

Budgeted figure of direct wages and variable overhead (in year 2)

= 30% × 1,400 lakhs

= 420 lakhs

3. Statement of figures extracted from working results of a company.

(Figures in lakhs of Rs.)

	Year 1 Actual	*Years 2 (Budgeted)*	*Years 2 Actual*	*Total variance*
	(a)	*(b)*	*(c)*	*(d)=(c)-(b)*
Sales (A)	1,200	1,400 (Refer to w.n. 1)	1,540	140 (Fav)
Variable costs:				
Direct material (Refer to w. n. 2)	600	700	648	52 (Fav)
Direct wages and variable overhead (Refer to w. n. 2)	360	420	412	8 (Fav.)
Total variable costs (B)	960	1120	1060	60 (Fav.)
Contribution (C) = [(A) – (B)]	240	280	480	200 (Fav)
Less: Fixed cost	160	160	300	140 (Adv.)
Profit	80	120	180	60 (Fav.)

4. (i) Data for Material variances:

Standard data for actual output			*Actual data*		
Quantity of material m/t	*Rate per m/t*	*Amount*	*Quantity of material m/t*	*Rate per m/t*	*Amount*

	Rs.	Rs.		Rs.	Rs.
5,83,333	120	700 lakhs	5,40,000	120	648 lakhs

Material price variance

= (Standard rate – Actual rate) Actual quantity

= Nil

Material usage variance

= (Standard quantity – Actual quantity) Standard rate per m/t

= (5,83,333 – 5,40,000) Rs.120 – Rs.52 lakhs (Fav.)

(ii) Date for Labour and variable overhead variances

Standard data for actual output			*Actual data*		
Labour hours	*Rate per hours*	*Amount*	*Labour hours*	*Rate per hours*	*Amount*
	Rs.	*Rs.*		*Rs.*	*Rs.*
87,50,000	4.80	420 lakhs	80,00,000	5.15	412 lakhs

Labour rate variance:

= (Standard rate – Actual rate) Actual labour hours

= (Rs.4.80 – Rs.5.15) 80,00,000 = Rs.28 lakhs (Adv.)

Labour and variable overhead efficiency variance:

= (Standard labour hours – Actual labour hours) × Standard rate per hour

= (87,50,000 – 80,00,000) Rs.4,80 = Rs.36 lakhs (Adv.)

Question 16

(a) "Standard costing variances centre around comparison of actual Performance with the standard and the standards or plans are normally based on the environment anticipated when the targets are set and if the current environment is different from that anticipated, such analysis cannot measure managerial performance". Comment on the statement and how will you deal with the situation with reference to material, labour and sales variances.

(Nov 2000)

(b) F Manufacturing Ltd., uses the three variances method to analyse the manufacturing overhead variances for the fiscal year just ended were computed as follows:

Spending	*Rs.86,000*	*Adverse*
Efficiency	*Rs.36,000*	*Favourable*
Volume	*Rs.80,000*	*Favourable*

The manufacturing overhead application rate for the year was Rs.160 per machine hours of which Rs.60 per machine hour was the variable component. The year end balance the manufacturing overhead control account was Rs.16,50,000 and the standard machine hours for the year were 11,300.

From the above data compute:

(i) Budgeted Machine Hours

(ii) Actual Machine Hours

(iii) Applied Manufacturing Overhead

(iv) Total Amount of Fixed Overhead Cost *(Nov 2000)*

Answer

(a) The statement give in the question highlights practical difficulties faced by our industries today.

When the current environmental conditions are different from the anticipated environmental conditions (prevailing at the time of setting standard or plans) the use of routine analysis of variance for measuring managerial performance is not desirable / suitable.

The variance analysis can be useful for measuring managerial performance if the variances computed are determined on the basis of revised targets / standards based on current actual environmental conditions. In order to deal with the above situation i.e. to measure managerial performance with reference to material, labour and sales variances, it is necessary to proceed and compute the following variances.

Material variances:

In the case of material purchase price variance, suppose the standard price of raw material determined was Rs.5 per unit, the general market price per unit at the time of purchase was Rs.5.20 and actual price paid per unit was Rs.5.18 on the purchase of say 10,000 units of raw material.

In this case the variances to be computed should be:

Uncontrollable material purchase price planning variance:

= (Standard price p.u. – General market price p.u.) Actual quantity purchased

= (Rs.5 – Rs.5.20) 10,000 units = Rs.2,000 (Adverse)

Controllable material purchase price efficiency variance:

= (General market price p.u. – Actual price paid p.u.) Actual quantity purchased

= (Rs.5.20 – 5.18) 10,000 units

= Rs.200 (Fav.)

In the case of material usage variance, suppose the standard quantity per unit be 5 kgs, actual production units be 250 and actual quantity of material used is 1,450 kgs. Standard cost of material per kg. was Re.1. Because of shortage of skilled labour it was felt necessary to use unskilled labour and that increased material usage by 20%. The variances to be computed to deal with the current environmental conditions will be: Uncontrollable material usage planning variances:

= (Original std. quantity in kgs. – Revised std. quantity in kgs.) Standard price per kg.

= (1,250 kgs. – 1,500 kgs) Re.1

= Rs.250 (Adverse)

Controllable material usage efficiency variance:

= (Revised standard quantity in kgs. Actual quantity used in kgs.) Standard price per kg.

= (1,500 kgs. – 1,450 kgs.) Re.1

= Rs.50 (Favourable)

Labour variances:

Like material variances, here also labour efficiency and wage rate variances should also be adjusted to reflect changes in environmental conditions that prevailed during the period. The labour efficiency variances would be equivalent to the following two variances.

(a) Uncontrollable labour efficiency planning variance

(b) Controllable labour efficiency variance

The above variances would arise when unskilled labour is substituted for skilled labour.

Similarly, one uncontrollable and other controllable variance would arise in the case of wage rate variance as well under current environmental conditions.

Sales variances:

The conventional sales volume variance reports the difference between actual and budgeted sales, priced at the budgeted contribution per unit. The variance merely indicates whether sales volume is greater or less than expected. It does not indicate how well sales management actual sales volume should be compared with an expert estimate that reflects the market conditions prevailing during that period.

Total sales margin variance (planning element):

= {Expert's budgeted sales volume × (Expert's selling price – Standard cost) – Original budgeted sales volume × (Budgeted selling price – Standard cost)}

Total sales margin variance (appraisal element):

= {Actual sales volume × (Actual selling price – Standard cost)}

= Expert's budgeted sales volume × (Expert's selling price – Standard cost)}

The figure of "Expert's budgeted sales volume" for a particular product can be determined by estimating the total market sales volume for the period and then multiplying the estimate by the target percentage of market share.

(b) (i) Budgeted Machine Hours:

We know that:

Volume variance

$$= \frac{\text{Std. fixed overhead}}{\text{rate per hour}} \left(\frac{\text{Std. machine hours}}{\text{for actual output}} - \frac{\text{Budgeted machined hours}}{\text{for actual output}} \right)$$

or Rs.80,000 (Fav.) = Rs.100 (11,300 – Y)

or 800 = 11,300 – Y

or Y = (11,300 – 800) hours

or Y = 10,500 hours

Hence budgeted machine hours for actual output are 10,500 hours.

(ii) Actual machine Hours: We know that:

$$\text{Efficiency variance} = \frac{\text{Std. variable overhead}}{\text{rate per hour}} \left(\frac{\text{Std. hours for}}{\text{actual output}} - \frac{\text{Actual hours}}{\text{for actual output}} \right)$$

or Rs.36,000 (Fav.) = Rs.60 (11,300 hours – X)

or 600 = 11,300 hours – X

or X = 10,700 hours.

Hence Actual machine hours are 10,700 hours.

(iii) Applied Manufacturing Overhead:

Applied Manufacturing overhead

Actual overhead incurred + Total Variance

= Rs.16,50,000 + Rs.30,000

(Refer to working note)

= Rs.16,80,000

Hence total applied manufacturing overhead are Rs.16,80,000.

(iv) Total Amount of Fixed Overhead Cost:

We know that:

Spending variance = (Flexible budget for actual hours – Actual factory overhead incurred)

Rs.86,000 (Adv.) = 10,700 hours × Rs.60 + total amount of fixed overhead) – Rs.16,50,000)

Rs.86,000 (Adv.) = (Rs.6,42,000 + Total amount of fixed overhead cost (budgeted) – Rs.16,50,000)

Total amount of fixed overhead cost = Rs.10,08,000 – Rs.86,000 = Rs.9,22,000

Total amount of fixed overhead cost = Rs.9,22,000

Working note:

Given that:

Spending variance (Rs.)	86,000 (Adv.)
Efficiency variance (Rs.)	36,000 (Fav.)
Volume variance (Rs.)	80,000 (Fav.)

Therefore,

Total variance = Spending variance + Efficiency variance + Volume variance

= Rs.86,000 (Adv.) + Rs.36,000 (Fav.) + Rs.80,000 (Fav.)

= Rs.30,000 (Fav.)

Alternative approach:

Total factory overhead variance = {factory overhead applied actual factory overhead incurred}

= (Std. hours for actual output × Budget rate per hour – Actual cost incurred)

= (11,300 hours × Rs.160 – Rs.16,50,000)

= Rs.1,58,000 (Fav.)

Under alternative approach, Applied Manufacturing Overhead and Total Amount of Fixed Overhead Cost would come to Rs.18,08,000 and Rs.10,50,000. Budgeted and actual machine hours would come to 10,500 and 10,700. Spending, Efficiency and Volume Variances would come to Rs.42,000 (Fav.), Rs.36,000 (Fav.) and Rs.80,000 (Fav.) respectively.

Question 17

(a) State the features of Partial plan of Standard Cost Accounting procedure. *(May 2001)*

(b) The following is the Operating Statement of a company for April 2001:

				Rs.
Budgeted Profit				*1,00,000*
Variances:		*Favourable Rs.*	*Adverse Rs.*	
Sales Volume			*4,000*	
	Price	*9,600*		
Direct Material	*Price*		*4,960*	
	Usage		*6,400*	

Direct Labour	*Rate*		*3,600*	
	Efficiency	*3,600*		
Fixed Overheads	*Efficiency*	*2,400*		
	Capacity		*4,000*	
	Expense	*1,400*		
		17,000	*22,960*	*5,960 (A)*
Actual profit				*94,040*

Additional information is as under:

Budget for the year	*1,20,000 units*
Budgeted fixed overheads	*Rs.4,80,000 per annum*
Standard cost of one unit of product is:	
Direct Materials	*5 kg.@ Rs.4 per kg.*
Direct Labour	*2 hours @ Rs.3 per hour*

Fixed overheads are absorbed on direct labour hour basis.

Profit	*25% on sales*

You are required to prepare the Annual Financial Profit / Loss Statemetn for April, 2001 in the following format:

Account	*Qty./ Hours*	*Rate / Price*	*Actual Value Rs.*
Sales			
Direct Materials			
Direct Labour			
Fixed Overheads			
Total Costs			
Profit			

(May 2001)

Answer

(a) Features of Partial Plan of Standard Cost Accounting procedure:

Standard cost operations can be recorded in the books of account by using partial plan, Features of partial plan of standard costing procedure are as follows:

(i) Partial plan system uses current standards in which the inventory will be valued at current standard cost figure.

(ii) Under this method WIP account is charged at the actual cost of production for the month and is credited with the standard cost of the month's production of finished product.

(iii) The closing balance of WIP is also shown at standard cost. The balance after making the credit entries represent the variance from standard for the month.

(iv) The analysis of variance is done after the end of the month.

(b) Working notes:

1. (a) Budgeted fixed overhead per unit:

= (Budgeted fixed overheads p.a / Budgeted output for the year)

= Rs.4,80,000 p.a. / 1,20,000 units = Rs.4 per unit.

(b) Budgeted fixed overhead hour:

= Budgeted fixed overhead per unit / Standard labour hours per unit

= Rs.4 / 2 hours = Rs.2 per hour

2. (a) Standard cost per unit:

	Rs.
Direct material	20
(5 kg × Rs.4/- per kg)	
Direct labour	6
(2 hours × Rs.3/- per hour)	
Fixed overhead	4
(2 hours × Rs.2)	
Total standard cost (per unit)	30

(b) Budgeted selling price per unit

Standard cost per unit	30
Standard profit per unit	10
(25% on slaes or 33 – 1/3% of standard cost)	
Budgeted selling price per unit	40

3 (a) Actual output units for April, 2001:

Fixed overhead volume Variance

= Efficiency variance + Capacity variance

or (Budgeted output units – Actual output units) Budgeted fixed overhead p.u.

Rs.2,400 (Favourable) + Rs.4,000 (Adverse) = Rs.1,600 (Adverse)

or (10,000 units – x units) Rs.4 – Rs.1,600 (Adverse)

or (10,000 units – 400 units) = x (Actual output units)

or Actual output units = 9,600 units

(b) Actual fixed overhead expenses:

(budgeted fixed overhead – Actual fixed overhead) = Fixed overhead expenses variance

or (Rs.40,000 – x) = Rs.1,400 (Favourable)

or x = Rs.40,000 – Rs.1,400

= Rs.38,600

4. (a) Actual sales quantity units: Sales volume variance

$$= \text{Budgeted margin per unit} \left(\begin{matrix} \text{Actual sales} \\ \text{quantity units} \end{matrix} - \begin{matrix} \text{Budgeted} \\ \text{quantity units} \end{matrix} \right)$$

= Rs.4,000 (Adverse) = Rs.10 (x – 10,000 units)

or 400 units = x – 10,000 units

or x (Actual sales quantity) = 9,600 units

(b) Actual selling price per units

Sales price variance = $\left(\begin{matrix}\text{Actual Selling} \\ \text{price per unit}\end{matrix} - \begin{matrix}\text{Budgeted selling} \\ \text{price per unit}\end{matrix}\right)\begin{matrix}\text{Actual} \\ \text{Sales units}\end{matrix}$

or Rs.9,600 (Fav.) = (x – Rs.40) × 9,600 units

or Actual selling price per unit = Rs.41/-

5. (a) Actual quantity of material consumed:

Material usage variance = $\left(\begin{matrix}\text{Standard} \\ \text{quantity}\end{matrix} - \begin{matrix}\text{Actual} \\ \text{quantity}\end{matrix}\right)\begin{matrix}\text{Standard price} \\ \text{per unit}\end{matrix}$

or 6,400 (Adv.) = (9,600 units × 5 kgs.) Rs.4

or x kgs. = 49,600 kgs.

(actual quantity of material consumed)

(b) Actual price per kg:

Actual price per kg.:

Material price variance = (Standard price per kg – Actual price per kg) Actual quantity of material consumed

-Rs.4,960	=	(Rs.4 –Rs. y per kg.) 49,600 kg.
-0.1	=	(Rs.4 – Rs. y per kg)
or y	=	Rs.4.10 per kg.

6. (a) Actual direct labour hour used:

Labour efficiency variance = (Standard hours – Actual hours) Standard rate per hour

Rs.3,600 (Favourable) = (9,600 units × 2 hours – p hours) Rs.3

Rs.3,600 (Favourable) = (19,200 hours – p hours) Rs.3

P hours = (19,200 hours – 1,200 hours) – 18,000 hours

(Actual direct labour hours)

(b) Actual direct labour hour rate:

Labour rate variance = $\left(\begin{matrix}\text{Standard} \\ \text{rate per hour}\end{matrix} - \begin{matrix}\text{Actual rate} \\ \text{per hour}\end{matrix}\right)\begin{matrix}\text{Actual Direct} \\ \text{labour hours}\end{matrix}$

Rs.3,600 (Adverse) = (Rs.3 per hour – t per hour) 18,000 hours

or t = Rs.3 + Rs.0.20 – Rs.3.20 per hour

(actual direct labour hour rate)

7. Actual fixed overheads:

Fixed overhead expense variance = Budgeted fixed overhead – Actual fixed overhead

or Rs.1,400 (Favourable) = 10,000 units × Rs.4 p.u. – Actual fixed overhead

or Actual fixed overhead = Rs.40,000 – Rs.1,400

or Actual fixed overhead = Rs.38,600

Annual financial Profit /Loss Statement

(for April, 2001)

Account	*Qty./ Hours*	*Rate/Price*	*Actual/ Value*
(a)	*(b)*	*(c)*	*(d)=(b)×(c)*
Sales: (A)	9,600 units	41	3,93,600
(Refer to working note 4)			
Direct Materials	49,600 kgs.	4.10 per kg.	2,03,360
(Refer to working note 5)			
Direct labour	18,000 hours	3,20 per hour	57,600
(Refer to working note 6)			
Fixed Overheads	18,000 hours	2.14444 per hour	38,600
(Refer to working note 6 (a) and 7)			
(Rs.38,600/18,000 hours)			
(absorbed on direct labour hour basis)			
Total costs: (B)			2,99,560
Profit : [(A) – (B)]			94,040

Question 18

C Preserves produces Jams, Marmalade and Preserves. All the products are produced in a similar fashion; the fruits are cooked at low temperature in a vacuum process and then blended with glucose syrup with added citric acid and pectin to help setting.

Margins are tight and the firm operates, a system of standard costing for each batch of Jam.

The standard cost data for a batch of raspberry jam are

Fruits extract	*400 kgs @ Rs. 16 per kg.*
Glucose syrup	*700 kgs @ Rs. 10 per kg.*
Pectin	*99 kgs. @ 33.2 per kg.*
Citric acid	*1 kg at Rs. 200 per kg.*
Labour	*18 hours @ Rs. 32.50 per hour.*
Standard processing loss 3%.	

The climate conditions proved disastrous for the raspberry crop. As a consequence, normal prices in the trade were Rs. 19 per kg for fruits abstract although good buying could achieve some savings. The impact of exchange rates for imported sugar plus the minimum price fixed for sugarcane, caused the price of syrup to increase by 20%.

The retail results for the batch were –

Fruit extract	*428 kgs at Rs. 18 per kg.*
Glucose syrup	*742 kgs at Rs. 12 per kg.*
Pectin	*125 kgs at Rs 32.8 per kg.*
Citric acid	*1 kg at Rs. 95 per kg.*
Labour	*20 hrs. at Rs. 30 per hour.*

Actual output was 1,164 kgs of raspberry jam.

You are required to:

(i) Calculate the ingredients planning variances that are deemed uncontrollable.

(ii) Calculate the ingredients operating variances that are deemed controllable.

(iii) Calculate the mixture and yield variances.

(iv) Calculate the total variances for the batch.

Answer

Details of original and revised standards and actual achieved

	Original standards		Revised standards		Actual	
Fruit	400 Kgs × Rs16	Rs6,400	400 Kgs × Rs 19	Rs7,600	428 Kgs × Rs 18	Rs7,704
Glucose	700 Kgs × Rs10	Rs7,000	700 Kgs × Rs12	Rs 8,400	742 Kgs × Rs 12	Rs 8,904
Pectin	99 Kgs × Rs 33.2	Rs 3286.8	99 Kgs × Rs 33.2	Rs 3286.8	125Kgs × Rs 32.8	Rs 4,100
Citric acid	1 Kg × Rs 200	Rs 200	1 Kg × Rs 200	Rs 200	1 Kg × Rs 95	Rs 95
	1,200 kgs	Rs16,886.8	1,200 kgs	Rs19,486.8	1,296 kgs	Rs20,803
Labour		Rs 585.0		Rs 585.0		Rs 600
	1,200 kgs	17,471.8	1,200 kgs	20,071.8	1,296 kgs	21,403
Loss	36 kgs		36kgs		132	
	1,164kgs	Rs 17,471.8	1,164kgs	Rs 20,071.8	1,164 Kgs	Rs 21,403

(i) Planning variances

* Fruit extract (6,400 less 7,600)	Rs 1,200(Adverse)
Glucose syrup (7,000 less 8,400)	Rs1,400(Adverse)
Total	Rs 2,600(Adverse)

* (Std qty × Std price less Std qty × Revised Std price)

(ii) Ingredients operating variances

Total (19,486.8 less 20,803) = Rs 1,316.2(Adverse)

Ingredients Price variance

(Revised Material Price – Actual Material Price) × (Actual Qty Consumed)

		Variance in Rs
Fruit extract	(19 – 18) × 428	428(F)
Glucose syrup		Nil
Pectin	(33.2 – 32.8) × 125	50(F)
Citric acid	(200 – 95) × 1	105(F)
		583(F)

Usage variance

(Std Qty on Actual Production less Actual Qty on Actual Production) × Revised Std Price/Unit

	Rs	*Variance in Rs*
Fruit extract	(400 – 428) × 19	532(A)
Glucose syrup	(700 – 742) ×12	504(A)
Pectin	(99 – 125) ×33.2	863.2(A)
Citric acid		Nil
		1,899.2(A)

(iii) Mix Variance

(Actual usage in std mix less Actual usage in actual mix) $\times$ std price

		Variance in Rs
Fruit extract	(432 – 428) $\times$ 19	76(F)
Glucose syrup	(756 – 742) $\times$ 12	168 (F)
Pectin	(106.92 – 125) $\times$ 33.2	600.3(A)
Citric acid	(1.08 – 1) $\times$ 200	16(F)
		340.3 (A)

Yield variance

(Actual yield – Std yield from actual output) $\times$ Std cost per unit of output

$$= (1{,}164 - 1{,}296 \times 0.97) \times \frac{19486.8}{1164} = 1{,}558.9(A)$$

Labour operating variance

585 – 600 = 15(A)

(iv) Total variance = Planning variance + Usage Variance + Price Variance + labour operating Variance.

Or Total Variance = (2,600) + (1,899.2) + 583 + (15) = 3931.2 (A).

Question 19

Rainbow Ltd. manufactures paint in batches. The company uses standard costing system and the variances are reported weekly. You have taken the account sheet for study for variance analysis discussion. While working coffee was spilled on these sheets and only following could have been retrieved:

Dr.			*Cr.*
	Raw Material -1		
Beg. Balance	*0*		*18,000*
		Closing Balance	*6,000*
	Raw Material -2		
Beg. Balance	*18,000*		
		Closing Balance	*41,400*
	Work in Progress		
Beg. Balance	*0*		
Raw Material -2	*72,000*	*Closing Balance*	*0*
	Sundry Creditors		
			1,27,200
	Wages outstanding		
	51,750		
	Quantity Variance-Material-1		
	1,200		
	Price Variance-Material-2		
			6,600
	Efficiency Variance-Labour		
			7,200

Other information's are: standard cost of Material – 2 is Rs180 per litre and standard quantity is 5 litres. Standard wages rate is Rs24 per hour and a total 2,300 hours were worked during the week. 1,000 kg of Material -1and 550 litres of Material-2 were purchased. Sundry creditors are for material acquisition, and wages outstanding pertain to direct labour.

You are required to compute Material-1 Rate Variance, Material-2 Quantity Variance & Labour Spending Variance, Standard hours allowed for production and purchase value of Material-1 for variance analysis discussion.

Answer

Material – 1 Rate Variance	= Standard cost of material purchased – Actual cost
	= Rs24, 000 – Rs21, 600 = Rs2, 400 (F)
Material – 2 Quantity Variance	= SR × SQ – SR × AQ
	= Rs900 × 80 units – Rs75, 600
	= Rs3, 600 (A)
Labour Spending Variance	= SR × AH – AR × AH
	= Rs24/per hour × 2300 hours – Rs51, 750
	= Rs3, 450 (A)
Labour Efficiency Variance	= SR × (SH – AH)
	– 7200 = 24 (SH – 2300)
	SH = 2000 Hrs.

	Rs
Total Cost of material purchased	1,27,200
Less Purchase Value of Material – 2	1,05,600
Cost of material –1	21,600

Working Notes:

(1)	Standard Cost of Material – 2 actually consumed in production = Rs72, 000 (Given)	
	Standard cost of Material – 2 per unit: 5 litres × Rs180	= Rs900
	∴ No of units produced	= Rs72, 000 / Rs900 = 80 units
	Total material – 1 used in production	= Rs18, 000 (Given)
	Add Closing Inventory	= Rs6, 000 (Given)
	Less Opening Inventory	= 0
	Hence Standard Cost of Material – 1 purchased	= Rs24, 000
(2)	Standard Rate of Material -1	= Rs24, 000 / 1,000kg = Rs24 per kg
	Standard Cost of Material – 1	= Rs18, 000
	Add favourable Quantity Variance	= Rs1, 200
	Material – 1 allowed	= Rs19, 200
	Standard quantity of Material – 1 allowed	= Rs19, 200/Rs24= 800 Kg.
	Standard quantity per unit	= 800kg/80units = 10 kg

	Standard purchase price for Material – 2	= (550liters × Rs180)= Rs99, 000
	Add unfavourable Rate Variance	= Rs6, 600
	Actual cost Price of Material – 2	= Rs1, 05, 600
(3)	Opening balance of Material – 2	= Rs18, 000
	Add Standard Cost of Purchase (550 litres × Rs180)	= Rs99, 000
	Less Closing Balance	= Rs41, 400
	Material-2 Consumed at Standard cost	= Rs75, 600

Question 20

"Overhead variances should be viewed as interdependent rather than independent". Explain.

Answer

The operations of a firm are so inter linked that the level of performance in one area of operation will affect the performance in other areas. Improvements in one area may lead to improvements in other areas. A sub-standard performance in one area may be compensated by a favourable performance in another area. Because of such interdependency among activities in the firm, the managers should not jump to conclusions merely based on the label of variances namely favourable or unfavourable. They should remember that there is a room for trade off amongst variances. Hence, variances need to be viewed as 'attention directors' rather than problem solvers. Thus, a better picture will be captured when overhead variance are not viewed in isolation but in an integrated manner.

Question 21

A company following standard marginal costing system has the following interim trading statement for the quarter ending 30th June, 2005, which reveals a loss of Rs. 17,000, detailed below:

		Rs.
Sales		*4,99,200*
Closing stock (at prime cost)		*18,000*
		5,17,200
Costs:		
Direct material	*1,68,000*	
Direct labour	*1,05,000*	
Variable overhead	*42,000*	
	3,15,000	
Fixed overhead	*1,20,000*	
Fixed Admn. Overhead	*40,000*	
Variable distribution Overhead	*19,200*	
Fixed selling Overhead	*40,000*	
	2,19,200	
Total costs		*5,34,000*
Loss		*17,000*

Additional information is as follows:

(i) *Sales for the quarter were 1,200 units. Production was 1,400 units, of which 100 units were scrapped after complete manufacture. The factory capacity is estimated at 2,000 units.*

(ii) *Because of low production, labour efficiency during the quarter is estimated to be 20% below normal level.*

You are required to analyse the above and report to the management giving the reasons for the loss.

Answer

(i)

	Details	Working	Amount (Rs.)
(1)	Selling price at cost	$\frac{4,99,200}{1,200}$	416
(2)	Raw materials	$\frac{1,48,000}{1,400}$	120
	Labour	$\frac{1,05,000}{1,750}$	60
	[Equivalent units (1,400/80%)]		
	Factory overhead	$\frac{42,000}{1,400}$	30
	Total manufacturing cost		210
	Distribution overheads	$\frac{19,200}{1,200}$	16
Total cost			226
Contribution			190
Total fixed cost: factory		1,20,000	
	Administration	40,000	
	Selling	40,000	2,00,000

(ii) Standard Profit for 1,200 units sold:

	Rs.	
Contribution	1,200 × 190	2,28,000
Less: Fixed costs		2,00,000
Profit		28,000

(iii) Reconciliation

	Rs.	
Budgeted profit	(2,000 × 190 – 2,00,000)	1,80,000
Less: Volume variance	800 × 190	1,62,000
Standard profit		28,000
Factors causing loss:		
Units scrapped	100 × 210	21,000
Labour inefficiency	350 × 60	21,000
Undervaluation of closing stock	100 × (210 – 180)	3,000
Actual profit		–17,000

Question 22

The following figures are available. Find out the missing figures, giving appropriate formulae:

Rs.

Budgeted profit		*15,000*
Less: Adverse variances:		
Contribution price variance	*10,600*	
Direct materials variance	*1,000*	
Fixed overhead variance	*600*	*(12,200)*
		2,800
Add: Favourable variances		
Contribution quantity variance	*1,800*	
Direct wages variance	*600*	
Variable overhead variance	*1,800*	*4,200*
Actual profit		*7,000*

There is no inventory

Production units = Sales units for both actual and budget.

Standard selling price	*Rs. 18/unit*
Standard variable cost	*Rs. 15/unit*
Standard contribution	*Rs. 3/unit*
Actual selling price	*Rs. 17/unit*
Budgeted sales	*10,000 units*

Standard material cost p.u. = Re. 1 (which is 5 kg. @ Rs. 20 Paise/kg.).

Material usage variance = 400 (Adv.)

Actual labour hours @ actual rate = Rs. 63,000

Actual labour hours @ standard rate = Rs. 61,950

Variable overhead standard rate = Rs. 2

Standard hours of production = 4 per unit

Variable overhead at standard rate = Rs. 84,800.

Variable overhead expenditure variance = 400 (A).

Budgeted fixed overhead = Rs. 15,000.

Find out the following:

(i) Actual sales units

(ii) Actual sales rupees

(iii) Actual quantity of raw materials used

(iv) Labour efficiency variance

(v) Actual variable overhead in rupees

(vi) Variable overhead efficiency variance

(vii) Actual fixed overheads

(viii) Operating profit variance.

Answer

		Rs.
(1)	Budgeted contribution = Budgeted Profit + Budgeted Fixed Cost	15,000 + 15,000

			= 30,000
	Plus Contribution quantity variance		1,800
	Total Standard contribution		31,800
	Standard Contribution per unit		3
	Actual Sales Volume		10,600 units
(2)	Actual Sales Volume 10,600 × 17		1,80,200
(3)	Actual quantity of Raw Materials used		
	Standard consumption 10,600 × 5		2,000 Kgs.
	Add: Material Usage Variance $\frac{400}{.2}$		2,000 kgs.
	Actual consumption		55,000 Kgs.
(4)	Labour Efficiency variance		
	Standard labour cost for Standard hours	(63,000 + 600)	63,600
	Standard labour cost for actual hours		61,950
	Labour efficiency variance		1,650 F
(5)	Actual variable overhead		
	Selling Overhead variance – Variable overhead	Rs. 84,800 – Rs. 1,800 = Rs. 83,000	
(6)	Variable Overhead efficiency variance		
	Actual hours (AH)	$\frac{61,950}{1.5}$	41,300 hours
	Standard hours (SH)	60,600 × 4	42,400 hours
	Standard rate per hour (SR)	$\frac{63,600}{10,600 \times 4}$	Rs. 1.5

Efficiency variance SR (SH – AH) = 2 (42,400 – 41,300) = 2,200F

(7) Actual fixed overheads: Budgeted Overhead + Fixed Overhead variance = 15,000 + 600 = Rs. 15,600.

(8) Operating profit variance

If budgeted profit is considered (15,000 – 7,000) = Rs. 8,000 adverse

If standard profit is considered (16,800 – 7,000) = Rs. 9,800 adverse

Question 23

Under the single plan, record the journal entries giving appropriate narration, with indication of amounts of debits or credits alongside the entries, for the following transactions using the respective control A/c.

(i) Material price variance (on purchase of materials)

(ii) Material usage variance (on consumption)

(iii) Labour rate variance.

Answer

(i)	Dr. Material Control A/c Dr. or Cr. Material Price Variance A/c Cr. Creditors A/c (Being price variance during purchase of materials)
(ii)	Dr. WIP Control A/c Dr. or Cr. Material Usage Variance A/c Cr. Material Control A/c

(Being recording of usage variance at Standard cost of excess/under utilized quantity)

(iii) Dr. Wages Control A/c

Dr. or Cr. Labour Rate Variance A/c

Cr. Cash

(Being entry to record wages at standard rate)

6

PRICING DECISIONS, PARETO ANALYSIS

Question 1

Name the pricing policy which aims at high selling price in the beginning of a product's, life cycle?
(May 1996)

Answer

Skimming Pricing.

Question 2

What is meant by Cost-plus pricing?

Answer

Cost-plus pricing: It is the most widely used method of pricing a product as it ensures that the selling price is greater than the total cost of a product. This method helps business firms to generate profits and survive in the future.

Under cost plus pricing the selling price of the product is determined by adding a percentage of mark-up to the estimated unit cost of the product.

The unit cost of the product can be determined by using different methods viz., total cost; manufacturing cost or variable/incremental cost. The percentage of mark-up to be added to estimated cost also very and depends upon the cost figure used. For example, if total cost is used, the mark up will be added to provide an acceptable profit per unit.

Alternatively if total manufacturing cost is used, the 'plus' that is added must be sufficient to cover non-manufacturing overheads and to provide an acceptable profit per unit.

Question 3

Enumerate the circumstances which are favourable for the adoption of a penetrating pricing policy
(May 1999)

Answer

Penetrating pricing Policy: It means a pricing policy for penetrating mass market as quickly as possible through lower price offers. This method is also used for pricing a new product. In order to popularise a new product penetrating pricing policy is used initially. The company may not earn profit by resorting to this policy during the initial stage. Later on, the price may be increased as and when the demand picks up. Penetrating pricing policy can also be adopted at any stage of the product life cycle for products whose market is approached with low initial price. The use of this policy by the existing concerns will discourage the new concerns to enter the market. The pricing policy is also known as "stay-out-pricing".

Favourable Circumstances: The three circumstances favourable for resorting to penetrating pricing policy are as under:

When demand of the product is elastic to price. In other words, the demand of the product increases when price is low.

When there are substantial savings on large scale production. Here increase in demand is sustained by the adoption of low pricing policy.

When there is threat of competition, the prices fixed at a low level will act as an entry barrier to the prospective competitors.

Question 4

Chum-Chum Ltd. is about to introduce a new product with the following estimates:

Price per unit (in rupees)	*Demand (in thousand units)*
30-00	*400*
31-50	*380*
33-00	*360*
34.50	*340*
36-00	*315*
37-50	*280*
39-00	*240*

Costs:

Direct material	*Rs.12 per unit*
Direct labour	*Rs.3 per unit*
Variable overhead	*Rs.3 per unit*
Selling expenses	*10% on sales*
Fixed production overheads	*Rs.14,40,000*
Administration expenses	*Rs.10,80,000*

Judging from the estimates, determine the tentative price of the new product to earn maximum profits.
(Nov 1999)

Answer

Chum-Chum Ltd.

Statement for determining tentative price of the new product, from estimates, to earn maximum profit

Price per Unit (Rs.	*Demand (in lakhs of unit)*	*Sales revenue (in Rs. Lakhs)*	*Variable cost (in Rs. Lakhs (Rs.18 p.u. + 10% of selling price)*	*Contribution (in Rs. Lakhs)*
30-00	4.00	120.00	84.00	36.00
31-50	3.80	119.70	80.37	39.33
33-00	3.60	118.80	76.66	42.12
34-50	3.40	117.30	72.93	44.37
36-00	3.15	113.40	68.04	45.36
37-50	2.80	105.00	60.90	44.10
39-00	2.40	93.60	52.56	41.04

The tentative price of the new product should be Rs.36 per unit. At this price the profit of Chum-Chum Ltd. is maximum, the maximum profit of the concern comes to Rs.20,16,000 (Refer to working note).

Working note:

Maximum profit

= Maximum contribution – (Fixed production overhead + Administration expenses)

= Rs.45,36,000 – (Rs.14,40,000 + Rs.10,80,000)

= Rs.45,36,000 – Rs.25,20,000

= Rs.20,16,000

Question 5

Explain the concept of cost plus pricing. What are its advantages and disadvantages?

(May 2000)

Answer

Cost plus pricing: The most common method of price fixing in a business is to arrive at full cost, add a margin of profit and then set the selling price. During the world wars, the concept of cost plus pricing became very much prevalent, as most of the defence contracts were priced at full cost plus a pre-agreed quantum of profit.

In cost plus pricing, the capacity utilisation of the concern has an important bearing and unless the same is considered on a realistic basis the determination of cost would get vitiated.

At present, in Government sometimes Tariff Commission, Bureau of Industrial Cost & Prices (BICP) are required to fix prices of certain products and services. They mainly adopt a system of cost plus pricing. Similarly, government has also set up a separate agency to fix prices for pharmaceutical products.

The advantages and disadvantages of cost plus pricing are as under:

Advantages:

(i) It is a fair method and recovery of full costs is assured under it.

(ii) It leaves out scope for any uncertainty.

(iii) After arriving at full cost, the profit percentage can be flexibly adjusted to take care of market competition.

Disadvantages:

(i) Covering full cost all the time may ignore the competition.

(ii) It can lead to a distorted price fixation unless the cost is determined in a scientific manner.

(iii) It ignores the concepts of Marginal Costing, Incremental Costing etc.

(iv) It is difficult to predetermine capacity utilization.

Question 6

In what circumstances it may be justifiable to sell at a price below marginal cost? (May 2000)

Answer

It may be justifiable to sell at a price below marginal cost for a limited period under the following circumstances:

(i) Where materials are of perishable nature

(ii) Where stocks have been accumulated in large quantities and the market prices have fallen.

(iii) To popularize a new product

(iv) Where such reduction enables the firm to boost the sale of other products having larger profit margin.

(v) To capture foreign markets

(vi) To obviate shut down costs

(vii) To retain future market

Question 7

P. W. Perfume Company manufactures various qualities of perfumes and colognes. One popular line of colognes includes three products that result from a joint production process. Below are data from the most recent month of production:

Product	*Sales Price*	*Quantity*	*Joint cost*	*Cost after split off*	*Total cost*
Evergreen	*Rs.40*	*10,000*	*Rs.28*	*Rs.20*	*Rs.48*
Morning Flower	*Rs.100*	*6,000*	*Rs.28*	*Rs.40*	*Rs.68*
Evening Flower	*Rs.150*	*4,000*	*Rs.28*	*Rs.50*	*Rs.78*

As the Controller, you are called into the Presidents Office with the Director of Marketing. The President says, "I don't understand your product cost report. Either, we are selling our largest-volume product at a loss or the product cost data are all wrong. Now what is it?"

Required:

(i) Respond to the Presidents question.

(ii) Another company has just introduced a product that competes directly with Morning Flower to compete successfully with the other company's product, the price of Morning Flower cologne must be reduced to Rs.60. Should the company do so and sell below cost?

(iii) If P. W. Perfume Company has a policy of maintaining a gross margin of 20 per cent on sales, what would your answer be in response to the price reduction in part (ii)?

(iv What is the minimum price for which Morning Flower can self and still meet the 20 per cent product gross margin for the group of products? (Nov 2000)

Answer

(i) Statement of Profitability of three Joint Products resulting from the joint production process of a popular line of colognes.

	Evergreen	*Morning Flower*	*Evening Flower*	*Total*
	Rs.	*Rs.*	*Rs.*	*Rs.*
Sales revenue	4,00,000	6,00,000	6,00,000	16,00,000
	(10,000 units × Rs.40)	(6,000 units × Rs.100)	(4,000 units × Rs.150)	--
Less: cost after point of split off	2,00,000 (10,000 units × Rs.20)	2,40,000 (6,000 units × Rs.40)	2,00,000 (4,000 units × Rs.50)	6,40,000 - -
Net realization value at the point of spilt off	2,00,000	3,60,000	4,00,000	9,60,000
Less: Joint cost apportioned (Refer to	1,16,667	2,10,000	2,33,333	5,60,000

working note)				
Profit	83,333	1,50,000	1,66,667	4,00,000

Response to the President's question. Review of the above profitability statement clearly shows that the concern is not selling its largest-volume product viz. evergreen at a loss. It yields a profit of Rs.83,333. In fact the figure of joint cost data given in the statement of the question is misleading. The total joint cost viz. Rs.5,60,000 should have been apportioned ever the three joint products by using net realisable value method. The use of net realisable value method would give joint cost per-unit of three respective joint products as Rs.11,666; Rs.35 and Rs.58.33. (Refer to working note)

Working note:

Statement of Joint cost apportionment over three products obtained under a joint production process.

	Evergreen	*Morning Flower*	*Evening Flower*	*Total*
	Rs.	*Rs.*	*Rs.*	*Rs.*
Total Joint cost	2,80,000	1,68,000	1,12,000	5,60,000
	(10,000 units × Rs.28)	(6,000 units × Rs.28)	(4,000 units × Rs.28)	--
Joint cost apportionment (One the basis of net realization value i.e. (Rs.2,00,000 : Rs.3,60,000 : Rs.4,00,000 or (5:9:10)	1,16,667	2,10,000	2,33,333	5,60,000 --
Joint cost per unit	11,666 (Rs.1,16,667 / 10,000 units)	35 (Rs.2,10,000 / 6,000 units)	58.33 (Rs.2,33,333 / 4,000 units)	

(ii) Should the company sell Morning Flower Cologne below cost: To compete successfully with the other company's product, if the price of Morning Flower Cologne is reduced to Rs.60, it will still contribute Rs.20 per unit (Rs.60 – Rs.40) towards joint cost and profit. On a volume of 6,000 units it will contribute Rs.1,20,000 in total. Hence the company should do so and go ahead to sell Morning Flower below cost.

(iii) Response to price reduction: (Refer to working note) A reduction in sales price of Morning Flower fails to maintain a gross margin of 20% on sales of three products obtained from the joint production process of a popular line of colognes. Hence the company cannot reduce the sales price of Morning Flower to Rs.60. A reduction in sale price would result in a loss of revenue or Fs.1,40,000.

Working note:

	Rs.
Total joint cost (20,000 units × Rs.28)	5,60,000
Total cost after split off (10,000 × Rs.20 + 6,000 units × Rs.40 + 4,000 units × Rs.50)	6,40,000
Total cost	12,00,000
Add: Profit margin (20% on ales or 25% on total cost	3,00,000

Expected desired sales revenue	15,00,000
Less: Sales revenue of Evergreen and Evening Flower (10,000 units × Rs.40) + (4,000 × Rs.150)	10,00,000
Expected sales revenue from Morning Flower	5,00,000
By reducing sales price of morning flower to Rs.60/- total sale revenue received will be	3,60,000
Loss of revenue resulting from the sale of Morning Flower	1,40,000

(iv) Minimum price for Morning Flower

Expected Sales revenue from Morning Flower to maintain a gross margin of 20% of sales: (Rs.)	5,00,000
(Refer to (ii) part	
Quantity (in units)	6,000
Hence minimum price per unit (Rs.)	83.33
(Rs.5,00,000 / 6,600 units)	

Question 8

Describe two pricing practices in which non-cost reasons are important, when setting prices. (Nov 2000)

Answer

Two pricing practices in which non-cost reasons are important when setting price are:

(i) Price discrimination and (ii) Peak load pricing.

(i) **Price discrimination:** This is the practice of charging to some customers a higher price than that charged to other customers e.g. Airlines tickets for business travellers and LTC travellers are priced differently.

(ii) **Peak load pricing:** This pricing system is based on capacity constraints. Under this pricing system a higher price for the same service or product is demanded when it approaches physical capacity limits e.g. telephones, tele-communication, hotel, car rental and electric utility industries are charged higher price at their peak load.

Question 9

What is Penetration pricing? What are the circumstances in which this policy can be adopted? (May 2001)

Answer

Penetration pricing: This pricing policy is in favour of using a low price as the principal instrument for penetrating mass markets early. It is opposite to skimming pricing. The low pricing policy is introduced for the sake of long-term survival and profitability and hence it has to receive careful consideration before implementation. It needs an analysis of the scope for market expansion and hence considerable amount of research and forecasting are necessary before determining the price.

Penetration pricing means a price suitable for penetrating mass market as quickly as possible through lower price offers. This method is also used for pricing a new product. In order to popularize a new product penetrating pricing policy is used initially. The company may not earn profit by resorting to this policy during the initial stage. Later on, the price may be increased as and when the demand picks up. Penetrating pricing policy can also be adopted at any stage of the product life cycle for products whose market is approached with low initial price. The use of this policy by the existing concerns will discourage the new concerns to enter the market. This pricing policy is also known as “stay-out-pricing”.

Circumstances for adoption:

The three circumstances in which penetrating pricing policy can be adopted are as under:

(i) When demand of the product is elastic to price. In other words, the demand of the product increases when price is low.

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

(iii) When there is threat of competition. The prices fixed at a low level act as an entry barrier to the prospective competitions.

Question 10

C Ltd. and Indian company, ahs entered into an agreement of strategic alliance with Z Inc. of United States of America for the manufacture of personal computers in India. Broadly, the terms of agreement are:

(i) Z will provide C with kits in a dismantled condition. These will be used in the manufacture of the personal computer in India. On a value basis, the supply, in terms of the FOB price will be 50% thereof.

(ii) C will procure the balance of materials in India.

(iii) Z will provide to C with designs and drawings in regard to the materials and supplies to be procured in India. For this, C will pay Z a technology fee of Rs.3 crores.

(iv) Z will also be entitled total royalty at 10% of the selling price of the computers fixed for sales in India as reduced by the cost of standard items procured in India and also the cost of imported kits from Z.

(v) C will furnish to Z detailed quarterly returns.

Other information available:

(i) FOB price agreed $510.

Exchange rate to be adopted $1 = Rs.47.059

[Note: In making calculations, the final sum may be rounded to the next rupees)

(ii) Insurance and freight – Rs.500 per imported kit;

(iii) Customs duty leviable is 150% of the CIF prices; but as a concession, the actual rate leviable has been fixed at 30% of CIF.

(iv) The technology agreement expires with the production of 2,00,000 computers;

(v) The quoted price on kits includes a 20% margin of profits on cost to Z.

(vi) The estimated cost of materials and supplies to be obtained in India will be 140% of the cost of supplies made by Z.

(vii) 48% of the value in rupees of the locally procured goods represent cost of the standard items.

(viii) Cost of assembly and other overheads in India will be Rs.2,000 per personal computer.

Required: Calculate the selling price, of a personal computer in India bearing in mind that C has targeted a profit of 20% to itself on the selling price. (Nov 2001)

Answer

Working Notes:

1. FOB price of dismantled kit:

FOB price of dismantled kit (in$)	510
FOB price of dismantled kit (in Rs.)	24,000

($510 × Rs.47.059)

2. Cost of a dismantled kit to Z Inc.

If Rs.120 is the S. P. of kit to Z Inc. then its C Rs.100

Re 1 $= \frac{\text{Rs.100}}{\text{Rs.120}}$

If Rs.24,000 is the S. P. then C. P. is $= \frac{\text{Rs.100}}{\text{Rs.120}} \times \text{Rs.24,000}$

= Rs.20,000

3. Cost of local procurements:

140% of the supplies made by Z Inc. or 140% × Rs.10,000* = Rs.14,000

*Being 50% of cost of a dismantled kit to Z Inc.

4. Landed cost of a dismantled kit:

	Rs.
FOB price	12,000
(50% × Rs.24,000) (Refer to working note 1)	
Add: Insurance & freight	500
CIF price	12,500
Add: Customs duty	3,750
(30% × Rs.12,500)	
Landed cost of a dismantled kit	16,250

5. Cost of the standard items procured locally:

48% of the cost of locally procured goods

= 48% × Rs.14,000

= Rs.6,720

6. Royalty payment per computer:

Let x = Selling price per unit of personal computer

y = Royalty paid per computer

Since 20% is the margin of profit on S.P. it main a margin of 25% on C.P.

Therefore we have

X = 1.25 (Rs. 32,250+ Rs. 150 + y)

Y = 10% {x – (Rs. 6,720 + Rs. 16,250)}

On solving the above equations we get:

X = Rs. 43,000

Y = Rs. 2003.43 or Rs. 2,000 (Approx)

Statement showing the selling price of a personal computer in India	Rs.
A. Landed cost of a dismantled kit	
(Refer to working note 4)	16,250

B.	Cost of local procurement	
	(Refer to working note 3)	4,000
C.	Cost of assembly and other overheads per computer	2,000
D.	Total cost of manufacture: (A+ B + C)	33,250
E.	Technology fee per computer	150
	(Rs. 3,00,00,000 / 2,00,000 computer)	
F.	Royalty payment per unit	
	(Refer to working note 6)	
G.	Total cost (D + E+ F)	34,400
H.	Profit (20% on selling price of 25% o total cost)	8,600
I.	Selling price (per computer)	43,000

Question 11

Explain Skimming pricing strategy. *(4 Marks)*

Answer

Skimming pricing

It is a policy where the prices are kept high during the early period of a product's existence. This can be synchronised with high promotional expenditure and in the latter years the prices can be gradually reduced. The reasons for following such a policy are as follows:

(1) The demand is likely to be inelastic in the earlier stages till the product is established in the market.

(2) The gradual reduction in price in the latter years will tend to increase the sales.

(3) This method is preferred in the beginning because in the initial periods when the demand for the product is not known the price covers the initial cost of production.

(4) High initial capital outlays needed for manufacture, results in high cost of production. In addition to this, the producer has to incur huge promotional activities resulting in increased costs. High initial prices will be able to finance the cost of production particularly when uncertainties block the usual sources of capital.

Question 12

How Pareto analysis is helpful in pricing of product in the case of firm dealing with multi-products?

Answer

In the case of firm dealing with multi products, it would not be possible for it to analyse price-volume relationship for all of them. Pareto Analysis is used for analysing the firm's estimated sales revenue from various products and it might indicate that approximately 80% of its total sales revenue is earned from about 20% of its products. Such analysis helps the top management to delegate the pricing decision for approximately 80% of its product to the lower level of management, thus freeing them to concentrate on the pricing decisions for products approximately 20% of which is essential for the company's survival. Thus, a firm can adopt more sophisticated pricing methods for small proportion of products that jointly account for 80% of total sales revenue. For the remaining 80% products, which account for 20% of the total sales value the firm may use cost based pricing method.

Question 13

An organisation manufactures a product, particulars of which are detailed below:

Annual Production (Units)	*20,000*

Cost per annum (Rs.)	
Material	*50,000*
Other variable cost	*60,000*
Fixed cost	*40,000*
Apportioned Investment (Rs.)	*1,50,000*

Determine the unit selling price under two strategies mentioned below. Assume that the organisation's Tax rate is 40%—

(a) 20% return on investment.

(b) 6% profit on list sales, when trade discount is 40%.

Answer

(i) Selling price to yield 20% return on investment:

		Rs.
Investment		1,50,000
After tax required ROI 20%		30,000
Tax	40%	
After tax profit	100 – 40 = 60%	
Pre tax profit (return) (30,000 ÷ 60) × 100		50,000
Sales = cost + return or 1,50,000 + 50,000		2,00,000
Number of units produced		20,000

Selling price Rs. 2,00,000 ÷ 20,000 = Rs. 10 per unit

Alternative solution

(Sales – cost) (1 – Tax) = ROI

(Sales – 1, 50,000) (1 – 0.40) = 1, 50,000 × 20%

(0.60 Sales – 90,000) = 30,000

0.60 Sales = 1, 20,000

Sales = 1, 20,000 ÷ 0.60 = Rs. 2, 00,000

Number of units 20,000

Selling price Rs. 2, 00,000 ÷ 20,000 = Rs. 10.

(ii) Selling price to yield 6% profit on list price.

	Rs.	Rs.
Investment		1,50,000
Let the list price be	100	
Desired after tax profit of 6%	6	
Pre-tax profit (1– 0.40) = 0.60 = (6÷0.60) =	10	
List price		100
Discount		40
Net price		60
Profit desired		10
Cost		50

Cost of 50% = Rs. 1,50,000

Sales = (Rs.1,50,000 ÷ 50) × 100 = Rs. 3,00,000

Number of units 20,000

List selling price (3,00,000 ÷ 20,000) = Rs. 15

Discount 40%

Net price (15 × 60%) Rs. 9 per unit

Alternative solution

Let s be the list sales

[List Sales (1 – tax discount) – cost] (1 – Tax rate) = 0.60s

[s (1– .40) – 1, 50,000] (1– 0.40) = .06s

s = Rs. 3, 00,000

List sales price per unit is Rs. 15 $\left(\frac{3,00,000}{20,000}\right)$

Net selling price per unit is Rs. 9 (Rs. 15 – 40% of 15%).

Question 14

Outline the features of penetration pricing strategy

Answer

(i) Penetration Pricing: It is a policy of using a low price as the principal instrument for penetrating mass markets early.

(ii) This method is used for pricing a new product and to popularize it initially.

(iii) 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.

(iv) The low price policy is introduced for the sake of long term survival and profitability and hence it has to receive careful consideration before implementation. It needs an analysis of the scope for market expansion and hence considerable amount of research and forecasting are necessary before determining the price.

(v) The circumstances in which penetrating pricing can be adopted are:

Elastic demand: The demand of the product is high when price is low. Hence, lower prices mean large volumes and hence more profits.

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

Frighten off competition: The prices fixed at a low-level acts as an entry barrier to the prospective competitors. The use of this policy by existing concerns will discourage the new concerns to enter the market. This pricing policy is also known as “stay-out-pricing”.

7

COSTING OF SERVICE SECTOR

Question 1

A Multinational company runs a Public Medical Health Centre. For this purpose, it has hired a building at a rent of Rs. 10,000 per month with 5% of total taking. Health centre has three types of wards for its patients namely. General ward, Cottage ward and Deluxe ward. State the rent to be charged to each bed-day for different type of ward on the basis of the following informations:

(i) The number of beds of each type are General ward 100, Cottage ward 50, Deluxe ward 30.

(ii) The rent of Cottage ward bed is to be fixed at 2.5 times of the General ward bed and that of Deluxe ward bed as twice of the Cottage ward bed.

(iii) The occupancy of each type of ward is as follows:

General ward 100%, Cottage ward 80% and Deluxe ward 60%. But, in general ward there were occasions when beds are full, extra beds were hired at a charges of Rs. 20 per bed. The total hire charges for the extra beds incurred for the whole year amount to Rs. 12,000.

(iv) The Health Centre engaged a heart specialist from outside and on an average fees paid to him was Rs. 15,000 per trip. He makes three trips in the whole year.

(v) The other expenses for the year were as under:

	Rs.
Salary of Supervisors, Nurses, Ward boys	*4,25,000*
Repairs and maintenance	*90,000*
Salary of doctors	*13,50,000*
Food supplied to patients	*40,000*
Laundry charges for their bed linens	*80,500*
Medicines supplied	*74,000*
Cost of oxygen, X-ray etc. other than directly borne for	
Treatment of patients	*49,500*
General administration charges	*63,000*

(vi) Provide profit @ 20% on total taking.

(vii) The Health Centre imposes 8% service tax on rent received.

(viii) 360 days may be taken in a year.

Answer

(a) Statement of Total Cost

Total cost	Amount (Rs)
Salary of Supervisor , Nurses, Ward boys	4,25,000
Repairs and Maintenance	90,000
Salary of doctors	13,50,000

Food supplied to patients	40,000	
Laundry charges for their bed linens	80,500	
Medicines supplied	74,000	
Cost of oxygen, X ray etc, other than directly borne for treatment of patients	49,500	
General administration charges	63,000	Rs 21,72,000
Building rent	(10 × 12,000)	Rs 1,20,000
Additional building rent on takings		5% on Total Taking
Hire charges extra beds		Rs 12,000
Fees to heart specialists	(3 × 15,000)	Rs 45,000
Total cost		Rs 23,49,000 + 5% on Total Taking
Profit		20% on Total Taking
Total takings		Rs 23,49,000 + 25% of Total Taking
Total taking(assuming X to be the rent per day)		1,05,000 × X

Rent to be charged

1,05,000 × X = 23,49,000 +25% (1,05,000 × X) = 78750 X = 23,49,000 or X = 29.83(Rounded Off)

No of beds with Equivalent Rent

Nature of wards	Occupancy	Weight of rent	Ward Days
General ward	100 × 360 × 100%	36,000 × 1	36,000
Additional general ward	$\frac{12{,}000}{20}$	600 × 1	600
Cottage ward	50 × 360 × 80%	14,400 × 2.5	36,000
Deluxe ward	50 × 360 × 60%	6,480 × 5	32,400
Total			1,05,000

Rent to be charged

Particulars	Basic	Service tax	Total
General ward	29.83	2.39	32.22
Cottage ward	74.58	5.97	80.55
Deluxe ward	149.15	11.93	161.08

Note : You may assume Total Taking to include Service Tax also.

Rent = 23,49,000 + 25% × (1,05,000 X × 1.08) + 0.08 × (1,05,000X) = 1,05,000X × 1.08

= 23,49,000 + 28350X + 8400X = 1,13,400X Therefore X = Rs 30.65

Rent to be charged

Particulars	Basic	Service tax	Total
General ward	30.65	2.45	33.10
Cottage ward	76.63	6.13	82.76
Deluxe ward	153.25	12.26	165.51

8

TRANSFER PRICING

Question 1

In transfer pricing what is common conflict between a division and the company as a whole. (May 1997)

Answer

Usually a conflict between a division of the company and the company as a whole is faced by the management of decentralized units when products or services are exchanged among different divisions of the company. Such a conflict becomes more significant in the case of those concerns where profitability is used as a criteria for evaluating the performance of each division.

The essence of decentralisation is reflected in the freedom to make decisions. Under such set up it is expected that the top management should not interfere with the decision making process of its subordinates heading different units. In other words, management of decentralized units is given autonomy with regard to decision-making. In this system top management is expected to preserve 'autonomy in decision making'. The management of such companies also expects that each division should not only achieve its own objective necessary for evaluating the performance but should also achieve the objective of goal congruence.

A divisional head in a company under aforesaid set up is free to use a price as a transfer price for goods and services, which may provide incentive. Such a transfer price may fail to achieve the objective of 'Goal congruence' (which means a perfect congruence between division's goal and the goal of the company). In case of failure of a division to achieve the objective of 'goal congruence' the management of the company may 'dictate their 'transfer price'. Such an interference of management of the company is usually the main basis of conflict between a division and the company as a whole.

Further this conflict is aggravated if the management advocates the transfer of goods and services at cost. As such the transfer price will not reflect a good: picture about the performance of the transferring division. The profitability of the transferring division will not be known by the use of such a transfer price.

Each division appreciates the transfer of its goods/services at usual selling price/market price so as to arrive at the correct return/profitability figure, used for measuring the performance. There is no incentive to the transferring division if goods and services are transferred at variable cost.

Question 2

A Company has two Division, Division 'A' and Division 'B'. Division 'A' has a budget of selling 2,00,000 nos. of a particular component 'x' to fetch a return of 20% on the average assets employed. The following particulars of Division 'A' are also known:

Fixed Overhead	*Rs.5 lakhs*
Variable Cost	*Re.1 per unit*
Average Assets	
Sundry Debtors	*Rs.2 lakhs*
Inventories	*Rs.5 lakhs*
Plant & Equipments	*Rs.5 lakhs*

However, there is constraint in Marketing and only 1,50,000 units of the component 'x' be directly sold to the proposed price.

It has been gathered that the balance 50,000 units of component 'x' can be taken up by Division 'B' Division 'A' wants a price of Rs.4 per unit of 'x' but Division 'B' is prepared to pay Rs.2 per unit of 'x'.

Division 'A' has another option in hand, which is to produce only 1,50,000 units of component 'x'. This will reduce the holding of assets by Rs.2 lakhs and fixed overhead by Rs.25,000.

You are required to advise the most profitable course of action for Division 'A".

Answer

Working Notes:

1. Profit = 20% return on the average assets employed.

   = 20% × Rs.12,00,000

   = Rs.2,40,000

2. Desired revenue (on the sale of 2,00,000 units of component 'x')

   = Fixed cost + variable cost + profit

   = Rs.5,00,000 + Rs.2,00,000 + Rs.2,40,000

   = Rs.9,40,000

3. Selling price per unit:

   = Desired revenue/ No. of units to be sold of component x

   = Rs.9,40,000 / 2,00,000 units = Rs.4.70 per unit

Advice about the most profitable course of action for Division A:

	Option - 1	*Option – 2*
	(Sell 1,50,000 units in market and transfer 50,000 unit to Division B)	*Sell only 1,50,000 units in market*
	Rs.	*Rs.*
Sales revenue (1,50,000 units of component 'x' @ Rs.4.70 p. u.)	7,05,000	7,05,000
(Refer to working note 3)		
Unit of component 'x' transferred to Division 1,00,000 B @ Rs.2/- p. u.	1,00,000	
(Under option – 1 only)		
Total revenue : (A)	8,05,000	7,05,000
Costs incurred:		
Fixed overhead	5,00,000	4,75,000
Variable overhead	2,00,000	1,50,000
Total costs: (B)	7,00,000	6,25,000
Profit: (C) = [(A) – (B)]	1,05,000	80,000
Capital employed: (D)	12,00,000	10,00,000
Return on capital	8.75%	8%
Employed: [(C) / (D)] × 100		

Since the return on capital employed under option – 1 is more than that under option – 2, therefore option – 1 is preferred over option – 2, Selection of this option also gives an extra profit of Rs.25,000/-.

Question 3

Enumerate and briefly explain any three methods of determining transfer price. (May 1998)

Answer

Transfer price Transfer price is the price at which goods or services are transferred from one unit of a concern to the other. Various methods of pricing used for the purpose have been enumerated as below:

1. At cost or variants of cost e.g., actual manufacturing cost; standard cost; full cost and full cost plus.
2. At market price
3. At bargained or negotiated price:

Pricing at cost:

(a) Actual manufacturing cost: According to this method goods or services are transferred at their actual cost of production. It is a simple and useful method for units where responsibility of profit performance is centralized.

(b) Standard cost: Transfers of goods and services takes place at their standard cost. Variances if arise are usually absorbed by the supplying unit but sometime they may be transferred to the user unit as well.

(c) Fill Cost: It means the sum total of expenses viz., cost of production, selling and distribution, administration, research and development which is used as a transfer price. The use of this method does not permit the internal unit to earn profit by transferring goods and services internally, but permits them to do so while dealing with outsiders.

(d) Full Cost Plus: The supplying unit transfers goods and services at full cost plus (some mark-up). The mark-up added to full cost is either expressed as a percentage of full cost or of capital employed. Selling expenses here are recovered by the supplying unit without incurring them, specially when the goods / services are transferred internally. Due to this defect the use of this method is not appreciated by the internal receiving units.

Market price method: Under this method the transfer prices of goods / sales transferred to other units/divisions are based on market prices. In a competitive market goods/services cannot be transferred to its users at a higher price. Such a competitive market provides an incentive to efficient production. The man limitations of this method are:

(i) Difficulty in obtaining just market prices.

(ii) Difficulty in determining the elements of selling and distribution expenses such as commission, discounts, advertisement and sales promotion etc., so that necessary adjustment may be made in the market price to provide benefit of these expenses to the profit centre, receiving the goods.

Bargained / Negotiated prices method: Each decentralized unit is treated as an independent unit and such units decide the transfer price by bargaining or negotiations. Divisional mangers have full freedom to purchase their requirement from outside if the prices quoted by their sister unit are not acceptable to them. A system of negotiated prices develops business like attitude amongst divisions of the company. The buying division may be tempted to purchase from outside sources if the outside prices are lower than the internal division's price. IN order to avoid any reduction in overall profits of the company, the top management may impose restrictions on the external purchase / sale of goods.

Question 4

A company is organized on decentralized lines, with each manufacturing division operating as a separate profit centre. Each division manager has full authority to decide on sale of the division's output to outsiders and to other divisions.

Division C has always purchased its requirements of a component from Division A. But when informed that Division A was increasing its selling price to Rs.150, the manger of Division C decided to look at outside suppliers.

Division C can buy the component from an outside supplier for Rs.135. But Division A refuses to lower its price in view of its need to maintain its return on the investment.

The top management has the following information:

C's annual purchase of the component	*1,000 units*
A's variable costs per unit	*Rs.120*
A's fixed cost per unit	*Rs.20*

Required:

(i) Will the company as a whole benefit, if Division C bought the component at Rs.135 from an outside supplier?

(ii) If A did not produce the material for C, it could use the facilities for other activities resulting in a cash operating savings of Rs.18,000. Should C then purchase form outside sources?

(iii) Suppose there is no alternative use of A's facilities and the market price per unit for the component drops by Rs.20. Should C now buy from outside? (Nov 1998)

Answer

(i) The company as a whole will not benefit if Division C bought the component from an outside supplier at Rs.135/- per unit.

	Rs.
Purchase cost from outside supplier	1,35,000
(1,000 units × Rs.135 per unit)	
Less: Saving in variable cost of division	
A by reducing Division's output	1,20,000
(1,000 units × Rs.120 per unit)	
Net cost (benefit) to the company as a whole	15,000

The company as a while will not benefit, as it will be required to incur an additional cost of Rs.15,000 if Division C bought the component from outside supplier.

(ii) The company will be benefited if C purchased the component from an outside supplier and Division A uses the facilities for other activities.

	Rs.	*Rs.*
Purchase cost from outside supplier		1,35,000
(1,000 units × Rs.135)		
Less: Saving in variable cost of Division A for the units purchased by Division C from outside	1,20,000	
(1,000 units × Rs.120 per unit)		
Cash operating saving of Division A for the use of facilities for other activities	18,000	1,38,000
Net cost (benefit) to the company as a whole		(3,000)

It is advisable that Division C should purchase the component from outside sources as this decision will benefit the company by Rs.3,000.

(iii) The company will be benefited if C purchase the component from an outside supplier and there is no alternative use of Division A's facilities.

	Rs.
Purchase cost from outside supplier	1,15,000
(1,000 units × Rs.115)	
Less: Saving in variable cost of Division A by reducing division's output	1,20,000
(1,000 units × Rs.120)	.
Net cost (benefit) to the company	(5,000)

It is advisable that the Division C should buy the component from outside as this decision will benefit the company by Rs.5,000.

Question 5

"Transfer pricing is a widely debated and contested topic" – Discuss, *(Nov 1999)*

Answer

Usually a conflict between a division of the company and the company as a whole is faced by the management of decentralized units when products or services are exchanged among different divisions of the company. Such a conflict becomes more significant in the case of those concerns where profitability is used as criteria for evaluating the performance of each division.

The essence of decentralization is reflected in the freedom to make decisions. Under such a set up it is expected. That the top management should not interfere with the decision making process of its subordinates beading different units. In other words, management of decentralized units is given autonomy with regard to decision-making. In this system top management is expected to preserve 'autonomy in decision making'. The management of such companies also expects that each division should not only achieve its own objective – necessary for evaluating the performance but should also achieve the objective of goal congruence.

A divisional head in a company under aforesaid set up is free to use a price as a transfer price for goods and services, which may provide incentive. Such a transfer price may fail to achieve the objective of 'Goal congruence' (which means a perfect congruence between division's goal and the goal of the company. In case of failure of a division to achieve the objective of 'Goal congruence' the management of the company may dictate their transfer price. Such a interference of management of the company is usually the main basis of conflict between a division and the company as a whole.

Further this conflict is aggravated if the management advocates the transfer of goods and services at cost. As such, the transfer price will not reflect a good picture about the performance of the transferring division. The profitability of the transferring division will not be known by the use of such a transfer price.

Each division appreciates the transfer of its goods/services at usual selling price/market price so as to arrive at the correct return / profitability figure, used for measuring the performance. There is no incentive to the transferring division if goods and services are transferred at variable cost.

Question 6

What should be the basis of transfer pricing, if unit variable cost and unit selling price are not constant? (Nov 1999)

Answer

If unit variable cost and unit selling price were not constant then the main problem that would arise while fixing the transfer price of a product would be as follows:

There is an optimum level of output for a firm as a whole. This is so because there is a certain level of output beyond which its net revenue will not rise. The ideal transfer price under these circumstances will be that which will motivate these managers to produce at this level of output.

Essentially, it means that some division in a business house might have to produce its output at a level less than its full capacity and in all such cases a transfer price may be imposed centrally.

Question 7

Division Z is a profit centre, which produces four products A, B, C and D. Each product is sold in the external market also. Data for the period is as follows:

	A	*B*	*C*	*D*
Market Price per unit	*Rs.150*	*Rs.146*	*Rs.140*	*Rs.130*
Variable cost of Production per Unit	*Rs.130*	*Rs.100*	*Rs.90*	*Rs.85*
Labour Hours required per Unit	*3*	*4*	*2*	*3*

Product D can be transferred to division Y but the maximum quantity that might be required for transfer is 2,500 units of D.

The maximum sales in the external market are:

A	*2,800 units*
B	*2,500 units*
C	*2,300 units*
D	*1,600 units*

Division Y can purchase the same product at a slightly cheaper price of Rs.125 per unit instead of receiving transfers of product D from division Z.

What should be transfer price for each unit for 2,500 units of D, if the total labour hours available in division Z are:

(i) 20,000 hours?

(ii) 30,000 hours?

Answer

Working Notes:

Ranking of products when availability of time is the key factory

Product	*A*	*B*	*C*	*D*
Market Price per unit	Rs.150	Rs.146	Rs.140	Rs.130
Less: Variable cost of Production per Unit	Rs.130	Rs.100	Rs.90	Rs.85
Contribution per unit	20	46	50	45
Contribution per hour	6.66	11.50	25	15
	(Rs.20/3 hrs.)	(Rs.46/4 hrs.)	(Rs.50/2 hrs.)	(Rs.45/3 hrs.)
Ranking	IV	III	I	II

(i) Statement of production mix (when total available hours in division Z are 20,000)

Product (Refer to W.N.)	*Maximum demand (units)*	*Hours per unit*	*Units produced*	*Hours used*	*Balance hours*
(a)	*(b)*	*(c)*	*(d)*	*(e)=(b)×(c)*	*(f)*

C	2,300	2	2,300	4600	15,400 (20,000-4,600)
D	1,600	3	1,600	4800	10,600 (15,400-4,800)
B	2,500	4	2,500	10000	600 (10,600-10,000)
A	2,800	3	200	600	NIL(600 – 600)

Note: Time required to meet the demand of 2,500 units of product D for division Y is 7,500 hours. This requirement of time viz., 7,500 hours for providing 2,500 units of product D for division Y can be met by sacrificing the production of 1,725 units of product B (1,725 units × 4 hours) and 200 units of product B (200 units × 2 hours = 600 hours)

Statement of Transfer Price for each unit for 2,500 units of D

Transfer price	*2,500 units of product D*	*Per unit of Product D*
Variable cost (2,500 units × Rs.85)	2,12,500	85.00
Opportunity cost of the contribution foregone by not producing 200 units of A. (200 units × Rs.20)	4,000	1.60
Opportunity cost of the contribution foregone by not producing 1,725 units of B (1,725 units × Rs.46)	79,350	31.74
Transfer price	2,95,850	118.34

(ii) Statement of product mix (when total available hours in division Z are 30,000)

Product (Refer to W.N.)	*Maximum demand (units)*	*Hours per unit*	*Units produced*	*Hours used*	*Balance hours*
(a)	*(b)*	*(c)*	*(d)*	*(e)=(b)×(c)*	*(f)*
C	2,300	2	2,300	4600	25,400 (30,000-4,600)
D	1,600	3	1,600	4800	20,600 (25,400-4,800)
B	2,500	4	2,500	10000	10,600 (20,600-10,000)
A	2,800	3	2,800	8,400	2,200 (20,600 – 8,400)

Note: The required time for producing 2,500 units of product D for division y is 7,500 hours. This requirement can be met to the extent of 2,200 hours out of the balance hours (as shown in the last column of the above table). The remaining requirement of 5,300 hours can be met by sacrificing the output of 1,766.66 units of product A.

Statement of Transfer Price for each unit for 2,500 units of D

Transfer price	*2,500 units of product D*	*Per unit of Product D*
Variable cost (2,500 units × Rs.85)	2,12,500	85.00
Opportunity cost of the contribution foregone by not producing 1,766.66 units of product A. (1,766.66 units ×	35,333.20	14.13

Rs.20)		
Transfer price	2,47,833.20	99.13

Question 8

(a) *What will be the marketable transfer pricing procedure regarding the goods transferred under the following conditions (each condition is independent of the other)?*

   (i) *When division are not captives of internal divisions and the divisions are free to do business both internally and externally and when there are reasonably competitive external markets for the transferred products.*

   (ii) *If the external market for the transferred good is not reasonably competitive.*

(b) *Discuss the potential for maximization of income by a multinational through the use of transfer pricing mechanism.*

(c) *City Instrument Company (CIC) consists of the Semi-conductor Division and the Mini-computer Division, each of which operates as an independent profit centre. Semi-conductor Division employs craftsmen, who produce two different electronic components, the new – high performance Super chip and an older product called Okay-chip. These two products have the following cost characteristics:*

	Super-chip		*Okay-chip*	
Material	*Parts*	*Rs.20*	*Parts*	*Rs.10*
Labour	*2 hours × Rs.140*	*280*	*½ hours × Rs.140*	*70*

Annual Overhead in Semi-conductor Division is Rs.40,00,000 all fixed. Owing to high skill level necessary for the craftsmen, the Semi-conductor Divisions capacity is set at 50,000 hours per year.

To date, only one customer has developed a product utilizing super-chip, and this customer orders a maximum of 15,000 super-chips per year at a price of Rs.600 per chip. If CIC cannot meet his entire demand, the customer curtails his own production. The rest of the semi-conductor's capacity is devoted to Okay-chips, for which there is unlimited demand at Rs.120 per chip.

The Mini-computer Division produces only one product, a process control unit, which requires a complex circuit board imported at a price of Rs.600. The control units costs are:

	Control Unit	
Material	*Circuit board*	*Rs.600*
	Other parts	*80*
Labour	*5 hours @ Rs.100*	*500*

The Mini-computer Division is composed of only a small assembly plant and all overhead is fixed at a total of Rs.8,00,000 per year. The current market price for the control unit is Rs.1,400 per unit.

A joint research project has just revealed that with minor modifications, a single super-ship could be substituted for the circuit board currently used by the Mini-computer Division. The modification would require an extra one-hour of labour by Mini-computer's staff, for a total of 6 hours per control unit. Mini-Computer has therefore asked Semi-conductor division to declare a transfer price at which Semi-conductor division would sell super-chip internally.

Required:

(i) *Mini-computer expects to sell 5,000 control units this year .From the overall view point of CIC, how many super-chips should be transferred to Mini-computer Division to replace circuit boards?*

(ii) *If the demand for the control units is sure to be 5,000 units, but its price is uncertain, what should be the transfer price of super-chip to ensure proper decisions? (All other data unchanged)*

(iii) *If demand for the control unit rises to 12,000 units at a price of Rs.1,400 per unit, how many of 12,000 units should be built using super-chip? (All other data unchanged.)*

(Nov 2000)

Answer

(a) Marketable Transfer Pricing Procedure

(i) When division are not captives of internal divisions and the divisions are free to do business both internally and externally and when there are reasonably competitive external markets for the transferred products, then the most suitable transfer price would be, the market price, as it generally leads to optimal decisions.

(ii) In case, the external market for the transferred good is not reasonable competitive, following two situations may arise in this case.

(a) If there is idle capacity: Under this situation opportunity cost will be zero hence minimum transfer price should be equal to the additional outlay costs incurred upto the point of transfer (sometimes approximated by variable costs).

(b) If there is no idle capacity: Under this situation opportunity cost should be added to outlay costs for determining minimum transfer price.

(b) The potential for maximization of income by a multinational through the use of transfer pricing mechanism is based on the successful implementation of the following steps:

(i) Transfer pricing may be set relatively higher for affiliates in relatively high-tax countries that purchase inputs from affiliates located in relatively low-tax countries.

(ii) Transfer prices to affiliates in countries which are subject to import duties for goods or services purchase may be set low so as to avoid host country taxes.

(iii) Transfer prices to an affiliate in a country that is encountering relatively high inflation may be set relatively high to avoid some of the adverse effects of local currency devaluation that are related to the high inflation.

(iv) Transfer prices may be set high for goods and services purchased by an affiliate operating in a country that has imposed restriction on the repatriation of income to foreign companies.

(v) Transfer prices may be set low for an affiliate that is trying to establish a competitive advantage over a local company either to break into a market or to establish a higher share of the company's business.

(c) (i) Working notes:

1. Contribution per hour of Super-chips and Okay-chips:

	Super-chips	*Okay-chips*
Selling price per unit (Rs.)	600	120
Less: Variable cost per unit (Rs.)	300	80
Contribution per unit (Rs.)	300	40
Hours required per unit	2	0.5
Contribution per hour	150	80
	(Rs.300/2 hrs)	(Rs.40/0.5 hrs)

2. Details of hours utilized in meting the demand of 15,000 units of Super-chips and utilizing the remaining hours for Okay-chips out of available hours of 50,000 per annum:

	Rs.
Hours utilized for manufacturing 15,000 units of Super-chips	30,000
(15,000 units × 2 hours)	
Hours utilized for manufacturing 40,000 units of Okay-chips	20,000

(40,000 units × 0.5 hours)

	50,000

3. Contribution of a process control unit (using an imported complex circuit board):

	Rs.
Selling price per unit: (A)	1,400
Variable costs	
Circuit board (Imported)	600
Other parts	80
Labour cost (5 hours × Rs.100)	500
Total variable costs: (B)	1,180
Contribution per unit (Rs.) : [(A) – (B)]	220

4. Contribution of process control unit (using a Super-chips):

	Rs.
Selling price per unit: (A)	1,400
Variable costs	
Super-chip	300
(Material + Labour costs)	
Other parts	80
Labour (6 hours × Rs.100)	600
Total variable costs: (B)	980
Contribution per unit (Rs.) : [(A) – (B)]	420

5. Incremental contribution per unit of a process control unit, when instead of using imported complex circuit board Super-chip is used:

	Rs.
Incremental contribution per unit (Rs.420 – Rs.220) (Refer to W. N. 3&4)	200

(ii) Super-chips to be transferred to Mini Computer Division to replace Circuit Boards:

Out of 50,000 available hours 30,000 hours are utilized for meeting the demand of 15,000 unit of Super-chips, the rest 20,000 hours may be used for manufacturing 40,000 Okay-chips, which yields a contribution of Rs.40 per unit or Rs.80/- per hour (*Refer to working note 1*) or a contribution of Rs.160 per two equivalent hours.

In case the company decides to forego the manufacturing of 20,000 units of Okay-chips in favour of 5,000 additional units of Super-chips to be used by Mini-Computer division (instead of complex imported Circuit Board) for manufacturing process control units. This decision would increase the existing contribution of Mini-computer Division by Rs.200/- per two-equivalent hours (*Refer to working note 5*).

Hence the entire requirement of 5,000 units of Super-chips be produced and transferred to Mini-Computer Division.

(ii) Minimum transfer price of Super-chip to Mini Computer Division:

Variable cost of a Super-chip + Opportunity cost of foregoing the production of an Okay-chip and using craftsmen time for Super-chip

= Rs.300 + 2 hours × Rs.80

= Rs.460

(iii) Super –chips to be produced for the production of 12,000 units of process control units:

After meeting out the order of 15,000 Super-chips per year, the concern is left out with 20,000 hours. Use of Super-chips for control units production would increase the existing contribution of Mini-Computer Division by Rs.200/- per unit. Out of the remaining 20,000 craftsmen hours, 10,000 units of Super-chips can be made, which may be used for the production of 10,000 process control units.

Question 9

A company is engaged in the manufacture of edible oil. It has three divisions as under:

(i) Harvesting oil seeds and transportation thereof to the oil mill.

(ii) Oil Mill, which processes oil seeds and manufactures edible oil.

(iii) Marketing Division, which packs the edible oil in 2 kg. containers for sale at Rs.150 each container.

The Oil Mill has a yield of 1,000 kgs of oil from 2,000 kg of oil seeds during a period. The Marketing Division has a yield of 5,000 cans of edible oil of 2 kg each from every 1,000 kg of oil. The net weight per can is 2 kgs of oil.

The cost data for each division four the period are as under:

Harvesting division

Variable cost per kg of oil seed	*Rs.2.50*
Fixed cost per kg of oil seed	*Rs.5.00*
Oil Mill Division:	
Variable cost of processed edible oil	*Rs.10.00 per kg*
Fixed cost of processed edible oil	*Rs.7.50 per kg*
Marketing Division:	
Variable cost per can of 2 kg of oil	*Rs.3.75*
Fixed cost per can of 2 kg of oil	*Rs.8.75*

The fixed costs are calculated on the basis of the estimated quantity of 2,000 kg of oil seeds harvested, 1,000 kg of processed oil and 500 can s of edible oil packed by the aforesaid divisions respectively during the period under review.

The other oil mills buy the oil seeds of same quality at Rs.12.50 per kg in the market. The market price of edible oil processed by the oil mill, if sold without being packed in the marketing division is Rs.62.50 per kg of oil.

Required:

(i) Compute the overall profit of the company of harvesting 2,000 kg of oil seeds, processing it into edible oil and selling the same in 2 kg cans as estimated for the period under review.

(ii) Compute the transfer prices that will be used for internal transfers from (1) Harvesting Division to Oil Mill Division and (2) from Oil Mill Division to Marketing Division under the following pricing methods:

(1) Shared contribution in relation to variable costs; and

(2) Market price.

(iii) Which transfer pricing method will each divisional manager prefer to use? (May 2001)

Answer

(i) Statement of the overall profit of the company

(By harvesting 2,000 kgs of oil seeds, processing it into edible oil & selling the same in 2 kg cans)

	Harvesting Division	*Oil Mill Division*	*Marketing Division*	*Total Rs.*
Output of each department	2,000 kgs of oil seed	1,000 kgs. of oil produced	500 cans of 2 kg each	
Total costs				
Variable cost (Rs.) : (A)	5,000	10,000	1,875	16,875
	(2,000 kgs × Rs.2.50)	(1,000 kgs × Rs.10)	(500 × Rs.3.75)	
Fixed cost (Rs.): (B)	10,000	7,500	4,375	21,875
	(2,000 kgs × Rs.5)	(1,000 kgs × Rs.7.50)	(500 × Rs.8.75)	
Total cost (Rs.): (C) = [(A)+(B)]	15,000	17,500	6,250	38,750
Sales revenue (Rs.): (D)				75,000
(500 cans × Rs.150)				
Profit (Rs.) [(D) – (C)]				36,250

(ii) Working note:

(a) Total Contribution = (Sales revenue – total variable cost)

= Rs.75,000 – Rs.16,875 = Rs.58,125

(b) Amount of shared contribution in relation to variable costs:

Harvesting Division = $\text{Rs.}58{,}125 \times \frac{\text{Rs.}5{,}000}{\text{Rs.}16{,}875} = \text{Rs.}17{,}222$

Oil Mill Division = $\text{Rs.}58{,}125 \times \frac{\text{Rs.}10{,}000}{\text{Rs.}16{,}875} = \text{Rs.}34{,}445$

Marketing Division = $\text{Rs.}58{,}125 \times \frac{\text{Rs.}1{,}875}{\text{Rs.}16{,}875} = \text{Rs.}6{,}458$

Computation of Transfer Price (for internal transfers) under the following pricing methods:

(1) Shared contribution in relation to variable costs:

Transfer price from harvesting Division to Oil Mill Division

= Variable cost of Harvesting Division + Shared contribution of Harvesting Division in relation to variable costs

= Rs.5,000 + Rs.17,222 (Refer to working note 2) = Rs.22,222

Transfer price from Oil Mill Division to Marketing Division

= Transfer price from Harvesting Division to Oil Mill Division + Variable cost of Oil Mill Division + Shared contribution of Oil Mill Division in relation to variable costs

(Refer to working note 2)

= Rs.22,222 + Rs.10,000 + 34,445

= Rs.66,667

(2) Market price:

Transfer price from Harvesting Division to Oil Mill Division

= Market price of 2,000 kgs of Oil seeds transferred to Oil Mill Division

= 2,000 kgs. × Rs.12.50 = Rs.25,000

Transfer price from Oil Mill Division to Marketing Division

= Market price of 1,000 kgs of edible oil

= 1,000 of kgs × Rs.62.50 – Rs.62,500

(iii) Statement of profitability (under different transfer prices method)

	From Harvesting Division to Oil Mill Division	*From Oil Mil to Marketing Division*	*From Marketing Division to market (500 cans of 2 Kgs.)*
	Rs.	*Rs.*	*Rs.*
Shared contribution method			
Transfer price:	22,222	66,667	75,000
(Refer to (1) above)			
Less: Transfer price	__	22,222	66,667
(Refer to (ii) above)			
Less: Variable cost	5,000	10,000	1,875
Less: Fixed cost	10,000	7,500	4,375
(Refer to (i) above)			
Profit	7.222	26,945	2,083
Market price method			
Transfer price	25,000	62,500	75,000
(Refer to (2) above)			
Less: Transfer in price	__	25,000	62,500
(Refer to (ii) above)			
Less: Variable cost	5,000	10,000	1,875
(Refer to (ii) above)			
Less: Fixed cost	10,000	7,500	4,375
(Refer to (i) above)			
Profit	10,000	20,000	6,250

Decision: Divisional Manager of Harvesting Division would prefer the use of market price method for transferring 2,000 kgs of oil seeds to Oil Mill Division because its usage increases the profit by Rs.2,778 (Rs.7,222) over the shared contribution method.

Whereas Oil Mill Division manager would prefer the use of shared contribution method over the market price method because its use would increase its profit by Rs.6,945 (Rs.26,945 – Rs.20,000). Similarly Marketing Divisional Manager would be benefited to the extent of Rs.4,167 (Rs.6,250 – Rs.2,083) by using market price method.

Question 10

Indicate the possible disadvantages of treating divisions as profit centres. *(Nov 2001)*

Answer

The Possible disadvantages of treating divisions as profit centres are as follows:

1. Divisions may compete with each other and may take decisions to increase profits at the expense of other divisions thereby overemphasizing short term results.
2. It may adversely affect co-operation between the divisions and lead to lack of harmony in achieving organizational goals of the company. Thus it is hard to achieve the objective of goal congruence.
3. It may lead to reduction I the company's overall total profits.
4. The cost of activities, which are common to all divisions, may be greater for decentralized structure than centralized structure. It may thus result in duplication of staff activities.
5. Top management looses control by delegating decision making to divisional managers. There are risks of mistakes committed by the divisional managers, which the top management, may avoid.
6. Series of control reports prepared for several departments may not be effective from the point of view of top management.
7. It may under utilize corporate competence.
8. It leads to complications associated with transfer pricing problems.
9. It becomes difficult to identity and defines precisely suitable profit centres.
10. It confuses division's results with manager's performance.

Question 11

The two manufacturing divisions of a company is organized on profit centre basis. Division X is the only source of a component required by Division Y for their product 'P'. Each unit of P requires one unit of the said component. As the demand of the product is not steady, orders for increased quantities can be obtained by manipulating prices.

The manager of Division Y has given the following forecast:

Sales per day (Unit)	*Average price per unit of P (Rs.)*
5,000	*393.75*
10,000	*298.50*
15,000	*247.50*
20,000	*208.50*
25,000	*180.00*
30,000	*150.75*

The manufacturing cost (excluding the cost of the component from Division X) of P in Division Y is Rs.14,06,250 on first 5,000 units and Rs.56.25 per unit in excess of 5,000 units.

Division X incurs a total cost of Rs.5,62,500 per day for an output upto 5,000 components and the total costs will increase by Rs.3,37,500 per day for every additional 5,000 components manufactured. The Manager of Division X has set the transfer price for the component at Rs.90 per unit to optimize the performance of his Division.

Required:

(i) Prepare a divisional profitability statement at each level of output, for division X and Y separately;

(ii) Find out the profitability of the company as a whole at the output level where:

(a) Division X's net profit is maximum;

(b) Division Y's net profit is maximum.

(iii) Find out at what level of output, the company will earn maximum profit, if the company is not organized on profit centre basis. *(May 2002)*

Answer

(i) Statement of profitability of Division X

No. of components	*Transfer price for the component to Department Y@ Rs.90 per unit*	*Total cost of components (Rs.)*	*Profit / (Loss) (Rs.)*
(a)	*(b)*	*(c)*	*(d) = {(b) – (c)}*
5,000	4,50,000	5,62,500	(1,12,500)
10,000	9,000	9,00,000	—
15,000	13,50,000	12,37,500	1,12,500
20,000	18,00,000	15,75,000	1,25,000
25,000	22,50,000	19,12,500	3,37,500
30,000	27,00,000	22,50,000	4,50,000

Statement of profitability of Division Y

No. of Components	*Sale revenue on average price basis*	*Component cost (Transfer price) to Dept. Y*	*Manufacturing cost in division Y*	*Total cost*	*Profit/(Loss)*
	Rs.	*Rs.*	*Rs.*	*Rs.*	*Rs.*
(a)	*(b)*	*(c)*	*(d)*	*(e)={(c)+(d)}*	*(f)={(b)-(e)}*
5,000	19,68,750	4,50,000	14,06,250	18,56,250	1,12,500
10,000	29,85,000	9,00,000	16,87,500	25,87,500	3,97,500
15,000	37,12,500	13,50,000	19,68,750	33,18,750	3,93,750
20,000	41,70,000	18,00,000	22,50,000	40,50,000	1,20,000
25,000	45,00,000	22,50,000	25,31,250	47,81,250	(2,81,250)
30,000	45,00,000	27,00,000	28,12,500	55,12,500	(9,90,000)

(ii) Profitability of the company as a whole

(a) At 30,000 units level, at which Division X's net profit is maximum	*Rs.*
Profit of Division X	4,50,000
Profit of division Y	(9,00,000)
Operating profitability / (Loss) of the company	(5,40,000)
(b) At 10,000 units level, at which Division Y's net profit is maximum	*Rs.*
Profit of division X	NIL
Profit of division Y	3,97,500
Operating profitability of the company	3,97,500

(iii) Profitability of the company, if it is not organised on profit centre basis

No. of components	*Sales revenue on average*	*Cost of component to division X*	*Manufacturing cost in division Y*	*Total cost*	*Profit/ (Loss)*

	basis				
	(Rs.)	*(Rs.)*	*(Rs.)*	*(Rs.)*	*(Rs.)*
(a)	*(b)*	*(c)*	*(d)*	*(e)={(c) + (d)}*	*(f)={(b)–(e)}*
5,000	19,68,750	5,62,500	14,06,250	19,68,750	-
10,000	29,85,000	9,00,000	16,87,500	25,87,500	3,97,500
15,000	37,12,500	12,37,500	19,68,750	32,06,250	5,06,250
20,000	4170,000	15,75,000	22,50,000	38,25,000	3,45,000
25,000	45,00,000	19,12,500	25,31,250	44,43,750	56,250
30,000	45,22,500	22,50,000	28,12,500	50,62,500	(5,40,000)

The level of output, the company will earn maximum profit, if the company is not organized on profit centre basis is 15,000 components.

Question 12

Tycon Ltd. has two manufacturing departments organized into separate profit centres known as Textile unit and Process House. The Textile unit has a production capacity of 5 lacs metres cloth per month, but at present its sales is limited to 50% to outside market and 30% to process house.

The transfer price for the year 2004 was agreed at Rs. 6 per metre. This price has been fixed in line with the external wholesale trade price on 1st January, 2004. However, the price of yarn declined, which was the raw material of textile unit, with effect, that wholesale trade price reduced to Rs. 5.60 per metre with effect from 1st June, 2004. This price was however not made applicable to the sales made to the processing house of the company. The textile unit turned down the processing house request for revision of price.

The Process house refines the cloth and packs the output known as brand Rayon in bundles of 100 metres each. The selling price of the Rayon is Rs. 825 per bundle. The process house has a potential of selling a further quantity of 1,000 bundles of Rayon provided the overall prices is reduced to Rs. 725 per bundle. In that event it can buy the additional 1,00,000 metres of cloth from textile unit, whose capacity can be fully utilised. The outside market has no further scope.

The cost data relevant to the operations are:

	Textile unit	*Process house*
	Rs.	*Rs.*
Raw material (per metre) on 1st June, 2004	*3.00*	*Transfer price*
Variable cost	*1.20 (per metre)*	*80 (per bundle)*
Fixed cost (per month)	*4,12,000*	*1,00,000*

You are required to:

(i) Prepare statement showing the estimated profitability for June, 2004 for Textile unit and Process house and company as a whole on the following basis:

(a) At 80% and 100% capacity utilisation of the Textile unit at the market price and the transfer price to the Processing house of Rs. 6 per metre.

(b) At 80% capacity utilisation of the Textile unit at the market price of Rs. 5.60 per metre and the transfer price to the Processing house of Rs. 6 per metre.

(c) At 100% capacity utilisation of the Textile unit at the market price of Rs. 5.60 per metre and the transfer price to the Processing house of Rs. 5.60 per metre.

(ii) Comment on the effect of the company's transfer pricing policy on the profitability of Processing house. *(11 Marks)*

Answer

(i) (a) At 80% level (in Rs)

-Textile unit		-Process house	
Sales (4,00,000 × 6)	24,00,000	Sales(1,50,000/100) ×825	12,37,500
Less		Less	
Raw material (4,00,000 × 3)	12,00,000	Transfer Price (1,50,000 × 6)	9,00,000
Variable cost (4,00,000 ×1.2)	4,80,000	Variable cost (1,500 × 80)	1,20,000
Fixed cost	4,12,000	Fixed cost	1,00,000
Profit	3,08,000	Profit	1,17,500

Overall profit = 3,08,000 + 1,17,500 = Rs 4,25,500

At 100% level

Sales (5,00,000 × 6)	30,00,000	Sales (2,50,000/100) ×725	18,12,500
Less		Less	
Raw material (5,00,000 × 3)	15,00,000	Transfer Price (2,50,000 × 6)	15,00,000
Variable cost (5,00,000 × 1.2)	6,00,000	Variable cost	2,00,000
Fixed cost	4,12,000	Fixed cost	1,00,000
Profit	4,88,000	Profit	12,500

Overall profit = 4,88,000+12,500 = Rs 5,00,500

(b) At 80% level (market price 5.60 and transfer price 6/-) (in Rs)

Textile unit		Process house	
Sale (2,50,000 ×5.6)	1400000		
(1,50,000 ×6.0)	900000		
	23,00,000		
Less			
Raw material (4,00,000 ×3)	12,00,000		
Variable cost (4,00,000 ×1.2)	4,80,000		
Fixed cost	4,12,000		
Profit	2,08,000	Profit	1,17,500

Overall profit = 2,08,000+1,17,500 =Rs 3,25,500

(c) Sales 100% level at (5.60) (in Rs)

Sale (5,00,000 × 5.6)	28,00,000	Sales(2,50,000 ×725)	18,12,500
Less		Less	
Raw material (5,00,000 ×3)	15,00,000	Transfer Profit (2,50,000 ×5.6)	14,00,000
Variable cost (5,00,000 ×1.20)	6,00,000	Variable cost (2,500 × 80)	2,00,000
Fixed cost	4,12,000	Fixed cost	1,00,000
Profit	2,88,000	Profit	1,12,500

Overall profit = 2,88,000 + 1,12,500 =4,00,500

(ii) Comments on the profitability of processing units:-

		Transfer price (Rs)	Profit (Rs)
(a)	80% capacity	6.00	1,17,500
	100% capacity	6.00	12,500
(b)	80% capacity	6.00	1,17,500
(c)	100% capacity	5.60	1,12,500

Processing house will not be interested to buy more than 1,50,000 meters from textile units.

Question 13

AB Cycles Ltd. has 2 divisions, A and B which manufacture bicycle. Division A produces bicycle frame and Division B assembles rest of the bicycle on the frame. There is a market for sub-assembly and the final product. Each division has been treated as a profit centre. The transfer price has been set at the long-run average market price. The following data are available to each division:

Estimated selling price of final product	*Rs. 3,000 p.u.*
Long run average market price of sub-assembly	*Rs. 2,000 p.u.*
Incremental cost of completing sub-assembly in division B	*Rs. 1,500 p.u.*
Incremental cost in Division A	*Rs. 1,200 p.u.*

Required:

(i) If Division A's maximum capacity is 1,000 p.m. and sales to the intermediate are now 800 units, should 200 units be transferred to B on long-term average price basis.

(ii) What would be the transfer price, if manager of Division B should be kept motivated?

(iii) If outside market increases to 1,000 units, should Division A continue to transfer 200 units to Division B or sell entire production to outside market?

Answer

(i) In this case there are two options available –

(a)	Sell at the sub assembly stage (after completion of Div. A) @ Rs. 2000/-	
	Incremental cost in Div. A	Rs 1,200/-
	Contribution	Rs 800/-
(b)	Sell at the final product stage	Rs. 3,000
	Cost at Div. A and Div. B Rs(1200+1500)	Rs 2,700
	Contribution	Rs 300

Therefore it is profitable to sell at the subassembly stage because of higher contribution, provided there is a market.

Hence, if there is market at intermediate stage, first priority is to sell intermediary (sub assembly).Therefore, 800 units should be sold as sale of intermediary.

The balance capacity available of (1000 – 800) = 200 units should be transferred to B and B should complete the assembly and sell as final product, since the company can earn Rs. 300 per unit for each unit of such sale.

(ii) If B Div. receives the subassembly at market price of Rs. 2,000, plus its own incremental cost of Rs. 1,500 will give total cost of Rs. 3,500, thereby yielding a loss of Rs. 3500 – Rs. 3000 = Rs. 500 per unit, whereas the company makes a profit of Rs. 300 per unit.

In order to keep the manager of Div. B motivated, the profit earned of Rs. 300 per unit should be shared between A and B. Hence transfer price will be variable cost of Div. A + 50% of profit earned in the final product = 1200 + 150 = Rs. 1,350

(iii) Both Div. A and the Company make higher contribution by selling to intermediate market. If the market demand increases to 1,000 units, the full quantity should be sold outside as intermediary and nothing should be transferred to Div. B.

Question 14

A Company is organised into two divisions. Division X produces a component, which is used by division Y in making of a final product. The final product is sold for Rs540 each. Division X has capacity to produce 2,500 units and division Y can purchase the entire production. The variable cost of division X in manufacturing each component is Rs256.50.

Division X informed that due to installation of new machines, its depreciation cost had gone up and hence wanted to increase the price of component to be supplied to division Y to Rs297 , however division Y can buy the component from out side the market at Rs270 each. The variable cost of division Y in manufacturing the final product by using the component is Rs202.50 (excluding component cost).

Present the statement indicating the position of each Division and the company as whole taking each of the following situations separately:

(i) If there is no alternative use for the production facility of X, will the company benefit, if division Y buys from out side suppliers at Rs270 per component.

(ii) If internal facilities of X are not otherwise idle and the alternative use of the facilities will bring an annual cash saving of Rs50,625 to division X, should division Y purchase the component from outside suppliers ?

(iii) If there is no alternative use for the production facilities of division X and the selling price for the component in the outside market drops by Rs20.25, should division Y purchase from outside supplier?

(iv) What transfer price would be fixed for the component in each of the above circumstances?

Answer

(i) When component is purchased by division Y from outside

(a)	Rs	(Rs.)
Division Y sales 2500×540		13,50,000
Less: cost of purchase 2500×270	6,75,000	
Variable cost 2500×202.50	5,06,250	11,81,250
Division Y contribution		1,68,750
Division X contribution		Nil
Total contribution		1,68,750

(b) When component is purchased from division X

Division X		(Rs.)
Sales 2500×297	7,42,500	
Less variable cost 2500×256.50	6,41,250	1,01,250
Division Y		
Sales 2500×540	13,50,000	
Less: Variable cost		
Purchase cost 2500×297	7,42,500	

Variable cost of division Y 2500×202.50	5,06,250	1,01,250
Total contribution		2,02,500

Thus it will be beneficial for the company as whole to buy component from division X.

(ii) When there is alternative use of Division X with given cash saving

		(Rs.)
Division X Contribution from alternative use of facilities		50,625
Division Y sales 2500×540	13,50,000	
Less: Cost of purchase 2500×270	6,75,000	
Variable cost 2500×202.50	5,06,250	
Division Y contribution		1,68,750
Company's total contribution		2,19,375

(iii) When there is no alternative use of Division X & selling price of component reduces in the market

		Rs
Division Y sales 2500×540	13,50,000	
Less: Cost of purchase 2500×249.75	6,24,375	
Variable cost 2500×,*202.20	5,06,250	
Total contribution		2,19,375

It is beneficial to buy component from outside.

(iv) Transfer price

(a) Where there is no alternative use of capacity of division X, then variable cost i.e. Rs256.50 per component will be charged

(b) If facilities of division X can be put to alternative use then variable cost Rs256.50+ opportunity cost Rs20.25 =Rs276.75 will be transfer price.

(c) If market price gets reduced to Rs. 249.75 and there is no alternative use of facilities of Division X the variable cost Rs256.50 per component should be charged.

Question 15

What are some goals of a 'transfer-pricing' system in an organization?

Answer

The goals of transfer pricing are that it should:

1. provide information that motivates divisional managers to take good economic decisions which will improve the divisional profits and ultimately the profits of the company as a whole.
2. provide information which will be useful for evaluating the divisional performance.
3. seek to achieve goal congruence.
4. ensure that divisional autonomy is not undermined.

Question 16

Division Z is a profit center which produces four products A, B, C and D. Each product is sold in the external market also. Data for the period is:

	A	*B*	*C*	*D*
Market price per unit (Rs.)	*150*	*146*	*140*	*130*
Variable cost of pdn. Per unit (Rs.)	*130*	*100*	*90*	*85*
Labour hours required per unit	*3*	*4*	*2*	*3*

Product D can be transferred to division Y, but the maximum quantity that may be required for transfer is 2,500 units of D.

The maximum sales in the external market are:

A	*2,800 units*
B	*2,500 units*
C	*2,300 units*
D	*1,600 units*

Division Y can purchase the same product at a price of Rs. 125 per unit from outside instead of receiving transfer of product D from Division Z.

What should be the transfer price for each unit for 2,500 units of D, if the total labour hours available in division Z are 20,000 hours?

Answer

Ranking of products when availability of time is the key factor

Products	A	B	C	D
Market price	150	146	140	130
Less: Variable cost	130	100	90	85
Contribution p.u. (Rs.)	20	46	50	45
Labour hours p.u.	3	4	2	3
Contribution/labour hour	6.66	11.5	25	15
Ranking	IV	III	I	II
Maximum demand (units)	2,800	2,500	2,300	1,600
Total No of hours	8,400	10,000	4,600	4,800
Allocation of 20,000 hours on the basis of ranking	600*	10,000	4,600	4,800

*Balancing figure

Note: Time required meeting the demand of 2,500 units of product D for division Y is 7,500 hours. This requirement of time viz, 7,500 hours for providing 2,500 units of product D for division Y can be met by sacrificing 600 hours of Product A (200 units) and 6,900 hours of Product B (1,725 units)

Transfer Price = Variable cost + Opportunity cost

$$\text{Or } \frac{\text{Rs}85 + (\text{Rs}6{,}900 \times 11.5 + 600 \times 6.66)}{2{,}500} = \frac{\text{Rs.}85 + (79350 + 4000)}{2500}$$

= Rs (85 + 33.34) = Rs 118.34

9

TARGET COSTING, LIFE CYCLE COSTING

Question

What is Target Costing and what are the stages to the methodology ? (Nov 2000)

Answer

Target Costing: It is a management tool used for reducing a product cost over its entire life cycle. It is driven by external Market factors. Marketing management prior to designing and introducing a new product determines a target market price. This target price is set at a level that will permit the company to achieve a desired market share and sales volume. A desired profit margin is then deducted to determine the target maximum allowable product cost. Target costing also develops methods for achieving those targets and means to test the cost effectiveness of different cost-cutting scenarios. Stages to the methodology.

1. Conception (planning) Phase: Under this stage of life cycle, competitors products are to be analysed, with regard to price, quality, service and support, delivery and technology. The features which consumers would like to have like consumer value etc. established. After preliminary testing, the company may be asked to pinpoint a market niche, it believes, is under supplied and which might have some competitive advantage.
2. Development phase: The design department should select the most competitive product in the market and study in detail the requirement of material, manufacturing process along with competitors cost structure. The firm should also develop estimates of internal cost structure based on internal cost of similar products being produced by the company. If possible the company should develop both the cost structures (competitors and own) in terms of cost drivers for better analysis and cost reduction.
3. Production phase: This phase concentrates its search for better and less expensive products, cost benefit analysis in different features of a product priority wise, more towards less expensive means of production, as well as production techniques etc.

Question 2

What is Product Life-cycle Costing ? Describe its characteristics and benefits.(5 Marks)

Answer

Product life cycle costing.

It is an approach used to provide a long-term picture of product line profitability, feedback on the effectiveness of the life cycle planning and cost data to clarify the economic impact on alternatives choices in the design, engineering phase etc. It is also considered as a way to enhance the control of manufacturing costs. It is important to track and measure costs during each stage of a product's life cycle.

Characteristics:-

(i) Product life cycle costing involves tracing of costs and revenues of each product over the several calendar periods throughout their entire life cycle.

(ii) Product life cycle costing traces research and design and development costs and total magnitude of these costs for each individual product and compared with product revenue.

(iii) Report generation for costs and revenues.

Benefits: -

(i) The product life cycle costing results in earlier actions to generate revenue or to lower cost than otherwise might be considered.

(ii) Better decision should follow from a more accurate and realistic assessment of revenues and costs, at least within a particular life cycle stage.

(iii) Product life cycle thinking can promote long-term rewarding in contrast to short-term profitability rewarding.

(iv) It provides an overall framework for considering total incremental costs over the life span of a product.

Question 3

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

Answer

Total life cycle costing approach:

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

Importance:

Product life cycle costing is important for the following reasons:

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

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

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

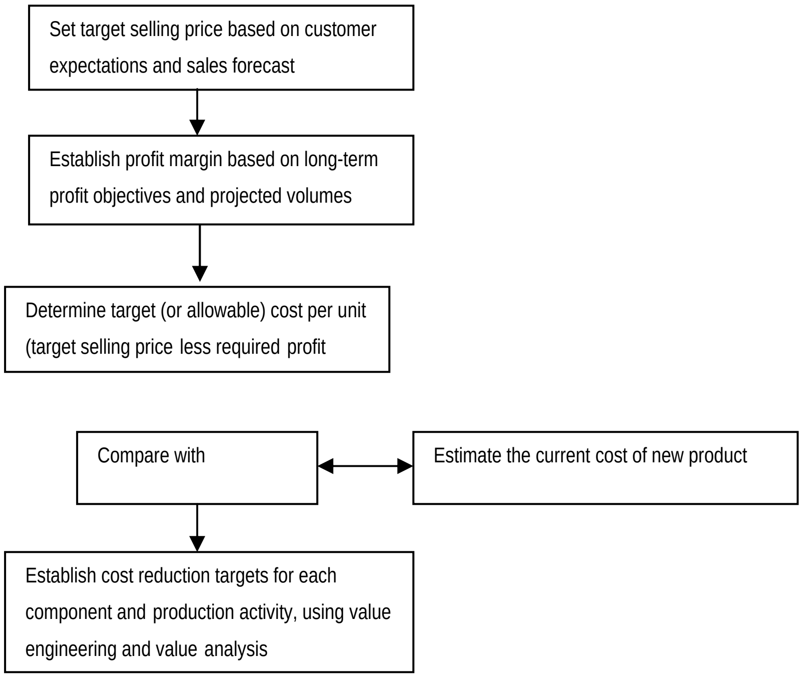
Total life-cycle costing approach accumulates product costs over the value chain. It is a process of managing all costs along the value chain starting from product's design, development, manufacturing, marketing, service and finally disposal.

Question 4

List the steps involved in target costing process with the help of a block diagram.

Answer

Target Costing Process



10
JIT, MRP & ERP

Question 1

What do you mean by 'Back flushing' in JIT system ? Explain briefly the problems with back flushing that must be corrected before it will work properly. (4 Marks)

Answer

Back flushing in a JIT system

Traditional accounting systems record the flow of inventory through elaborate accounting procedures . Such systems are required in those manufacturing environment where inventory/WIP values are large. However, since JIT systems operate in modern manufacturing environment characterized by low inventory and WIP values, usually also associated with low cost variances, the requirements of such elaborate accounting procedures does not exist.

Back flushing requires no data entry of any kind until a finished product is completed. At that time the total amount finished is entered into the computer system which is multiplied by all components as per the Bill of materials (BOM) for each item produced. This yields a lengthy list of components that should have been used in the production process and this is subtracted from the opening stock to arrive at the closing stock to arrive at the closing stock/inventory.

The problems with back flushing that must be corrected before it works properly are:

(i) The total production quantity entered into the system must be absolutely correct, if not, then wrong components and quantities will be subtracted from the stock.

(ii) All abnormal scrap must be diligently tracked and recorded. Otherwise materials will fall outside the black flushing system and will not be charged to inventory.

(iii) Lot tracing is impossible under the back flushing system. This is required when a manufacturer needs to keep records of which production lots were used to create a product in case all the items in a lot need be recalled.

(iv) The inventory balance may be too high at all times because the back flushing transactions that relieves inventory usually does so only once a day, during which time other inventory is sent to the production process. This makes it difficult to maintain an accurate set of inventory records in the warehouse.

Question 2

X Video Company sells package of blank video tapes to its customer. It purchases video tapes from Y Tape Company @ Rs140 a packet. Y Tape Company pays all freight to X Video Company. No incoming inspection is necessary because Y Tape Company has a superb reputation for delivery of quality merchandise. Annual demand of X Video Company is 13,000 packages. X Video Co. requires 15% annual return on investment. The purchase order lead time is two weeks. The purchase order is passed through Internet and it costs Rs2 per order. The relevant insurance, material handling etc Rs3.10 per package per year. X Video Company has to decide whether or not to shift to JIT purchasing. Y Tape Company agrees to deliver 100 packages of video tapes 130 times per year (5 times every two weeks) instead of existing delivery system of 1,000 packages 13 times a year with additional amount of Rs0.02 per package. X Video Co. incurs no stock out under its current purchasing policy. It is estimated X Video Co. incurs stock out *cost on 50 video tape packages under a JIT purchasing policy. In the event of a stock out, X Video Co. has to rush order tape packages which costs Rs4 per package. Comment whether X Video Company should implement JIT purchasing system.*

Z Co. also supplies video tapes. It agrees to supply @ Rs13.60 per package under JIT delivery system. If video tape purchased from Z Co., relevant carrying cost would be Rs3 per package against Rs3.10 in case of purchasing from Y Tape Co. However Z Co. doesn't enjoy so sterling a reputation for quality. X Video Co. anticipates following negative aspects of purchasing tapes from Z Co.

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

  Average stock out of 360 tapes packages per year would occur, largely resulting form late deliveries. Z Co. cannot rush order at short notice. X Video Co. anticipates lost contribution margin per package of Rs8 from stock out.

- *Customer would likely return 2% of all packages due to poor quality of the tape and to handle this return an additional cost of Rs25 per package.*

  Comment whether X Video Co places order to Z Co

Answer

(i) Comparative Statement of cost for purchasing from Y Co Ltd under current policy & JIT

Particulars	Current Policy	JIT
	Rs	Rs
Purchasing cost	18,20,000	18,20,260
	(13,000 × 140)	(13,000 × 140.02)
Ordering cost	26.00(2×13 orders)	260.00(2×130 orders)
Opportunity carrying cost	10,500.00	1,050.15
	(1/2×1000×140×15%)	(1/2×100×140.02×15%)
Other carrying cost (Insurance, material handling etc)	1,550.00(1/2×1000×3.10)	155.00
Stock out cost		200(4 × 50)
Total relevant cost	18,32,076	18,21,925.15

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

(ii) Statement of cost for purchasing from Z Co Ltd.

Particulars	*Rs.*
Purchasing cost	1,76,800 (13,000x13.60)
Ordering Cost	260.00 (2x130 orders)
Opportunity Carrying	102.00
Cost	(1/2×100×13.60× 15%)
Other Carrying Cost	150.00 (1/2×100×3.00)
Stock out Cost	2,880 (8x360)
Inspection Cost	650.00 (13,000 x .05)
Customer Return Cost	6,500.00 (13,000 x 2% x 25)
Total Relevant Cost	1,87,342

Comments : The comparative costs are as follows,

Under current policy Rs 18,32,076.00

Under purchase under JIT	Rs 18,21,925.10
Under purchase from Z Co Ltd	Rs 1,87,342.00

Packages should be bought from Z Co as it is the cheapest.

Question 3

(i) What do you mean by ERP?

(ii) Name six benefits of ERP in an enterprise

Answer

(i) Enterprise resource planning (ERP) software (i) attempts to integrate all departments and functions across a company into a single computer system that can serve all those different departments' particular needs. In fact ERP combines all computerized departments together with the help of a single integrated software that runs off a single database so that various departments can more easily share information and communicate with each other

(ii) Benefits of ERP

(a) Product costing.
(b) Inventory management.
(c) Distribution and delivery of pdts.
(d) E-commerce.
(e) Automatic control of quality.
(f) Sales service.
(g) Improved production planning.
(h) Quick response to change in market condition.
(i) Competitive edge by improving business process.

11

ACTIVITY BASED COST MANAGEMENT

Question 1

Explain the concept of cost drivers indicate what you will consider as cost drivers for the following business function:

Research & development; and Customer service. *(Nov 1998)*

Answer

A cost driver is any factor whose change cases a change in the total cost of a related cost object. In other words, a change in the level of cost driver will cause a change in the level of the total cost a related cost object.

The cost drivers fro business functions viz. Research & Development and Customer Service are as below:

Business Functions:

		Cost drivers
Research & Development	-	Number of research projects
	-	Personal hours on a project
	-	Technical complexities of projects
Customer Service	-	Number of service calls
	-	Number of products serviced
	-	Hours spent on servicing products

Question 2

What is activity based costing? *(May 2000)*

Answer

Activity based costing: It focuses on activities as the fundamental cost objects and uses the costs of these activities as building blocks for compiling the costs of other objects.

According to CIMA, it is defined as "Cost attribution to cost units on the basis of benefits received from indirect activities i.e. ordering, setting-up, assuring quality etc".

Under activity based costing costs are accumulated for each activity as a separate cost object. The collected costs are applied to products based on the benefits received from various activities. The final product costs are built up from the costs of the specific activities undergone. In the first stage the activity driven overhead cost is charged to activity based cost pools and in the second stage cost driver based rates are derived to charge cost to product lines. The cost driver based rates are based on activities.

Activities based costing can be used for:

(a) Pricing of products;

(b) Design and development of new products.

Question 3

What are the areas in which activity based information is used for decision making? (Nov 2000)

Answer

The areas in which Activity based information is used for making are as under:

(i) Pricing

(ii) Market segmentation and distribution channels

(iii) Make-or-buy decisions and outsourcing

(iv) Transfer pricing

(v) Plant closed down decisions

(vi) Evaluation of offshore production

(vii) Capital Investment decisions

(viii) Product line profitability.

Question 4

ABC electronics makes audio player model 'AB 100'. It has 80 components. ABC sells 10,000 units each month at Rs.3,000 per unit. The cost of manufacturing is Rs.2,000 per unit or Rs.200 lakhs per month for the production of 10,000 units. Monthly manufacturing costs incurred are as follows:

	(Rs. Lakhs)
Direct material costs	*100.00*
Direct manufacturing labour costs	*20.00*
Machining costs	*20.00*
Testing costs	*25.00*
Rework costs	*15.00*
Ordering costs	*0.20*
Engineering costs	*19.80*
	200.00

Labour is paid on piece rate basis. Therefore, ABC considers direct manufacturing labour cost as variable cost.

The following additional information is available for 'AB 100'

(i) Testing and inspection time per unit is 2 hours.

(ii) 10 per cent of 'AB 100' manufactured are reworked.

(iii) It currently takes 1 hour to manufacture each unit of 'AB 100'

(iv) ABC places two orders per month for each component. A different supplier supplies each component.

ABC has identified activity cost pools and cost drivers for each activity. The cost per unit of the cost driver for each activity cost pool is follows:

Manufacturing Activity	*Description of activity*	*Cost driver*	*Cost per unit of cost driver*
1. Machine costs	*Machining components*	*Machine hours of capacity*	*Rs.200*

2. Testing costs	*Testing components and finished products. (Each unit of 'AB 100' is tested individually)*	*Testing hours*	*Rs.125*
3. Rework costs	*Correcting and fixing errors and defects*	*Units of 'AB 100' reworked*	*Rs.1,500 per unit*
4. Ordering costs	*Ordering of components*	*Number of orders*	*Rs.125 per order*
5. Engineering costs	*Designing and managing of products and processes*	*Engineering hours*	*Rs.1,980 per engineering hour*

Over a long-run horizon, each of the overhead costs described above vary with chosen cost drivers. In response to competitive pressure ABC must reduce the price of its product to Rs.600 and to reduce the cost by at least Rs.400 per unit. ABC does not anticipate increase in sales due to price reduction. However, if it does not reduce price it will not be able to maintain the current sales level.

Cost reduction on the existing model is almost impossible. Therefore, ABC has decided to replace 'AB 100' by a new model 'AB 200', which is a modified versions of 'AB 100'. The expected effect of design modifications are as follows:

(i) The member of components will be reduced to 50.

(ii) Direct material costs to be lower by Rs.200 per unit.

(iii) Direct manufacturing labour costs to be lower by Rs.20 per unit.

(iv) Machining time required to be lower by 20 per unit.

(v) Testing time required to be lower by 20 per cent.

(vi) Rework to decline to 5 per cent.

(vii) Machining capacity and engineering hours capacity to remain the same.

ABC currently out sources the rework on defective units.

Required:

(i) Compare the manufacturing cost per unit of 'AB 100' and 'AB 200'.

(ii) Determine the immediate effect of design change and pricing decision on the operating to apply to 'AB 200'.

Ignore income tax, Assume that the cost per unit of each cost driver for 'AB 100' continues to apply to 'AB 200'. *(May 2002)*

Answer

(i) Comparison of manufacturing cost per unit.

	Audio Player Model	
	'AB 100'	*'AB 200'*
	Rs.	*Rs.*
Direct material cost	1,000.00	800.00
Direct manufacturing labour cost	200.00	180.00

Machining costs	200.00	160.00
Testing costs	250.00	200.00
Rework costs	150.00	75.00
Ordering costs	2.00	1.25
Engineering costs	198.00	198.00
Total manufacturing cost per unit	2,000.00	1,614.25

Working notes for audio player model 'AB 200'

(i) Machining hours and cost: Machining hours = (1 hour–0.20 hours) or 0.80 hours)

Machining cost is 0.80 hours × Rs.200 or Rs.160

(ii) Testing hours and cost: Testing hours = 2 hours × (1 hour – 0.20) or 1.60 hours.

Testing cost is 1.60 hours × Rs.125 or Rs.200

(iii) Rework cost per unit:

Rework units = 5% × 10,000 units or 500 units. Rework cost = 500 units × Rs.1,500 or Rs.7,50,000. Rework cost per unit Rs.7,50,000 / 10,000 units or Rs.75 per unit.

(iv) Ordering cost:

No. of orders per month 50 components × 2 orders = 100

Ordering cost per month 100 orders × Rs.125 per order = Rs.12,500

Ordering cost per unit = Rs.12,500 / 10,000 units = Rs.1.25 per unit.

(v) It is assumed that total available engineering hours will be used for manufacturing 'AB 200' model of audio player.

(ii) Effect of design change and pricing decision on operating income of ABC.

		(Rs. Lakhs)
Revenue loss on 10,000 units		(40)
(Rs.10,000 units × Rs.400)		
Saving in cost:		
Direct material costs	20.00	
(Rs.200 × 10,000 units)		
Direct manufacturing labour costs	2.00	
(Rs.20 × 10,000 units)		
Rework costs	7.50	29.50
(5% × 10,000 units × Rs.1,500)		
Net effect on operating income		(10.50)

Conclusion:

Operating income per month will be reduced by Rs. 10.50 Lakhs.

Effects of reduction in components, machining time, and testing time will not have any immediate effect, because it is difficult to adjust the available facilities in ordering department, machining department and testing department.

Question 5

XYZ Ltd. manufactures four products, namely A, B, C and D using the same plant and process. The following information relates to a production period: (11 Marks)

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

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

	Rs.
Machine operation and Maintenance cost	*63,000*
Setup costs	*20,000*
Store receiving	*15,000*
Inspection	*10,000*
Material handling and dispatch	*2,592*

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

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

It is also determined that:

- *Machine operation and maintenance cost should be apportioned between setup cost, store receiving and inspection activity in 4:3:2.*
- *Number of requisition raised on store is 50 for each product and the no. of order executed is 192, each order being for a batch of 12 of a product.*

Required:

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

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

(c) Comment briefly on differences disclosed between overhead traced by present system and those traced by activity based costing. (11 Marks)

Answer

(a) Total cost of different products (overhead absorption on Machine hour basis)

	A	B	C	D
	Rs.	Rs.	Rs.	Rs.
Direct material	42	45	40	48

Direct labour	10	09	07	08
Overhead	72	54	36	18
Cost of production per unit	124	108	83	74
Out put in unit	720	600	480	504
Total cost	89,280	64,800	39,840	37,296

Machine hours (720 $\times$ 4 + 600 $\times$ 3 + 480 $\times$ 2 + 504 $\times$ 1) = 6,144 hours.

Rate per hour = $\frac{\text{Rs}\,1{,}10{,}592}{6{,}144\ \text{hours}}$ = Rs18 per hour.

(b) Activity based costing system

	Set up	*Store receiving*	*Inspection*
Machine operation and maintenance cost of Rs 63,000 to be distributed in the ratio of 4: 3: 2.	28,000	21,000	14,000

Cost	*Rs*	*Drivers*	*No*	*Cost per unit of driver (Rs)*
Set up	48,000	Production runs	96	500
Store receiving	36,000	Requisitions raised	200	180
Inspection	24,000	Production runs	96	250
Material handling and disp	2,592	Orders	192	13.50

Production Run for A (720/24) = 30 ; B (600/24) = 25 ; C (480/24) = 20 ; D (504/24) = 21.

	A (Rs)	*B(Rs0*	*C(Rs)*	*D(Rs)*
Direct material	30,240	27,000	19,200	24,192
Direct labour	7,200	5,400	3,360	4,032
Setup	15,000	12,500	10,000	10,500
Store receiving	9,000	9,000	9,000	9,000
Inspection	7,500	6,250	5,000	5,250
Material handling and dispatch	810	675	540	567
Total cost	69,750	60,825	47,100	53,541
Per unit cost	96.875	101.375	98.125	106.23

(c)

	A	*B*	*C*	*D*
Cost per unit (a)	124	108	83	74
Cost per unit (b)	96.88	101.38	98.13	106.23
Difference	(27.12)	(6.62)	15.13	32.23

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

Question 6

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

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

	(Rs. '000)
Equipment operation expenses	*125*
Equipment maintenance expense	*25*
Wages paid to technicians	*85*
Wages paid to Store men	*35*
Wages paid to despatch staff	*40*
	310

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

(i) Receiving component consignments from suppliers

(ii) Setting up equipment for production runs

(iii) Quality inspections

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

It was further observed that in the short-term KL's overheads are 40% fixed and 60% variable. Approximately, half the variable overheads vary in relating to direct labour hours worked and half vary in relation to the number of quality inspections.

Equipment operation and maintenance expenses are apportioned as:

- *Component stores 15% , manufacturing 70% and goods dispatch 15%*

  Technician's wages are apportioned as :

- *Equipment maintenance 30% , set up equipment for production runs 40% and quality inspections 30%*

  During the quarter :

  (i) a total of 2000 direct labour hours were worked (paid at Rs. 12 per hr.)

  (ii) 980 components consignments were received from suppliers

  (iii) 1020 production runs were set up

  (iv) 640 quality inspections were carried out

  (v) 420 orders were dispatched to customers.

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

	Component R	*Component S*	*Component T*

Direct labour Hrs worked	*25*	*480*	*50*
Direct Material	*Rs. 1,200*	*Rs. 2,900*	*Rs. 1,800*
Component Consignments Recd.	*42*	*24*	*28*
Production runs	*16*	*18*	*12*
Quality Inspections	*10*	*8*	*18*
Orders (goods) despatched	*22*	*85*	*46*
Quantity produced	*560*	*12,800*	*2,400*

Required:

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

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

Answer

(1) Single factory direct labour hour overhead rate = $\frac{\text{Rs } 3{,}10{,}000}{2{,}000}$ = Rs 155 per direct labour hour

Computation of unit cost (existing system)

	R (Rs)	S(Rs)	T(Rs)
Direct labour cost @ Rs 12 per hour	300	5,760	600
Direct material	1,200	2,900	1,800
Overheads(direct labour hours × Rs 155 per hour	3,875	74,400	7,750
	5,375	83,060	10,150
Quantity Produced (No)	560	12,800	2,400
Cost per unit	9.60	6.49	4.23

(2) ABC system involves the following stages,

1. Identifying the major activities that take place in an organisation.
2. Creating a cost pool /cost centre for each activity
3. Determining the cost driver for each activity
4. Assigning the cost of activities to cost objects (e.g. products, components, customers etc)

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

(Rs ,000)

	Receiving supplies	*Set ups*	*Quality inspection*	*Despatch*	*Total*
Equipment operation expenses	18.75	87.50		18.75	125.00
Maintenance	3.75	17.50		3.75	25.00
Technicians wages initially allocated to Maintenance(30% of Rs 85,000= Rs 25,500 and then reallocated on same basis on maintenance)	3.83	17.85		3.82	25.50
Balance of technicians wages allocated to set ups and quality		34.00	25.50		59.50

inspections					
Stores wages - Receiving	35.00				35.00
Despatch wages - Despatch				40.00	40.00
	61.33	156.85	25.50	66.32	310.00

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

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

Receiving supplies ($\frac{\text{Rs } 61{,}330}{980}$) = Rs 62.58 per component.

Performing set ups ($\frac{1{,}56{,}850}{1{,}020}$) = Rs 153.77 per set up

Despatching goods ($\frac{66{,}320}{420}$) = Rs 157.93 per despatch

Quality inspection ($\frac{25{,}500}{640}$) = Rs 39.84 per quality inspection

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

	R (Rs)	*S(Rs)*	*T(Rs)*
Direct labour	300	5,760	600
Direct materials	1,200	2,900	1,800
Receiving supplies	2,628.36	1,501.92	1,752.24
Performing set ups	2,460.32	2,767.86	1,845.24
Quality inspections	398.40	318.72	717.12
Despatching goods	3,474.46	13,424.05	7,264.78
Total costs	10,461.54	26,672.55	13,979.38
No of units produced	560	12,800	2,400
Cost per unit	18.682	2.08	5.82

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

(Component R)

Receiving supplies (42 receipts at Rs 62.58)

Performing set ups (16 production runs at Rs 153.77)

Quality inspections (10 at Rs 39.84)

Despatching goods (22 at Rs 157.93).

Question 7

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

Answer

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

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

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

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

Question 8

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

Answer

ABC is an accounting methodology that assigns costs to activities rather than products and services. This enables resources and overhead costs to be more accurately assigned to products and services that consume them when compared to traditional methods where either labour or machine hrs are considered as absorption basis over cost centres. In order to correctly associate costs with products and services, ABC assigns cost to activities based on their resources . It then assigns cost to 'Cost objects', such as products and customers, based on their use of activities. ABC can track the flow of activities in organization by creating a link between the activity and the cost objects.

ABC supports corporate strategy in many ways such as:

- ABC system can effectively support the management by furnishing data, at the operational level and strategic level. Accurate product costing will help the management to compare the profits of various customers, product lines and to decide on price strategy etc.
- Information generated by ABC system can also encourage management to redesign the products.
- ABC system can change the method of evaluation of new process technologies, to reduce setup times, rationalization of plant lay out in order to reduce or lower material handling cost, improve quality etc.
- ABC system will report on the resource spending.
- ABC analysis helps managers' focus their attention and energy on improving activities and the actions allow the insights from ABC to be translated into increased profits.
- Performance base accurate feedback can be provided to cost centre managers.
- Accurate information on product costs enables better decisions to be made on pricing, marketing, product design and product mix.

Question 9

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

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

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

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

	(Rs. in thousand)		
	P	*Q*	*Total*
Direct Material cost (variable)	*4,200*	*3,000*	*7,200*
Labour cost (variable)	*1,500*	*1,000*	*2,500*
*Direct Machining cost (See Note)**	*700*	*550*	*1,250*

Indirect Costs:	
Machine set up cost	*462*
Testing cost	*2,375*
Engineering cost	*2,250*
	16,037

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

Additional information is as follows:

	P	*Q*
Production Batch Size	*1,000 units*	*500 units*
Set up time per batch	*30 hours*	*36 hours*
Testing time per unit	*5 hours*	*9 hours*
Engineering cost incurred on each product	*8.40 lacs*	*14.10 lacs*

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

- *Direct Material cost is expected to decrease by Rs. 5 per unit.*
- *Labour cost is expected to decrease by Rs. 2 per unit.*
- *Machine time is expected to decrease by 15 minutes; previously it took 3 hours to produce 1 unit of 'P'. The machine will be dedicated to the production of new design.*
- *Set up time will be 28 hours for each set up.*
- *Time required for testing each unit will be reduced by 1 hour.*
- *Engineering cost and batch size will be unchanged.*

Required:

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

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

(c) What is the Target cost per unit for new design to maintain the same mark up percentage on full cost per unit as it had earlier? Assume cost per unit of cost drivers for the new design remains unchanged.

(d) Will the new design achieve the cost reduction target?

(e) List four possible management actions that the Computo Ltd. should take regarding new design.

Answer

Working Notes:

	Particulars	*P*	*Q*
(a)	Production/Sales Quantity (units)	1,00,000	50,000
(b)	Batch Size (units)	1000	500

(c)	No of batches $\left(\frac{a}{b}\right)$	100	100
(d)	Set up time per batch (hours)	30	36
(e)	Total set up hours $(c \times d)$ (hours)	3,000	3,600
(f)	Machine set up cost (Rs.)		4,62,000
(g)	Cost driver per machine set up hour $\frac{4,62,000}{6,600}$ = Rs. 70		
(h)	Testing time per unit	5 hours	9 hours
(i)	Total testing time $(a \times h)$ (hours)	5,00,000	4,50,000
(j)	Testing cost Rs. 23,75,000		
(k)	Cost driver per testing hour $\frac{23,75,000}{9,50,000}$ = Rs. 2.50		

(a) Computation of full cost per unit using Activity Based Costing:

Particulars	*Basis*	*P*	*Q*
Direct material	Direct	42,00,000	30,00,000
Direct labour	Direct	15,00,000	10,00,000
Direct machine cost	Direct	7,00,000	5,50,000
Machine set up cost	3,000 hours @ Rs. 70	2,10,000	
	3,600 hours @ Rs. 70		2,52,000
Testing cost	5,00,000 hours @ Rs. 2.50	12,50,000	
	4,50,000 hours @ Rs. 2.50		11,25,000
Engineering cost	Allocated	8,40,000	14,10,000
Total cost (Rs.)		87,00,000	73,37,000
Cost per unit (Rs.)		87.00	146.74

(b) Mark up on full cost basis for Product P:

Particulars	*Per unit*
Selling price	100.05
Less: Full cost	87.00
Mark up	13.05
Percentage of mark up on full cost	$\frac{13.05}{87.00} \times 100 = 15\%$

(c) Target cost of Product P after new design is implemented

	Rs.
Target price (given)	86.25
Mark-up $\frac{86.25 \times 15}{115}$	11.25
Target cost per unit (Rs.)	75.00

(d) Statement of cost for new design of P

Particulars	Basis	*Cost P.U.*	*Total Cost*
Direct Material	Decreased by Rs. 5 p.u.	37.00	37,00,000
Direct Labour	Decreased by Rs. 2 p.u.	13.00	13,00,000
Direct Machining cost	No change as machine is dedicated	7.00	7,00,000
Machine set up cost	100 set up × 28 hours × Rs. 70	1.96	1,96,000
Testing cost	1,00,000 units ×Rs. 2.5 × 4 hours	10.00	10,00,000
Engineering cost	No change	8.40	8,40,000
Total cost		77.36	77,36,000

The target cost is Rs. 75 p.u. and estimated cost of new design is Rs. 77.36 p.u. The new design does not achieve the target cost set by Computo Ltd. Hence the target mark up shall not be achieved.

(e) Possible Management Action:

- Value engineering and value analysis to reduce the direct material costs.
- Time and motion study in order to redefine the direct labour time and related costs.
- Exploring possibility of cost reduction in direct machining cost by using appropriate techniques.
- Identification of non-value added activities and eliminating them in order to reduce overheads.
- The expected selling price based on estimated cost of Rs. 77.36 per unit is (Rs.77.36 + 15%) Rs. 88.96. Introduce sensitivity analysis after implementation of new design to study the sales quantity changes in the price range of Rs. 86.25 to Rs. 88.96.

Question 10

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

Answer

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

Activity Based Costing (ABC) system aims at refining the costing system used in automated plants in the following manner:

1. ABC systems trace more costs as direct costs.

2. ABC systems create homogeneous cost pools linked to different activities.
3. For each activity cost pool, ABC systems seek a cost allocation base that has a cause-and-effect relationship with costs in the cost pool.

Question 11

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

Answer

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

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

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

Question 12

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

(i) Unit level activities

(ii) Batch level activities

(iii) Product level activities

(iv) Facility level activities.

Answer

(i) Unit level activities	(i) Use of indirect materials
	(ii) Inspection or testing of every item produced or say every 100th item produced
	(iii) Indirect consumables
(ii) Batch level activities	(i) Material ordering
	(ii) Machine set up costs
	(iii) Inspection of products – like first item of every batch
(iii) Product level	(i) Designing the product
	(ii) Producing parts to a certain specification
	(iii) Advertising costs, if advertisement is for individual products
(iv) Facility level	(i) Maintenance of buildings
	(ii) Plant security
	(iii) Production manager's salaries
	(iv) Advertising campaigns promoting the company

12

TOTAL QUALITY MANAGEMENT

Question 1

Define Total Quality Management? What are the six Cs for successful implementation of TQM?

Answer

The total quality management is a set of concepts and tools for getting all employees focused on continuous improvement in the eyes of the customer. Quality is an important aspect of world-class manufacturing. The success of Japanese companies is grass rooted in their long-term commitment to improvement of quality. A world class manufacturing approach demands that the quality must be designed into product and the production process, rather than an attempt to remove poor quality by inspection. This means that the objectives of quality assurance in a world- class-manufacturing environment, is not just reject defective product, but to systematically investigate the cause of defects so that they can be gradually eliminated. Though the goal is zero defect, the methodology is one of continuous improvement.

Six Cs of TQM

(i) Commitment - If a TQM culture is to be developed, so that quality improvement becomes normal part of everyone's job, a clear commitment, from the top must be provided. Without this all else fails.

(ii) Culture - Training lies at the centre of effecting a change -in culture and attitudes. Negative perceptions must be changed to encourage individual contributions.

(iii) Continuous improvement - TQM is a process, not a program, necessitating that we are committed in the long term to the never ending search for ways to do the job better.

(iv) Co-operation: The on-the-job experience of all employees must be fully utilized and their involvement and co-operation sought in the development of improvement strategies and associated performance measures.

(v) Customer focus: Perfect service with zero defects in all that is acceptable at either internal or external levels.

(vi) Control: Documentation, procedures and awareness of current best practice are essential if TQM implementations are to function appropriately The need for control mechanisms is frequently overlooked, in practice.

Question 2

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

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

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

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

	Before the implementation of QMP		After the implementation
1.	5% of incoming material from suppliers scrapped due to poor receipt and storage organisation.	1.	Reduced to 3%.
2.	4% of material X input to the machine process is wasted due to processing problems.	2.	Reduced to 2.5%
3.	Inspection and storage of Material X costs Re. 1 per square metre purchased.	3.	No change in the unit rate
4.	Inspection during the production cycle, calibration checks on inspection equipment vendor rating and other checks cost Rs. 2,50,000 per period	4.	Reduction of 40% of the existing cost.
5.	Production Qty. is increased to allow for the downgrading of 12.5% of the production units at the final inspection stage. Down graded units are sold as seconds at a discount of 30% of the standard selling price.	5.	Reduction to 7.5%
6.	Production Quantity is increased to allow for return from customers (these are replaced free of charge) due to specification failure and account for 5% of units actually delivered to customer.	6.	Reduction to 2.5%
7.	Product liability and other claims by customers is estimated at 3% of sales revenue from standard product sale.	7.	Reduction to 1%.
8.	Machine idle time is 20% of Gross machine hrs used (i.e. running hour = 80% of gross/hrs.).	8.	Reduction to 12.5%.
9.	Sundry costs of Administration, Selling and Distribution total – Rs. 6,00,000 per period.	9.	Reduction by 10% of the existing.
10.	Prevention programme costs Rs. 2,00,000	10.	Increase to Rs. 6,00,000.

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

Required:

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

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

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

Answer

(a)

	Existing	After TQM Programme

i.	Total production units (Preinspection)			
	Total sales requirements	5,000		5,000
	Specification losses 5%	250	2.5%	125
		5,250		5,125
	Downgrading at inspection $\frac{12.5}{87.5} \times 5{,}250$	750	$\frac{7.5}{92.5} \times 5{,}125$	416
	Total units before inspection	6,000		5,541
ii	Purchase of material 'X'(Sq Mtr)			
	Material required to meet pre inspection production requirement 6,000 × 8 SqMtr	48,000 SqMtr	5,541×8 SqMtr	44,328 SqMtr
	Processing loss $\frac{4}{96} \times 48{,}000$	2,000	$\frac{2.5}{97.5} \times 44{,}328$	1,137
	Input to the process	50,000		45,465
	Scrapped material $\frac{5}{95} \times 50{,}000$	2,632	$\frac{3}{97} \times 45{,}465$	1,406
	Total purchases	52,632		46,871
iii	*Gross Machine Hours*			
	Initial requirements 6,000 × 0.6	3,600	5,541 × 0.5	2,771
	Idle time $\frac{20}{80} \times 3{,}600$	900	$\frac{12.5}{87.5} \times 2{,}771$	396
	Gross time	4,500		3,167

(b) **Profit and loss statement**

	Rs		*Rs*
Sales revenue 5,000 Units× Rs 1,000	50,00,000		50,00,000
Sales downgraded 750 Units×Rs 700	5,25,000	416 Units × Rs 700	2,91,200
	55,25,000		52,91,200
Costs:			
Material 52,632 Sq Mtr ×Rs 40	21,05,280	46,871Sq Mtr × Rs 40	18,74,840
Inspection and storage costs 52,632 Sq Mtr ×Re 1	52,632	46,871Sq Mtr × Re 1	46,871
Machine cost 4,500 Hrs × Rs 400	18,00,000	3,167 Hrs× Rs 400	12,66,800
Inspection and other cost	2,50,000	2,50,000 × 60%	1,50,000
Product liability (3% × 50,00,000	1,50,000	1% × 50,00,000	50,000
Sundry cost of selling, distribution and administration.	6,00,000	6,00,000 × 90%	5,40,000

Preventive programme cost	2,00,000	6,00,000
	51,57,912	45,28,511
Net profit	3,67,088	7,62,689

13

VALUE CHAIN ANALYSIS

Question 1

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

Answer

Most corporations define their mission as one of creating products and services. In contrast, the other companies are acutely aware of the strategic importance of individual activities within their value chain, They are concentrating on those activities that allow them to capture maximum value for their customers and themselves.

These firms use the value chain analysis approach to better understand which segments, distribution channels, price points. product differentiation. selling prepositions and value chain configuration will yield them the greatest competitive advantage.

The way the value chain approach helps these organizations to assess competitive advantage includes the use of following steps of analysis.

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

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

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

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

Question 2

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

Answer

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

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

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

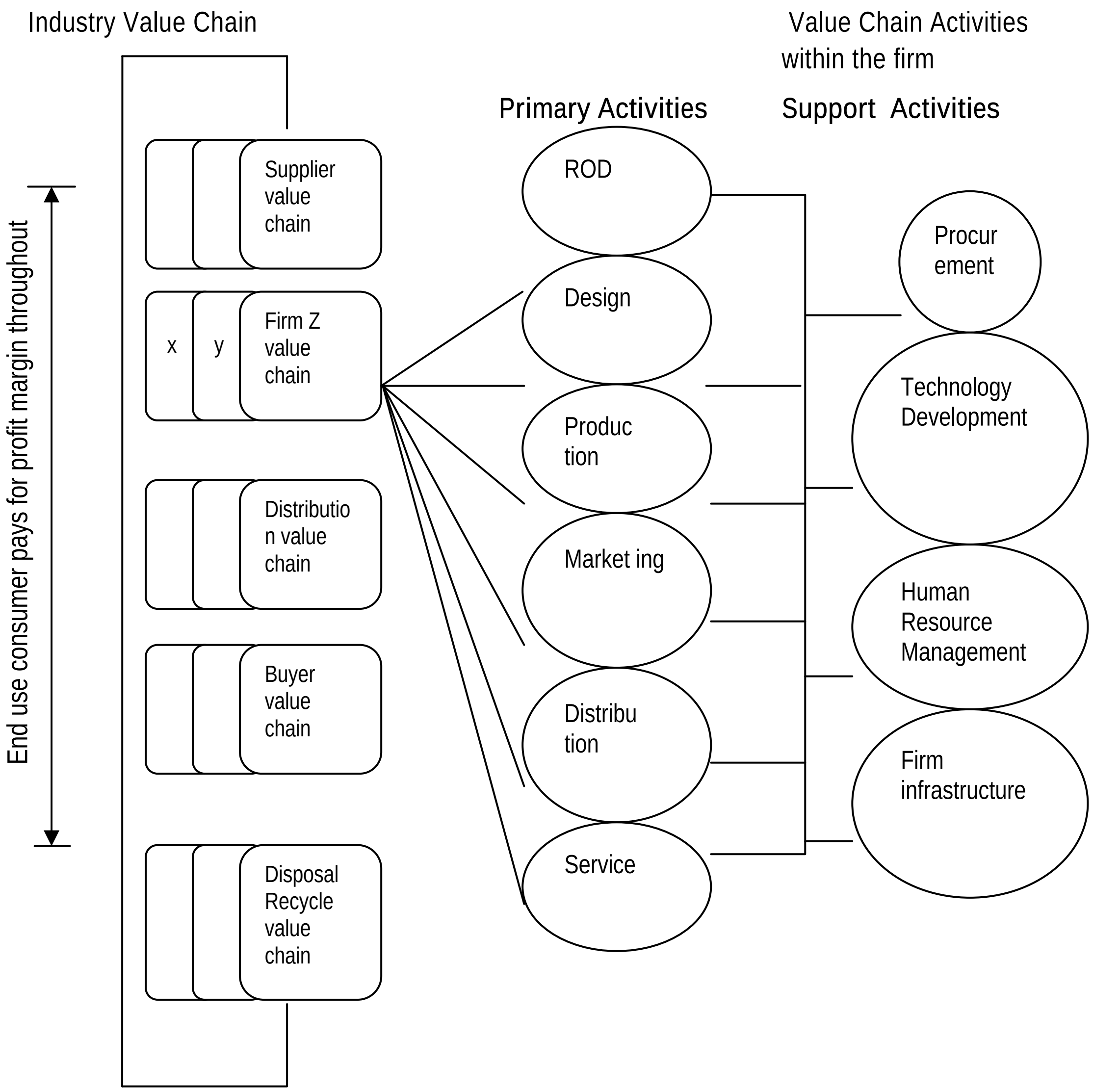
1. The firm should identify the industry value chain and then assign costs, revenues and assets to value activities.
2. Diagnose the cost drivers regulating each value activity.
3. Develop sustainable cost advantage either by controlling cost drivers better than competitors or by reconfiguring the chain value.

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

Question 3

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

Answer



14

BUDGETING CONTROL AND PERFORMANCE MANAGEMENT

Question 1

A company manufactures two products X and Y Product X requires 5 hours to produce while Y requires 10 hours. In July, 1996, of 25 effective working days of 8 hours a day, 1,000 units of X and 600 units of Y were produced. The company employees 50 workers in the production department to produce X and Y. The budgeted hours are 1,02,000 for the year.

Calculate capacity ratio, activity ratio and efficiency ratio. Also establish their inter-relationship. (Nov 1996)

Answer

Capacity Ratio $= \dfrac{\text{Actual working hours}}{\text{Budgeted working hours}} \times 100$

$= \dfrac{25 \text{ days} \times 8 \text{ hours} \times 50 \text{ workers}}{8{,}500 \text{ hours (i.e. } 102{,}000 \div 12)} \times 100$

$= (10{,}000 \div 8{,}500) \div 100 = 117.65\%$

Activity ratio $= \dfrac{\text{Actual production in standard hours}}{\text{Budgeted hours}} \times 100$

$= \dfrac{(1{,}000 \text{ units} \times 5 \text{ hours}) + (600 \text{ units} \times 10 \text{ hours})}{8{,}500} \times 100$

$= 129.41\%$

Efficiency Ratio $= \dfrac{\text{Standard hours for actual production}}{\text{Actual hours}} \times 100$

$= \dfrac{(1{,}000 \text{ units} \times 5 \text{ hours}) + (600 \text{ units} \times 10 \text{ hours})}{10{,}000} \times 100$

$= 110\%$

Inter-relationship:

Capacity ratio ÷ Efficiency ratio = Activity ratio

117.65% × 110% = 129.41%

Question 2

The Financial controller of ACE Ltd. has prepared the following estimates of working results for the year ending 31st March, 1999:

		Year ending 31.3.1999
Direct Material	*Rs. / unit*	*16.00*
Direct wages	*Rs. / unit*	*40.00*

Variable Overheads	*Rs. / unit*	*12.00*
Selling Price	*Rs. / unit*	*125.00*
Fixed Expenses	*Rs.*	*6,75,000 per annum*
Sales	*Rs*	*25,00,000 per annum*

During the 1999-2000, it is expected that the material prices and variable overheads will go up by 10% and 5 % respectively. As a result of re-engineering of business processes, the overall direct labour efficiency will increase by 12%, but the wage rate will go up by 5%. The fixed overheads are also expected to increase by Rs.1,25,000.

The Vice-President-Manufacturing states that the same level of output as obtained in 1998-1999 should be maintained in 1999-2000 also and efforts should be make to maintain the same level of profit by suitably increasing the selling price.

The Vice President-Marketing states that the market will not absorb any increase in the selling price. On the other hand, he proposes that publicity involving advertisement expenses as given below will increase the quantity of sales as under:

Advertisement Expenses (Rs.)	*80,000*	*1,94,000*	*3,20,000*	*4,60,000*
Additional units of Sales	*2,000*	*4,000*	*6,000*	*8,000*

Required:

Present an Income Statement for 1999-2000.

Find the revised price and the percentage of increase in the price for 1999-2000, if the views of the Vice-President. Manufacturing are accepted.

Evaluate the four alternative proposals put forth by the Vice-President – Marketing Determine the best output level to the budgeted and prepare an overall Income Statement for 1999-2000 at that level of output. *(May 1999)*

Answer

Working Note:

1. Number of units produced and sold for the year ending on 31st March, 1999.

$$= \frac{\text{Total sales revenue upto 31st March, 1999}}{\text{Selling price p.u.}}$$

$$= \frac{\text{Rs.25,00,000}}{\text{Rs.125 p.u.}} = 20{,}000 \text{ units}$$

2. Statement of variable cost per unit

Year	*1998-99*	*1999-2000*
	Rs.	*Rs.*
Direct material	16	17.60
		(Rs.15 + 10% × Rs.16)
Direct wages	40	37.50
		(Rs.40×100/112 × 105/100)
Variable overheads	12	12.60
		(Rs.12 + 5% × Rs.12)

Variable cost per unit	68	67.70

3. Contribution per unit during 1999-2000

   = Selling price per unit – Variable cost p.u.

   = Rs.125 – Rs.67.70 = Rs.57.30

4. Profit in 1998-1999

   Contribution per unit = S. P. (p. u.) – V. C. (p. u.)

   = Rs.125 – Rs.68 = Rs.57 p. u.

   Total contribution = Rs.11,40,000

   (20,000 units × Rs.57/- p.u.)

   Less: Fixed expenses = 6,75,000

   Profit = 4,65,000

(a) Income Statement for the year 1999-2000

	Rs.
Sales revenue	25,00,000
20,000 units × Rs.125	
Less: Variable cost	13,54,000
20,000 units × Rs.67.70	
(Refer to working note 2)	
Total contribution	11,46,000
Less: Fixed expenses	8,00,000
Profit	3,46,000

(b) Statement for determining revised price and the percentage of increase in the price for 1999-2000 based on the views of Vice President Manufacturing:

	Rs.
Variable cost	13,54,000
(20,000 units × Rs.67.70)	
Fixed expenses	8,00,000
Profit	4,65,000
(Refer working note 4)	
Desired sales revenue	26,19,000
Revised selling price (per unit)	130.95
(Rs.26,19,000/20,000 units)	

Percentage increase in selling price: $\frac{\text{Rs.130.95 - Rs.125}}{\text{Rs.125}} \times 100 = 4.76\%$

(c) Evaluation of four alternative proposals of Vice President Marketing:

Additional units of sales	2,000	4,000	6,000	8,000
	Rs.	Rs.	Rs.	Rs.
Total contribution	1,14,600	2,29,200	3,43,800	4,58,400

(Refer to working note 3)	(2,000 units × Rs.57.30)	(4,000 units × Rs.57.30)	(6,000 units × Rs.57.30)	(8,000 units × Rs.57.30)
Less: Advertisement expenses	80,000	1,94,000	3,20,000	4,60,000
Additional Profit/ (Loss)	34,600	35,200	23,800	(1,600)

Evaluation of four alternatives: Since the additional profit is maximum at the additional sales of 4,000 units, therefore the second alternative is adjudged as the best out of the four alternatives proposed by the Vice President of Marketing. Hence the concern should produce and sell 24,000 units during the year 1999-2000.

Overall Income Statement for 1999-2000

Output and sales		24,000 units
		Rs.
Sales revenue		30,00,000
24,000 units × Rs.125/-		
Less: Variable cost		
24,000 units × Rs.67.70		16,24,800
Contribution		13,75,2000
Less: Advertisement expenses	Rs.1,94,000	
Fixed expenses	Rs.8,00,000	9,94,000
Profit		3,81,200

Question 3

(a) *What are the advantages and limitations of Zero base Budgeting ?* *(4 Marks)*

(b) *What are benchmarking code of conduct ?* *(3 Marks)*

(c) *Explain briefly the main features of ERP.* *(4 Marks)*

(d) *A Company manufactures two Products A and B by making use of two types of materials, viz., X and Y. Product A requires 10 units of X and 3 units of Y. Product B requires 5 units of X and 2 units of Y. The price of X is Rs. 2 per unit and that of Y is Rs. 3 per unit. Standard hours allowed per product are 4 and 3, respectively. Budgeted wages rate is Rs. 8 per hour. Overtime premium is 50% and is payable, if a worker works for more than 40 hours a week. There are 150 workers.*

The Sales Manager has estimated the sales of Product A to be 5,000 units and Product B 10,000 units. The target productivity ratio (or efficiency ratio) for the productive hours worked by the direct worker in actually manufacturing the product is 80%, in addition, the non-productive downtime is budgeted at 20% of the productive hours worked. There are twelve 5-day weeks in the budget period and it is anticipated that sales and production will occur evenly throughout the whole period.

It is anticipated that stock at the beginning of the period will be:

Product A 800 units; Product B 1,680 units. The targeted closing stock expressed in terms of anticipated activity during the budget period are Product A 12 days sales; Product B 18 days sales. The opening and closing stock of raw material of X and Y will be maintained according to requirement of stock position for Product A and B.

You are required to prepare the following for the next period:

(i) *Material usage and Material purchase budget in terms of quantities and values.*

(ii) *Production budget.*

(iii) *Wages budget for the direct workers.* *(8 Marks)*

Answer

(a) Advantage of ZBB

(i) It provides a systematic approach for evaluation of different activities and ranks them in order of preference for allocation of scare resource.

(ii) It ensures that the various functions undertaken by the organisation are critical for the achievement of its objectives and are being performed in the best way.

(iii) It provides an opportunity to the management to allocate resources for various activities only after having a thorough cost-benefit analysis.

(iv) The area of wasteful expenditure can be easily identified and eliminated.

(v) Departmental budgets are closely linked with corporate objectives.

(vi) The technique can also be used for the introduction and implementation of the system of 'management by objective'.

Limitations of ZBB

(i) Various operational problems are likely to be faced in implementing the technique.

(ii) The full support of top management is required.

(iii) It is time consuming as well as costly.

(iv) It requires proper trained managerial staff.

(b) Benchmarking code of conduct

Bench marking is the process of identifying and learning from the best practices anywhere in the world. It is a powerful tool for continuous improvement. To contribute to efficient, effective and ethical bench marking, individuals agree for themselves and their organisation to be abided by the following principles for the benchmarking with other organisations.

Suggested benchmarking code of conduct:

(i) Principle of legality

(ii) Principle of exchange

(iii) Principle of confidentiality

(iv) Principle of use

(v) Principle of first party contact

(vi) Principle of third party contact

(vii) Principle of preparation

(c) Features of ERP

- It facilitates company wide integrated information systems covering all functional areas like manufacturing, purchase, payables, inventory etc.
- It performs core activities and increases customer services thereby projecting and enhancing the corporate image.
- It bridges the information gap across organisations.
- It offers a solution to better project management.
- It allows automatic introduction of the latest technologies like Electronic Fund Transfer, Internet, Video Conferencing etc.
- It eliminates business problems like shortage of material, inventory problems etc.
- It provides for improving and refining the business process.

- It provides complete integration of systems, not only across departments, but also across the companies under same management.

(d) (i) Material usage budget

	Products A (units)	*Products B (units)*	*Total material usage units*	*Cost per unit (Rs)*	*Total cost of materials (Rs)*
Estimated sales	5,000	10,000			
Material X : 10 units per product A and 5 units per product B	50,000	50,000	1,00,000	2	2,00,000
Material Y : 3 units per product A and 2 units per product B	15,000	20,000	35,000	3	1,05,000
Total	65,000	70,000	1,35,000		3,05,000

Material Purchase Budget

	X Units	*Y Units*	*Total*
Required for sales	1,00,000	35,000	
Add: desired closing stock			
Product A:			
1,000 units (A) × 10 units (X) =10,000 units of X 3,000 units (B) × 5 units (X) =15,000 units of X.	25,000		
Product B:		9,000	
1,000 units (A) × 3 units (Y) = 3000 units of Y 3,000 units (B) × 2 units (Y) = 6,000 units of Y.			
	1,25,000	44,000	
Less: Opening stock			
Product A:			
800 units (A) × 10 units (X) = 8,000 units of X 1,680 units (B) × 5 units (X) = 8,400 units of X	16,400		
Product B			
800 units (A) × 3 units (Y) = 2,400 units of Y 1,680 units (B) × 2 units (Y) = 3,360 units of Y.		5,760	
Units to be purchased	1,08,600	38,240	1,46,840

Cost per unit	Rs.2	Rs.3	
Cost of purchase (Rs.)	2,17,200	1,14,720	3,31,920

(ii) Production Budget

	Product A	*Product B*
	Units	*Units*
Sales	5,000	10,000
Add: Closing stock**	1,000	3,000
	6,000	13,000
Less: Opening stock	800	1,680
Production	5,200	11,320

**Calculation of closing stock:

Budgeted period is 12 weeks of 5 days each =60 days.

Product A = $\frac{5{,}000 \times 12}{60}$ =1,000 units

Product B = $\frac{10{,}000 \times 18}{60}$ =3,000 units

(iii) Wages budget for direct workers

	Product A	*Product B*	*Total*
	(hrs)	*(hrs)*	*(hrs.)*
Standard hours (budgeted)			
5,200 units (A) × 4 hours per unit and 11,320 units (B) × 3 hours per unit.	20,800	33,960	54,760
Standard hours at 80% efficiency ratio			68,450
Add: non productive time (20% of 68,450)			13,690
			82,140
Labour hours required (150 workers × 8 hours per day × 60 days)			72,000
Overtime			10,140

Wages for normal hours(72,000 × 8) = Rs 5,76,000

Wages for overtime (10,140 × 8 × 1.5) = Rs 1,21,680

Total wages = Rs 6,97,680

Question 4

A company manufactures two products X and Y. Product X requires 8 hours to produce while Y requires 12 hours. In April, 2004, of 22 effective working days of 8 hours a day, 1,200 units of X and 800 units of Y were produced. The company employs 100 workers in production department to produce X and Y. The budgeted hours are 1,86,000 for the year.

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

Answer

			Standard hours produced
	Product X	*Product Y*	*Total*
Out put (units)	1,200	800	

Hours per unit	8	12	
Standard hours	9,600	9,600	19,200

Actual hours worked

100 workers $\times$8 hours $\times$ 22 days =	17,600

Budgeted hours per month

1,86,000/12 =	15,500

Capacity Ratio = $\frac{\text{actual hours}}{\text{Budgeted hours}} \times 100 = \frac{17{,}600}{15{,}500}$ = 113.55 %

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

Activity Ratio = $\frac{\text{Standard Hours Produced}}{\text{Budget hours}} \times 100 = \frac{19{,}200}{15{,}500} \times 100$ 123.87%

Relationship : Activity Ratio = Efficiency Ratio $\times$ Capacity Ratio

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

Question 5

"Balanced score card and performance measurement system endeavours to create a blend of strategic measures, outcomes and drive measures and internal and external measures". Discuss the statement and explain the major components of a balanced score card.

Answer

The balanced score card translates an organization's mission and strategy into a comprehensive set of performance measures that provides the framework for implementing its strategy. The balanced score card does not focus solely on achieving financial objectives. It is an approach, which provides information to management to assist in strategic policy formulation and achievement. It emphasizes the need to provide the user with a set of information, which addresses all relevant areas of performance in an objective and unbiased manner. As a management tool it helps companies to assess overall performance, improve operational processes and enables management to develop better plans for improvements.

Major components of a balanced scorecard - The components of balanced score cards varies form business to business. A well designed balanced scorecard combines financial measures of post performance with measures of firm's drivers of future performance. The specific objectives and measures of an organization-balanced scorecard can be derived from the firm's vision and strategy. Generally, balanced score card has the following four perspectives from which a company's activity can be evaluated.

(i) *Financial perspective:* Financial perspective measures the results that the organization delivers to its stakeholders. The measures are: operating income, revenue growth, revenues from new products, gross margin percentage, cost reduction in key areas, economic value added, return on investment.

(ii) *Customer perspective:* The customer perspective considers the business through the eyes of customers, measuring and rejecting upon customer satisfaction.

The measures are: - market share. customer satisfaction, customer retention percentage, time taken to fulfil customer's requests.

(iii) *Internal business perspective:* The internal perspective focuses attention on the performance of the key internal processes, which drive the business such as innovative process, operation process and post-sales services.

(iv) *Learning & growth perspective*: The measure are:- employee education & skills levels, employee turnover ratio, information system availability, percentage of employee suggestion implemented etc.

Question 6

"Because a single budget system is normally used to serve several purposes, there is a danger that they may conflict with each other". Do you agree? Discuss.

Answer

A single budget system may be conflicting in planning and motivation, and planning and performance evaluation roles as below:

(i) Planning and motivation roles – Demanding budgets that may not be achieved may be appropriate to motivate maximum performance but they are unsuitable for planning purposes. For these, a budget should be a set based on easier targets that are expected to be met.

(ii) Planning and performance evaluation roles - For planning purposes budgets are set in advance of the budget period based on an anticipated set of circumstances or environment. Performance evaluation should be based on a comparison of active performance with an adjusted budget to reflect the circumstance under which managers actually operated.

Question 7

Kitchen King Company makes a high-end kitchen range hood 'Maharaja'. The company presents the data for the year 2003 and 2004:

		2003	*2004*
1.	*Units or maharaja produced and sold*	*40,000*	*42,000*
2.	*Selling Price per unit in Rs.*	*1,000*	*1,100*
3.	*Total Direct Material (Square feet)*	*1,20,000*	*1,23,000*
4.	*Direct material cost per square feet in Rs.*	*100*	*110*
5.	*Manufacturing Capacity (in units)*	*50,000*	*50,000*
6.	*Total Conversion cost in Rs.*	*1,00,00,000*	*1,10,00,000*
7.	*Conversion cost per unit of capacity (6)/(5)*	*200*	*220*
8.	*Selling and customer service capacity*	*300 customer*	*290 customer*
9.	*Total selling and customer service cost in Rs.*	*72,00,000*	*72,50,000*
10.	*Cost per customer of selling and customer service capacity (9)/(8)*	*24,000*	*25,000*

Kitchen King produces no defective units, but it reduces direct material used per unit in 2004. Conversion cost in each year depends on production capacity defined in terms of Maharaja units that can be produced. Selling and Customer service cost depends on the number of customers that the selling and service functions are designed to support. Kitchen King has 230 customers in 2003 and 250 customers in 2004.

You are required

1. *Describe briefly key elements that would include in Kitchen King's Balance Score Card.*

2. *Calculate the Growth, Price-recovery and productivity component that explain the change in operating income from 2003 to 2004.*

Answer

Kitchen King's Score card should describe its product differentiation strategy. The key points that should be included in its balance score card are

- Financial Perspective – Increase in operating income by charging higher margins on Maharaja.
- Customer Perspective – Market share in high-end kitchen range market and customer satisfaction.
- Internal business Perspectives: Manufacturing quality, order delivery time, on time delivery and new product feature added.
- Learning and Growth Perspective: Development time for designing new end product and improvement in manufacturing process.

Operative Income:

	(Amount in 000 Rs.)	
	2003	2004
Revenue (40000×1000: 42000×1100)	40000	46200
Direct Material	12000	13530
Conversion cost	10000	11000
Selling and Customer service	7200	7250
Total cost	29200	31780
Operative Income	10800	14420

Change in operating Income 36, 20,000 (F)

A. Growth Component

(a) Revenue effect = Output Price in 2003{Actual units sold in 04 – Actual units sold in 03}

= Rs1, 000 (42,000 units – 40,000 units) = Rs20, 00,000 (F)

(b) The cost effect = Input price in 2003{Actual units of input to produce 2003 output less Actual units of input which would have been used to produce year 2004 output on the basis of 2003}

(i) Direct Material = Rs100 [1, 20,000sqft – 1, 20,000sqft × $\frac{42{,}000\text{ units}}{40{,}000\text{ units}}$] = Rs6, 00,000 (A)

(ii) Conversion cost and selling and customer service will not change since adequate capacity exists in 2003 to support 2004 output and customers. Hence variance

Conversion cost = 200(50000 – 50000) = 0

S & Customer Service = 25000 (300 – 300) = 0

Increase in operating effect of Growth component is Rs14, 00,000 (F)

B Price recovery Component:

(i) Revenue effect = Actual output in 2004 [Selling price per unit in 2004 less Selling price per unit in 2003]

= 42,000units (Rs1, 100 – Rs1, 000) = Rs42, 00,000 (F)

(ii) Cost effect = Unit of input based on 2003 actual that would have been used to produce 2004 output {Input prices per unit in 2003 less Input prices per unit in 2004}

(a) Direct material = 1, 26,000sqft (Rs100/sqft – Rs110/sqft)=Rs12, 60,000 (A)

(b) Conversion Cost = 50,000 units (Rs200/unit –Rs220/unit)
= Rs10, 00,000(A)

(c) S & Custr Service = 300 customers (Rs24, 000 –Rs25,000)
= Rs3,00,000 (A) = Rs 25, 60,000 (A)

Increase in Operating income due to Price Recovery is Rs16, 40,000 (F) {Rs42, 00,000 – Rs25, 60,000}

C Productivity Component

Productivity component = Input Prices in 04{Actual units of input which would have been used to produce year 2004 output on the basis of 2003 actual less Actual Input}

(i) Direct Material: Rs110/sqft (1, 26,000 units – 1, 23,000 units) = Rs3, 30,000(F)

(ii) Conversion Cost: Rs200/unit (50,000 units – 50,000 units) = 0

(iii) Selling & Customer = Rs25, 000 (300 customers – 290 customers) = Rs2,50,000 (F)

= Rs 5,80,000 (F)

The change in operating income from 2003 to 2004 is analysed as follows:

(Amount in 000 Rs.)

	2003	*Growth component*	*Price recovery*	*Cost effect of productivity component*	*2004*
Revenue	40000	2000 (F)	4200 (F)	------------	46200
Cost	29200	600 (A)	2560 (A)	580 (F)	31780
Operating Income	10800	1400(F)	1640 (F)	580 (F)	14420

Question 8

What are the elements of a Balanced Score card? Also explain how it can be used as a Financial Planning model.

Answer

The elements of a balanced score card are:

(i) Financial perspective

(ii) Customer perspective

(iii) Internal business process perspective

(iv) Learning and growth perspective.

The objective of the balanced score card is to provide a comprehensive framework for translating the company's strategic objectives into a coherent set of performance measures. It emphasizes the use of financial and non-financial measures as part of the programme to achieve future financial performance. It helps in planning, setting targets and aligning strategic initiatives.

To evaluate the success of the implementation of the strategy, the company can assess the change in the operating income by comparing the targeted operating income with the actual operating income. The change in the operating income may arise due to growth factor, change in the price of inputs and outputs and productivity factor. The company is said to be successful in implementation of strategy only if the change in the operating income closely aligns with that strategy.

Question 9

A Company is engaged in manufacturing two products 'X' and 'Y'. Product X uses one unit of component 'P' and two units of component 'Q'. Product 'Y' uses two units of component 'P', one unit of component 'Q' and two units of component 'R'. Component 'R' which is assembled in the factory uses one unit of component 'Q'.

Component 'P' and 'Q' are purchased from the market. The company has prepared the following forecast of sales and inventory for the next year:

	Product 'X'	*Product 'Y'*
Sales (in units)	*80,000*	*1,50,000*
At the end of the year	*10,000*	*20,000*
At the beginning of the year	*30,000*	*50,000*

The production of both the products and the assembling of the component 'R' will be spread out uniformly throughout the year. The company at present orders its inventory of 'P' and 'Q' in quantities equivalent to 3 months production. The company has compiled the following data related to two components:

	P	*Q*
Price per unit (Rs.)	*20*	*8*
Order placing cost per order (Rs.)	*1,500*	*1,500*
Carrying cost per annum	*20%*	*20%*

Required:

(a) Prepare a Budget of production and requirements of components during next year.

(b) Suggest the optimal order quantity of components 'P' and 'Q'.

Answer

(a) Production Budget for product X and Y

	X units	Y units
Inventory at the end of the year	10,000	20,000
Sales forecast	80,000	1,50,000
Total requirements	90,000	1,70,000
Less: Beginning inventory	30,000	50,000
Production	60,000	1,20,000

Budgeted requirements of components P, Q and R

Components	P	Q	R
For Product X: Production 60,000 units			
P: 60,000 × 1 per unit	60,000		
Q: 60,000 × 2 per unit		1,20,000	
For Product Y: Production 1,20,000 units			
P: 1,20,000 × 2 per unit	2,40,000		
Q: 1,20,000 × 1 per unit		1,20,000	
R: 1,20,000 × 2 per unit			2,40,000
For comp R: Production 2,40,000 comp			
Q: 2,40,000 × 1 per component R		2,40,000	
Total requirements	3,00,000	4,80,000	2,40,000

(b) The company is advised to adopt EOQ system.

P

$$\text{EOQ} \sqrt{\frac{2\times 3{,}00{,}000\times 1{,}500}{20\times 20\%}} = 15000 \text{ components}$$

Q

$$\sqrt{\frac{2\times 4{,}80{,}000\times 1{,}500}{8\times 20\%}} = 30000 \text{ components}$$

15

LINEAR PROGRAMMING

Question 1

A farm is engaged in breeding pigs. The pigs are fed on various products grown in the farm. In view of the need to ensure certain nutrient constituents (call them X, Y and Z), it becomes necessary to buy two additional products say, A and B. One unit of product A contains 36 units of X, 3 units of Y and 20 units of Z. One unit of product B contains 6 units of X, 12 units of Y and 10 units of Z. The minimum requirement of X, Y and Z is 108 units, 36 units and 100 units respectively. Product A costs Rs.20 per unit and product B Rs.40 per unit.

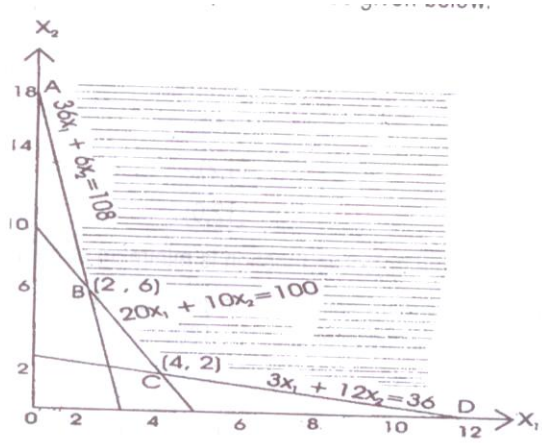
Formulate the above as a linear programming problem to minimize the total cost and solve this problem by suing graphic method. *(May 2002)*

Answer

The data of the given problem can be summarized as under:

Nutrient constituents	*Nutrient content in product*		*Minimum requirement of nutrient*
	A	*B*	
X	36	06	108
Y	03	12	36
Z	20	10	100
Cost of product	Rs.20	Rs.40	

Let x_1 units of product A and x_2 units of product B are purchased. Making use of the above table, the required mathematical formulation of L.P. problem is as given below:



Minimize $Z = 20x_1 + 40x_2$ subject to the constraints

$36x_1 + 6x_2 \geq 108$

$3x_1 + 12x_2 \geq 36$

$20x_1 + 10x_2 \geq 100$

and $x_1, x_2 \geq 0$

For solving the above problem graphically, consider a set of rectangular axis x_1ox_2 in the plane. As each point has the coordinates of type (x_1, x_2), any point satisfying the conditions $x_1 \geq 0$ and $x_2 \geq 0$ lies in the first quadrant only.

The constraints of the given problem as described earlier are plotted by treating them as equations:

36x1 + 6x2 = 108

3x1 + 12x2 = 36

20x1 + 10x2 = 100

Or

$$\frac{x_1}{2} + \frac{x_2}{18} = 1$$

$$\frac{x_1}{12} + \frac{x_2}{3} = 1$$

$$\frac{x_1}{5} + \frac{x_2}{10} = 1$$

The area beyond these lines represents the feasible region in respect of these constraints, any point on the straight lines or in the region above these lines would satisfy the constraints. The coordinates of the extreme points of the feasible region are given by

A = (0,18), B = (2,6), C = (4,2) and D = (12,0)

The value of the objective function at each of these points can be evaluated as follows:

Extreme Point	(x1, x2)	Z = 20x1 + 40x2	
A	(0,18)	720	
B	(2,6)	280	
C	(4,2)	160	Minimum ←
D	(12,0)	240	

The value of the objective function is minimum at the point C (4,2).

Hence, the optimum solution in to purchase 4 units of product A and 2 units of product B in order to have minimum cost of Rs.160.

Question 2

A Sports Club is engaged in the development of their players by feeding them certain minimum amount of Vitamins (say A, B and C), in addition to their normal diet. In view of this, two types of products X and Y are purchased from the market. The contents of Vitamin constituents per unit, are shown in the following table:

Vitamin Constituents	*Vitamin contents in products*		*Minimum requirement for each player*
	X	*Y*	
A	*36*	*06*	*108*
B	*03*	*12*	*36*

C	*20*	*10*	*100*

The cost of product X is Rs.20 and that of Y is Rs.40.

Formulate the linear programming problem for the above and minimize the total cost, and solve problem by using graphic method.

Answer

Let x & y quantity of X & Y product is purchased respectively.

Minimize Z = 20x + 40y

Subject to the conditions

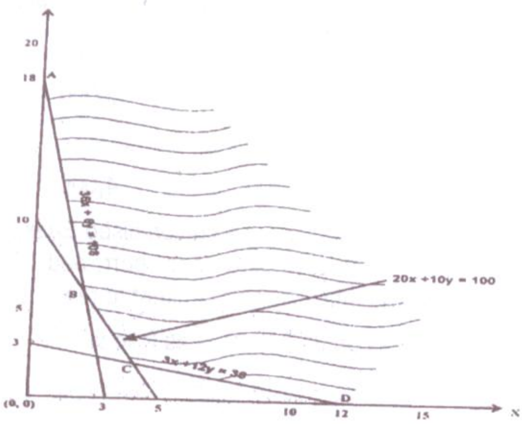
36x + 6y ≥ 108

3x + 12y ≥ 36

20x + 10y ≥ 100

and x, y ≥ 0

For finding the solution, we plot above equations on x – y plane as shown below



The feasible region is represented by the shaded area.

The extreme points are A, B, C & D which have the coordinates as

A = (0,18)

B = (2,6)

C = (4,2)

D = (12,0)

Extreme point	*(x, y)*	*Value ofz = 20x + 40y at extreme point*
A	(0, 18)	720
B	(2, 6)	280
C	(4, 2)	160 ← Minimum
D	(12, 0)	240

Hence, the optimal solution is to purchase 4 units of product X and 2 units of product Y in order to maintain a minimum cost of Rs.160/-.

Question 3

A Computer Company produces three types of models, which are first required to be machined and then assembled. The time (in hours) for these operations for each model is give below:

Model	*Machine Time*	*Assembly Time*
P III	*20*	*5*
P II	*15*	*4*
Celeron	*12*	*3*

The total available machine time and assembly time are 1,000 hours and 1,500 hours respectively. The selling price and other variable costs for three models are:

	P III	*P II*	*Celeron*
Selling Price (Rs.)	*3,000*	*5,000*	*15,000*
Labour, Material and other Variable Costs (Rs.)	*2,000*	*4,000*	*8,000*

The company has taken a loan of Rs.50,000 from a Nationalised Bank, which is required to be repaid on 1.4.2001. In addition, the company has borrowed Rs.1,00,000 from XYZ Cooperative Bank. However, this bank has given its consent to renew the loan.

The balance sheet of the company as on 31.3.2001 is as follows:

Liabilities	*Rs.*	*Assets*	*Rs.*
Equity Share Capital	*1,00,000*	*Land*	*80,000*
Capital reserve	*20,000*	*Buildings*	*50,000*
Profit & Loss Account	*30,000*	*Plant & Machinery*	*1,00,000*
Long-term Loan	*2,00,000*	*Furniture etc.*	*20,000*
Loan from XYZ Cooperative Bank	*1,00,000*	*Cash*	*2,10,000*
Loan from Nationalized Bank	*50,000*		
Total	*5,00,000*	*Total*	*5,00,000*

The company is required to pay a sum of Rs.15,000 towards the salary. Interest on long-term loan is to be paid every month@ 18% per annum. Interest on loan from XYZ Cooperative and Nationalised Banks may be taken as Rs.1,500 per month. The company has already promised to deliver three P III, Two P II and five Celeron type of computers to M/s. ABC Ltd. next month. The level of operation I the company is subject to the availability of cash next month.

The Company Manager is willing to know that how many units of each model must be manufactured next month, so as to maximize the profit.

Formulate a linear programming problem for the above. *(May 2001)*

Answer

Let X_1, X_2 and X_3 denote the number of P III, P II and Celeron computers respectively to be manufactured in the company. The following data is given:

	P III	P II	Celeron
Selling price per unit (Rs.)	3,000	5,000	15,000
Labour Material & other Variable	2,000	4,000	8,000

cost per unit (Rs.)			
Profit per unit (Rs.)	1,000	1,000	7,000

Since the company wants to maximize the profit, hence the objective function is given by:

Maximize $Z = 1{,}000X_1 + 1{,}000X_2 + 7{,}000X_3 - (\text{Rs.}15{,}000+3{,}000+\text{Rs.}1{,}500)$

From the data given for time required for various models and the total number of hours available for machine time and assembly time, we get the following constraints:

$20X_1 + 15X_2 + 12X_3 \leq 1{,}000$ (Machine Time Restriction)

$5X_1 + 4X_2 + 3X_3 \leq 1{,}500$ (Assembly Time Restriction)

The level of operations in the company is subject to availability of cash next month i.e.; the cash required for manufacturing various models should not exceed the cash available for the next month.

The cash requirements for X_1 units of P III, X_2 units of P II and X_3 units of Celeron computers are:

$2{,}000\ X_1 + 4{,}000\ X_2 + 8{,}000\ X_3$ ……(1)

The cash availability for the next month from the balance sheet is as below:

Cash availability (Rs.) = Cash balance (Rs.2,10,000)

- Loan to repay to Nationalized Bank (Rs.50,000)
- Interest on loan from XYZ Cooperative bank and Nationalized bank (Rs.1,500)
- Interest on long term loans $\left(\frac{0.18 \times 2{,}00{,}000}{12}\right)$
- Salary to staff (Rs.15,000)

or, Cash availability = Rs.2,10,000 – (Rs.50,000 + Rs.1,500 + Rs.3,000 +15,000)

= Rs.1,40,500 ……(2)

Thus, from (1) and (2),

$2{,}000\ X_1 + 4{,}000\ X_2 + 8{,}000\ X_3 \leq \text{Rs.}1{,}40{,}500$

The company has also promised to deliver 3 P III, 2 P II and 5 Celeron computers to M/s Kingspen Ltd.

Hence, $X_1 \geq 3$, $X_2 \geq 2$, $X_3 \geq 5$

The LP formulation of the given problem is as follows:

Maximize $Z - 1{,}000\ X_1 + 1{,}000\ X_2 + 7{,}000\ X_3 - (\text{Rs.}15{,}000 + \text{Rs.}3{,}000 + \text{Rs.}1{,}500)$

Subject to the constraints:

$20\ X_1 + 15\ X_2 + 12X_3 \leq 1{,}000$

$5\ X_1 + 4\ X_2 + 3\ X_3 \leq 1{,}500$

$2{,}000\ X_1 + 4{,}000\ X_2 + 8{,}000\ X_3 \leq \text{Rs.}1{,}40{,}500$

$X_1 \geq 3$, $X_2 \geq 2$, $X_3 \geq 5$

X_1, X_2 and X_3 can take only positive integral values.

Question 4

A manufacturer produces three products Y_1, Y_2, Y_3 from three raw materials X_1, X_2, X_3. The cost of raw materials X_1, X_2 and X_3 is Rs.30, Rs.50 and Rs.120 per kg respectively and they are available in a limited quantity viz 20 kg of X_1, 15 kg of X_2 and 10 kg of X_3. The selling price of Y_1, Y_2 and Y_3 is Rs.90, Rs.100 and

Rs.120 per kg respectively. In order to produce 1 kg of Y_1, ½ kg of X_1, ¼ kg of X_2 and ¼ kg of X_3 are required. Similarly to produce 1 kg of Y_2, 3/7 kg of X_1, 2/7 kg of X_2 and 2/7 kg of X_3 and to produce 1 kg Y_3, 2/3 kg of X_2 and 1/3 kg of X_3 will be required.

Formulate the linear programming problem to maximize the profit. *(Nov 2000)*

Answer

The information given in the question can be presented in the following tabular form.

Products	*Raw material (in kg) required to produce one kg of product* X_1	X_2	X_3	*Selling price (per kg)*
Y_1	1/2	1/4	1/4	Rs.90
Y_2	3/7	2/7	2/7	Rs.100
Y_3	--	2/3	1/3	Rs.120
Cost of raw material (Per kg)	Rs.30	Rs.50	Rs.120	
Availability of raw material	20 kg	15 kg	10 kg	

From the above table, the cost of producing 1 kg of Y_1, Y_2 and Y_3 can be calculated as given below:

Cost to produce 1 kg of Y_1 = ½ Rs.30 + ¼ Rs.50 + Rs.120

= Rs.15 + Rs.12.50 + Rs.30

= Rs.57.50

$\therefore$ Profit per kg of Y_1 = Rs.90 – Rs.57.50 = Rs.32.50

Similarly, cost to produce 1 kg of Y_2 = 3/7 Rs.30 + 2/7 Rs.50 + Rs.120

= 1/7 (Rs.90 + Rs.100 + Rs.240)

= Rs.430/7 = Rs.61.43

Profit per kg of Y_2 = Rs.100 – Rs.61.43 = Rs.38.57

and cost to produce 1 kg of Y_3 = 2/3 Rs.50 + 1/3 Rs.120 = Rs.220/3 = Rs.73.33

Profit per kg of Y_3 = Rs.120 – Rs.73.33 = Rs.46.67

Let the manufacturer produce y_1, y_2 and y_3 units of the products Y_1, Y_2 and Y_3 respectively.

Since the manufacturer wants to maximise the profit, the objective function is given by

Maximise $Z = 32.50\, y_1 + 38.57\, y_2 + 46.67\, y_3$

$\frac{1}{2} y_1 + 3/7\, y_2 \leq 20$ or $7 y_1 + 6 y_2 \leq 280$

$\frac{1}{4} y_1 + 2/7\, y_2 + 2/3\, y_3 \leq 15$ or $21 y_1 + 24 y_2 + 56 y_3 \leq 1{,}260$

$\frac{1}{4} y_1 + 2/7\, y_2 + 1/3\, y_3 \leq 10$ or $21 y_1 + 24 y_2 + 28 y_3 \leq 840$

where Y_1, Y_2 and $Y_3 \geq 0$

Question 5

Write short notes on applications and limitation of Linear Programming Techniques. (Nov 2000)

Answer

Application of Liner Programming: Linear programming was developed from 1947 onwards as a tool for finding optimal solutions to military planning problems. The early applications were restricted to problems involving military operations such as logistics, transportation and procurement, successful military applications led to business uses. Present day users range from agriculture, business and industry to government with the most extensive applications being those in industry and commerce. For example, problems involving blending of petroleum, animal feed blending, production planning and inventory control, problems determining optimal product mix, problems dealing with training and assignment of personnel, transport of commodities and allocation of funds are some of the areas of business applications of linear programming.

Limitations of Linear Programming: Important limitations of linear programming problems are as follows:

(a) A primary requirement of linear programming is that the objective function and every constraint function must be linear. This requires that the measure of effectiveness and resource usage must be proportional to the level of each activity conducted individually. However, programming problems which are non-linear arise quite frequently. It is occasionally possible to reformulate a non-linear programming problem into the linear programming format so that the simplex method can be used. This, however, is the fortunate exception rather than the rule.

(b) It may not be possible to solve those problems using linear programming in which non-linearity arises because of joint interactions between some of the activities regarding the total measure of effectiveness or total usage of some resource. Hence, linear programming problem requires that the total measure of effectiveness and total resource usage resulting from the joint performance of the activities must equal the respective sums of these quantities resulting from each activity being performed individually.

    In some situations, it may not be true. For example, consider a situation where a by-product is produced with the scrap material from two primary products. The material would still have to be produced it only one of the two products were produced. However, the total material requirements if both products are produced is less than the sum of requirements if each were produced individually. It may not be possible to handle such situations with linear programming problems.

(c) In linear programming problem, fractional values are permitted for the decision variables. However, many decision problems require that the solution for decision variables should be obtained in non-fractional values. Rounding-off the values obtained by linear programming techniques may not result into an optimal solution in such cases.

(d) In linear programming problems, coefficients in the objective function and the constraint equations must be completely known and they should not change during the period of study i.e. they should be known constraints. In practical situation, it may not be possible to state all coefficients in the objective function and constraints with certainty. Furthermore, these coefficients may actually be random variables, each with an underlying probability distribution for the values. Such problems cannot be solved suing linear programming.

Question 6

In a chemical industry two products A and B are made involving two operations. The production of B also results in a by-product C. The product A can be sold at a profit of Rs.3 per unit and B at a profit of Rs.8 per unit. The by-product C has a profit of Rs.2 per unit. Forecast show that upto 5 units of C can be sold. The company gets 3 units of C for each unit of B produced. The manufacturing times are 3 h per unit and on each of the operation one and two and 4 h and 5 h per unit for B on operation one and two respectively. Because the product C results from producing B, no time is used in producing C. The available times are 18 h and 21 h of operation one and two respectively. The company desires to know that how much A and B should be produced keeping c in mind to make the highest profit. Formulate LP model for this problem. (May 2000)

Answer

Let x1, x_2 x_3 be the number of units produced of products A, B and C respectively.

Then the profit gained by the industry is given by

$Z = 3x_1 + 8x_2 + 2x_3$

Here it is assumed that all the units of products A and B are sold.

In first operation, A takes 3 h of manufacturer's time and B takes 4 h of manufacturer's time. Therefore, total number of hours required in first operation becomes.

$3x_1 + 4x_2$

In second operation, per unit of A takes 2 h of manufacturer's time and per unit B takes 5 h of manufacturer's time. Therefore, the total number of hours used in second operation becomes

$3x_1 + 5x_2$

Since there are 18 h available in first operation and 21 h in second operation, the restrictions become

$3x_1 + 4x_2 \le 18$ …… (1)

$3x_1 + 5x_2 \le 21$ …… (2)

Since the maximum number of units of C that can be sold is 5, therefore,

$X_3 \le 5$ …… (3)

Further, the company gets three units of by product C for every unit of product B produced, therefore

$X_3 = 3x_2$ …… (4)

Now, the allocation problem of the industry can be finally put in the following linear programming problem:

Maximise $Z = 3x_1 + 8x_2 + 2x_3$

Subject to the constraints

$3x_1 + 4x_2 \le 18$

$3\ x_1 + 5x_2 \le 21$

$x_3 \le 5,\ x_3 = 3x_2$

$x_1,\ x_2,\ x_3 = 0$

Question 7

An advertising firm desires to reach two types of audiences – customers with annual income of more than Rs.40,000 (target audience A) and customers with annual income of less than Rs.40,000 (target audience B). The total advertising budget is Rs.2,00,000. One programme of T.V. advertising costs Rs.50,000 and one programme of Radio advertising costs Rs.20,000. Contract conditions ordinarily require that there should be at least 3 programmes on T.V. and the number of programmes on Radio must not exceed 5. Survey indicates that a single T.V. programme reaches 7,50,000 customers in target audience A and 1,50,000 in target audience B. One Radio programme reaches 40,000 customers in target audience A and 2,60,000 in target audience B.

Formulate this as a linear programming problem and determine the media mix to maximize the total reach using graphic method. (Nov 1999)

Answer

Let x_1 be the number of programmes of T.V. advertising and x_2 denote the number of programmes of radio advertising.

One T.V. programme reaches 7,50,000 customers in target audience A and 1,50,000 customers in target audience B, whereas one radio programme reaches 40,000 customers in target audience A and 2,60,000 in target audience B. Since the advertising firm desires to determine the media mix to maximise the total reach, the objective function in given by

Maximise $Z = (7{,}50{,}000 + 1{,}50{,}000)\ x_1 + (40{,}000 + 2{,}60{,}000)\ x_2$

or Maximise $Z = 9{,}00{,}000\ x_1 + 3{,}00{,}000\ x_2$

One programme of T.V. advertising costs Rs.50,000 and that of Radio advertising cots Rs.20,000. The total advertising budget is Rs.2,00,000.

Hence, $50{,}000\ x_1 + 20{,}000\ x_2 \leq 2{,}00{,}000$

Or $5x_1 + 2x_2 \leq 20$

Contract conditions require that there should be atleast 3 programmes on T.V. and the number of programmes on Radio must not exceed 5.

Therefore, $x_1 \geq 3$

$X_2 \leq 5$

The linear programming model for the given problem is

Maximise $Z = 9{,}00{,}000 + 3{,}00{,}000\ x_2$

Subject to the constraints

$5x_1 + 2\ x_2 \leq 20$

$X_1 \geq 3$

$X_2 \leq 5$

where $x_1, x_2 \geq 0$

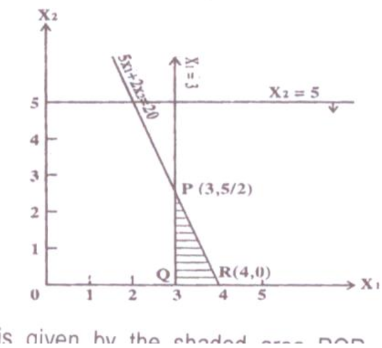
Point of intersection for lines $x_1 = 3$ and $5x_1 + 2x_2 = 20$ is P (3, 5/2).

Similarly, lines $x_2 = 5$ and $5x_1 + 2x_2 = 20$ intersect at point (2, 5).

Line $x_1 = 0$ meets $5x_1 + 2x_2 = 20$ at point (0, 10)

Line $x_2 = 0$ meets $5x_1 + 2x_2 = 20$ at point Q (4, 0)

The graphical solution for the problem is given below



The feasible region is given by the shaded area PQR, and the feasible points are P (3, 5/2), Q (3, 0) and R (4, 0).

Value of the objective function Z ar P (3, 5/2) is

$9{,}00{,}000 \times 3 + 3{,}00{,}000 \times 5/2 = 27{,}00{,}000 + 7{,}50{,}000 = 34{,}50{,}000$

Value of Z at Q (3,0) is

$9{,}00{,}000 \times 3 = 27{,}00{,}000$

and value of Z at R (4,0) is given by

9,00,000 × 4 = 36,00,000

It can be seen that the value of Z is maximum at point R (4,0). Thus, the solution to he given problem is:

$X_1 = 4$, $x_2 = 0$ and Maximum Z = 36,00,000.

In other words, the advertising firm should give 4 programmes on TV and no programme on Radio in order to achieve a maximum reach of 36,00,000 customers.

Question 8

Let us assume that you have inherited Rs.1,00,000 from your father-in-law that can be invested in a combination of only two stock portfolios, with the maximum investment allowed in either portfolio set at Rs.75,000. The first portfolio has an average rate of return of 10%, whereas the second has 20%. In terms of risk factors associated with these portfolios, the first has a risk rating of 4 (on a scale from 0 to 10), and the second has 9. Since you wish to maximize your return, you will not accept an average rate of return below 12% or a risk factor above 6. Hence, you then face the important question. How much should you invest in each portfolio?

Formulate this as a Linear Programming Problem and solve it by Graphic Method. (May 1999)

Answer

Let x_1 and x_2 be the amount to be invested in first and second stock portfolio respectively. The average rate of return for first portfolio is 10% and for second portfolio, it is 20%. Since the company wishes to maximize the return from investment, the objective function is as given below:

Maximise $Z = 0.1x_1 + 0.2x_2$

The maximum amount available for investment is Rs.1,00,000.

Hence, $x_1 + x_2 \leq 1,00,000$ …… (1)

Further, the maximum investment allowed in either portfolio set is Rs.75,000.

Therefore, $x_1 \leq 75,000$ …… (2)

and $x_2 \leq 75,000$ …… (3)

The first portfolio has a risk rating of 4 (on a scale from 0 to 10) and the second has 9. The company will not accept a risk factor above 6.

Therefore, $4x_1 + 9x_2 \leq 6\,(x_1+x_2)$ …… (4)

Further, the company will not accept an average rate of return below 12%.

Hence, $0.1x_1 + 0.2\,x_2 \geq 0.12\,(x_1 + x_2)$ …… (5)

Also, x_1 and $x_2 \geq 0$ …… (6)

The linear programming model for the given problem can now be formulated as follows:

Maximise $Z = 0.1x_1 + 0.2x_2$

Subject to the constraints

$x_1+x_2 \leq 1,00,000$ …… (1)

$x_1 \leq 75,000$ …… (2)

$x_2 \leq 75,000$ …… (3)

$4x_1 + 9x_2 \leq 6\,(x_1 + x_2)$

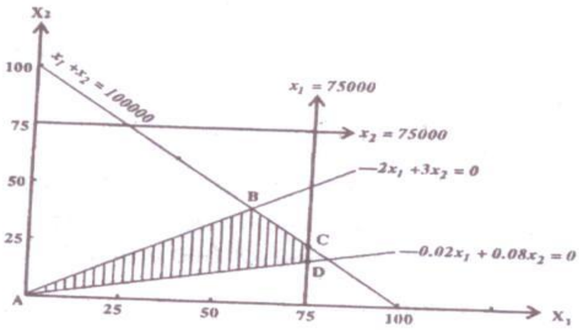
or $-2x_1 + 3x_2 \leq 0$ …… (4)

$0.1x_1 + 0.2x_2 \geq 0.12\ (x_1+x_2)$

or $-\ 0.02x_1 + 0.08x_2 \geq 0$ …… (5)

where $x_1,\ x_2 \geq 0$

The problem is solved graphically below:



The point of intersection for the lines

$-\ 2x_1 + 3x_2 = 0$

and $x_1 + x_2 = 1{,}00{,}000$

is given by B (60,000, 40,000)

The point of intersection for the lines

$X_1 = 75{,}000$

and $x_1 + x_2 = 1{,}00{,}000$

is given by C (75,000, 25,000)

Similarly, the lines

$x_1 = 75{,}000$

and $-\ 0.02x_1 + 0.08x_2 = 0$

intersect at point D (75,000, 18,750)

Thus, the feasible region is bounded by ABCDA and feasible points are A (0, 0); B(60,000, 40,000); C(75,000, 25,000) and D(75,000, 18,750).

Value of the objective function at the above mentioned feasible points is calculated below:

At A, Z=0

At B, $Z=0.1 \times 60{,}000 + 0.2 \times 40{,}000$

$= 6{,}000 + 8{,}000 =$ Rs.14,000

At C, $Z=0.1 \times 75{,}000 + 0.2 \times 25{,}000$

$= 7{,}500 + 5{,}000 =$ Rs.12,500

At D, $Z=0.1\times 75{,}000 + 0.2 \times 18{,}750$

$= 7{,}500 + 3{,}750 =$ Rs.11,250

We find that the value of the objective function is maximum (Rs.14,000) at point B(60,000, 40,000).

Hence, the company should invest Rs.60,000 in first portfolio and Rs.40,000 in second portfolio to achieve the maximum average rate of return of Rs.14,000.

Question 9

A firm buys casting of P and Q type of parts and sells them as finished product after machining, boring and polishing. The purchasing cost for casting are Rs.3 and Rs.4 each for parts P and Q and selling costs are Rs.8 and Rs.10 respectively. The per hour capacity of machines used for machining, boring and polishing for two products is given below:

	Parts	
Capacity (per hour)	*P*	*C*
Machining	*30*	*50*
Boring	*30*	*45*
Polishing	*45*	*30*

The running costs for machining, boring and polishing are Rs.30, Rs.22.5 and Rs.22.5 per hour respectively.

Formulate the linear programming problem to find out the product mix to maximize the profit.

(May 1998)

Answer

Let the firm by x units of castings of P and y units of castings of Q which are sold as finished product after machining, boring and polishing. According to the given data, the capacity constraints of machining, boring and polishing machines on per hour basis have been formulated as below:

$$\frac{x}{30}+\frac{y}{50} \le 1 \qquad \text{(Machining constraint)}$$

or $50x + 30Y \le 1{,}500$ …… (1)

$$\frac{x}{30}+\frac{y}{45} \le 1 \qquad \text{(boring constraint)}$$

or $45x + 30y \le 1{,}350$ …… (2)

$$\frac{x}{45}+\frac{y}{30} \le 1 \qquad \text{(Polishing constraint)}$$

or $30x + 45y \le 1{,}350$ …… (3)

In order to compute the profit/per unit of castings of P and castings of Q, we will first calculate the total cost per unit for each casting of P and Q. the running cost for machining is Rs.30 per hour and it can produce 30 units of casting of P type on one hour. Hence, cost of machiing for one unit of castings of P is Rs.30/30 i.e. Re 1. Following the same procedure, the total cost and the profit per unit for castings of P and castings of Q type are calculated ni the table given below:

	Cost/per unit	
	Castings of P type	*Casting of Q type*
Machining	Rs.30/30 = Rs.1.00	Rs.30/50 = Rs.0.60
Boring	Rs.22.5/30 = Rs.0.75	Rs.22.5/45 = Rs.0.50
Polishing	Rs.22.5/45 = Rs.0.50	Rs.22.5/30 = Rs.0.75
Purchasing cost	Rs.3.00	Rs.4.00
Total cost	Rs.5.25	Rs.5.85

Sale price	Rs.8.00	Rs.10.00
Profit	Rs.2.75	Rs.4.15

The required product mix to maximise the profit of the firm will be given by the following relation:

Maximise Z = $2.75x + 4.15y$

Subject to the constraints

$50x + 30y \leq 1{,}500$

$45x + 30y \leq 1{,}350$

$30x + 45y \leq 1{,}350$

where $x, y \geq 0$

Question 10

A Mutual Fund Company has Rs.20 lakhs available for investment in Government Bonds, blue chip stocks, speculative stocks and short-term bank deposits. The annual expected return and risk factor are given below:

Type of investment	*Annual Expected return (%)*	*Risk Factor (0 to 100)*
Government Bonds	*14*	*12*
Blue Chip Stocks	*19*	*24*
Speculative Stocks	*23*	*48*
Short term deposits	*12*	*6*

Mutual fund is required to keep at least Rs.2 lakhs in short-term deposits and not to exceed an average risk factor of 42. Speculative stocks must be at most 20 percent of the total amount invested. How should mutual fund invest the funds so as to maximize its total expected annual return? Formulate this as a Linear Programming Problem. Do not solve it. *(May 1996)*

Answer

Let x_1, x_2, x_3 and x_4 denote the amount of funds to be invested in government bonds, blue chip stocks, speculative stocks and short term deposits respectively. Let Z denote the total expected return.

Since the Mutual Fund Company has Rs.20 lakhs available for investment,

$x_1 + x_2 + x_3 + x_4 \leq 20{,}00{,}000$ …… (1)

Also, Mutual fund is required to keep at least Rs.2 lakhs in short-term deposits.

Hence, $x_4 \geq 2{,}00{,}000$ …… (2)

The average risk factor is given by

$$\frac{12x_1 + 24x_2 + 48x_3 + 6x_4}{x_1 + x_2 + x_3 + x_4}$$

Since the average risk factor for Mutual Fund should not exceed 42, we get the following constraint

$$\frac{12x_1 + 24x_2 + 48x_3 + 6x_4}{x_1 + x_2 + x_3 + x_4} \leq 42$$

or $12x_1 + 24x_2 + 48x_3 + 6x_4 \leq 42\,(x_1+x_2+x_3+x_4)$

or $-30x_1 - 18x_2 + 6x_3 - 36x_4 \leq 0$ …… (3)

Further, speculative stock must be at most 20 per cent of the total amount invested, hence

$x_3 \le 0.20\ (x_1+x_2+x_3+x_4)$

or $-\ 0.2x_1 - 0.2x_2 + 0.8x_3 - 0.2\ x_4 \le 0$ …… (4)

Finally, the objective is to maximise the total expected annual return, the objective function for Mutual Fund can be expressed as

Maximise $Z = 0.14x_1 + 0.19x_2 + 0.23x_3 + 0.12x_4$ …… (5)

Summarising equations (1) to (5), the linear programming model for the Mutual Fund company is formulated as below:

Objective function:

Maximise $Z = 0.14x_1 + 0.19x_2 + 0.23x_3 + 0.12x_4$

Subject to the constraints:

$x_1+x_2+x_3+x_4 \le 20{,}00{,}000$

$x_4 \ge 2{,}00{,}000$

$-\ 30x_1 - 18x_2 + 6x_3 - 36x_4 \le 0$

$-\ 0.2x_1 - 0.2x_2 + 0.8x_3 + 0.2x_4 \le 0$

Where $x_1 \ge 0$, $x_2 \ge 0$, $x_3 \ge 0$ and $x_4 \ge 0$

Question 11

The owner of Fancy Goods Shop is interested to determine, how many advertisements to release in the selected three magazines A, B and C. His main purpose is to advertise in such a way that total exposure to principal buyers of his gods is maximized. Percentages of readers for each magazine are known. Exposure in any particular magazine is the number of advertisements released multiplied by the number of principal buyers. The following data are available:

	Magazines		
Particulars	*A*	*B*	*C*
Readers	*1.0 Lakhs*	*0.6 Lakhs*	*0.4 Lakhs*
Principal buyers	*20%*	*15%*	*8%*
Cost per advertisement	*8,000*	*6,000*	*5,000*

The budgeted amount is at the most Rs.1.0 lakh for the advertisements. The owner has already decided that magazine A should have no more than 15 advertisements and that B and C each gets at least 8 advertisements. Formulate a Linear Programming model for this problem.

(*Nov 1996*)

Answer

Let x_1, x_2 and x_3 denote the number of advertisements to be released in three magazines A, B and C respectively. Let Z denote the total exposure to the principal buyers of the goods.

Since the exposure in any magazine is the number of advertisements multiplied by the number of principal buyers, therefore, the value of Z is given by:

$$Z = (0.20 \times 1{,}00{,}000)x_1 + (0.15 \times 60{,}000)x_2 + (0.08 \times 40{,}000)x_3$$

$$= 20{,}000\ x_1 + 9{,}000\ x_2 + 3{,}200\ x_3$$

The owner of Fancy Goods shop wishes to maximise the total exposure to principal buyer, hence the objective function is given by

Maximise Z = 20,000 x_1 + 9,000 x_2 + 3,200 x_3

Subject to the following constraints:

i) The budgeted amount for the advertisements is at the most Rs.1,00,000

Hence, 8,000 x_1 + 6,000 x_2 + 5,000 x_3 ≤ 1,00,000

ii) Also, the magazine A should have no more than 15 advertisements, B and C each should get at least 8 advertisements.

Hence, $x_1 \le 15$ and $x_2 \ge 8$, $x_3 \ge 8$

Thus, the linear programming model for the problem is

Maximise Z = 20,000 x_1 + 9,000 x_2 + 3,200 x_3

subject to 8,000 x_1 + 6,000 x_2 + 5,000 x_3 ≤ 1,00,000

$x_1 \le 15$, $x_2 \ge 8$,

where x_1, x_2 and $x_3 \ge 0$

Question 12

Write short notes on the characteristics of the dual problem. *(Nov 1996)*

Answer

Characteristics of the dual problem:

1. For any linear programming model called primal model, there exists a companion model called the dual model.
2. The number of constraints in the primal model equals the number of variables in the dual model.
3. The number of variables in the primal problem equals the number of constraints in the dual model.
4. If the primal model is a maximization problem then the dual model will be of the form less than or equal to, "≤" while the restrictions in the dual problem will be of the form-greater than or equal to, "≥".
5. The solution of the prima; model yields the solution of the dual model. Also, an optimal simplex table for the dual model yields the optimal solution to the primal model. Further, the objective functions of the two optimal tables will have identical values.
6. Dual of the prima's dual problem is the primal problem itself.
7. Feasible solutions to a primal and dual problem are both optimal if the complementary slackness conditions hold, that is, (value of a primal variable) x (value of the corresponding dual surplus variable) = 0 or (value of a primal slack variable) x (value of the corresponding dual variable) = 0.

   If this relationship does not hold, than either the primal solution or the dual solution or both are no optimal.
8. If the primal problem has no optimal solution because of infeasibility, then the dual problem will have no optimal solution because of unboundedness.
9. If the primal has no optimal solution because of unboundedness, then the dual will have no optimal solution because of infeasibility.

Question 13

An agriculturist has a farm with 125 acres. He produces Radish, Mutter and Potato. Whatever he raises is fully sold in the market. He gets Rs.5 for Radish per kg Rs.4 for Mutter per kg and Rs. for Potato per kg. The average yield is 1,500 kg of Radish per acre, 1,800 kg of Mutter per acre and 1,200 kg of Potato per acre. To produce each 100 kg of Radish and Mutter and to produce each 80 kg of Potato, a sum of

Rs.12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man days for Radish and Potato each and 5 man days for Mutter. A total of 500 man days of labour at a rate of Rs.40 per man day are available.

Formulate this as a Linear Programming model to maximize the Agriculturist's total profit.

(May 1997)

Answer

Let x_1, x_2 and x_3 be the number of acres allotted for cultivating radish, mutter and potato respectively.

Since the average yield of radish is 1,500 kg per acre, and the selling price for radish is Rs.5/kg hence the selling amount which the agriculturist gets from one acre is:

Rs.5 × 1,500 = Rs.7,500

To produce 100 kg of radish, the manure cost is Rs.12.50, so the manure cost per acre will be Rs.12.50 × 1,500/100 = Rs.12.50 × 15.

Labour cost per acre for radish = Rs.40 × 6 = Rs.240

Profit per acre for radish = Rs.7,500 – Rs.12.50 × 15 – Rs.240 = Rs.7,072.50

Similarly, the selling price, manure cost, labour cost and profit per acre of land for mutter and potato are also calculated and presented in the following table.

Per acre	*Radish*	*Mutter*	*Potato*
Selling price	Rs.5 × 1,500 = Rs.7,500	Rs.4 × 1,800 = Rs.7,200	Rs.5 × 1,200 = Rs.6,000
Manure cost	$\frac{\text{Rs.}12.50 \times 1{,}500}{100}$	$\frac{\text{Rs.}12.50 \times 1{,}800}{100}$	$\frac{\text{Rs.}12.50 \times 1{,}200}{80}$
Labour cost	Rs.40 × 6 = Rs.240	Rs.40 × 5 = Rs.200	Rs.40 × 6 = Rs.240
Profit	(Rs.7,500-Rs.187.50 – Rs,240) = Rs. 7,072.50	(Rs.7,200 – Rs.255 - Rs.200) = Rs.6,775	Rs.6,000–Rs.187.50 – Rs.240) = Rs. 5572.50

Since, the agriculturist wants to maximise the total profit, hence the objective function of the problem is given by:

Maximise $Z = 7{,}072.5x_1 + 6{,}775x_2 + 5572.5x_3$

Subject to following constraints:

$x_1 + X_2 + X_3 \leq 125$ …… (1) (land constraint)

$6x_1 + 5x_2 + 6x_3 \leq 500$ …… (2) (man day constraint)

Where x_1, x_2 and $x_3 \geq 0$

Question 14

A firm produces three products A, B and C. It uses two types of raw materials I and II of which 5,000 and 7,500 units respectively are available. The raw material requirements per unit of the products are given below:

Raw Material	*Requirement per unit of Product*		
	A	*B*	*C*
I	*3*	*4*	*5*

II	*5*	*3*	*5*

The labour time for each unit of product A is twice that of product B and three times that of product C. The entire labour force of the firm can produce the equivalent of 3,000 units. The minimum demand of the three products is 600, 650 and 500 units respectively. Also the ratios of the number of units produced must be equal to 2 : 3 : 4. Assuming the profits per unit of A, B and C as Rs.50, 50 and 80 respectively.

Formulate the problem as a linear programming model in order to determine the number of units of each product, which will maximize the profit. (Nov 1997)

Answer

Let the firm produce x_1 units of product A, x_2 units of product B and x_3 units of product C. The profit per unit of product A, B and C is Rs.50, Rs.50 and Rs.80 respectively. Since it objective of the firm is to maximize the profit, therefore, the objective function is given by

Maximise $Z = 50x_1 + 50x_2 + 80x_3$

The firm uses two types of raw materials I and II of which 5,000 and 7,500 units respective are available. As per the given data, the raw material constraints can be formulated as given below:

$3x_1 + 4x_2 + 5x_3 \leq 5,000$ ...... (i)

and $5x_1 + 3x_2 + 5x_3 \leq 7,500$ ..... (ii)

The labour time for each unit of product A is twice that of product B and three times that product C. Also the entire labour force can produce the equivalent of 3,000 units.

$$x_1 + \frac{x_2}{2} + \frac{x_3}{3} \leq 3,000$$

or $6x_1 + 3x_2 + 2x_3 \leq 18,000$ ...... (iii)

The minimum demand of the three products is 600 and 500 units respectively. Hence, $x_1 \geq 600$, $x_2 \geq 650$ and $x_3 \geq 500$ ...... (iv)

Since the ratios of the number of units produced must be equal to 2 : 3 : 4, therefore,

$$\frac{1}{2}x_1 = \frac{1}{3}x_2, \text{ and } \frac{1}{3}x_2 = \frac{1}{4}x_3$$

or $3x_1 = 2x_2$ and $4x_2 = 3x_3$ ...... (v)

The linear programming model can be formulated as follows:

Maximise $Z = 50x_1 + 50x_2 + 80x_3$

Subject to the constraints

$3x_1 + 4x_2 + 5x_3 \leq 5,000$

$5x_1 + 3x_2 + 5x_3 \leq 7,500$

$6x_1 + 3x_3 + 2x_3 \leq 18,000$

$3x_1 = 2x_2$ and $4x_2 = 3x_3$

$x_1 \geq 600$, $x_2 \geq 650$ and $x_3 \geq 500$

Question 15

Computer Company produces three types of models, which are first required to be machined and then assembled. The time (in hours) for these operations for each model is given below:

Model	*Machine Time*	*Assembly Time*
P III	*20*	*5*
P II	*15*	*4*
Celeron	*12*	*3*

The total available machine time and assembly time are 1,000 hours and 1,500 hours respectively. The selling price and other variable costs for three models are:

	P III	*P II*	*Celeron*
Selling Price (Rs.)	*3,000*	*5,000*	*15,000*
Labour, Material and other Variable Costs (Rs.)	*2,000*	*4,000*	*8,000*

The company has taken a loan of Rs.50,000 from a Nationalised Bank, which is required to be repaid on 1.4.2001. In addition, the company has borrowed Rs.1,00,000 from XYZ Cooperative Bank. However, this bank has given its consent to renew the loan.

The balance sheet of the company as on 31.3.2001 is as follows:

Liabilities	*Rs.*	*Assets*	*Rs.*
Equity share Capital	*1,00,000*	*Land*	*80,000*
Capital reserve	*20,000*	*Buildings*	*50,000*
Profit & Loss Account	*30,000*	*Plant & Machinery*	*1,00,000*
Long-term Loan	*2,00,000*	*Furniture etc.*	*20,000*
Loan from XYZ Cooperative Bank	*1,00,000*	*Vehicles*	*40,000*
Loan from National Bank	*50,000*		
Total	*5,00,000*	*Total*	*5,00,000*

The company is required to pay a sum of Rs.15,000 towards the salary. Interest on long-term loan is to be paid every month @ 18% per annum. Interest on loan from XYZ Cooperative Bank and Nationalised Bank may be taken as Rs.1,500 per month. The company has already promised to deliver three P III. Two P II and five Celeron Type of Computer of M/s ABC Ltd. next month. The level of operation in the company is subject to the availability of cash next month.

The Company Manager is willing to know that how many units of each model must be manufactured next month, so as to maximize the profit.

Formulate the linear programming problem for the above.

Answer

Let x_1, X_2 and X_3 denote the number of P III, P II and Celeron Computers respectively to the manufactured in the company. The following data is given:

	P III	*P II*	*Celeron*
Selling Price per unit (Rs.)	3,000	5,000	15,000
Labour, Material and other Variable Costs p.u. (Rs.)	2,000	4,000	8,000
Profit per unit (Rs.)	1,000	1,000	7,000

From the data given for time required for various models and the total number of hours available for machine time and assembly time, we get the following constraints:

$20x_1 + 15x_2 + 12x_3 \leq 1{,}000$ (Machine Time Restriction)

$5x_1 + 4x_2 + 3x_3 \leq 1{,}500$ (Assembly Time Restriction)

The level of operations in the company is subject to availability of cash next month i.e.; the cash required for manufacturing various models should not exceed the cash available for the next month.

The cash requirements for x_1 units of P III, x_2 units of P II and x_3 units of Celeron computers are:

$2{,}000x_1 + 4{,}000\ x_2 + 8{,}000x_3$ …… (1)

The cash availability for the next month from the balance sheet is as below:

Cash availability (Rs.) Cash balance (Rs. 2,10,000)

Loan to repay to Nationalized bank (Rs. 50,000)

Interest on loan from XYZ cooperative bank and Nationalized bank (Rs. 1500)

Interest on long term loans $\left[\dfrac{0.18 \times 2{,}00{,}000}{12}\right]$

Salary to staff (Rs. 15,000)

Or, Cash availability = Rs. 2,10,000-(Rs. 50,000 + Rs. 1,500 + Rs. 3,000 + Rs. 15,000)

= Rs. 1,40,500 …… (2)

Thus, from (1) and (2),

2000 X1 + 4000 X2 + X3 < Rs. 1,40,500

The company has also promised to deliver 3 P III, 2 P II and 5 Celeron computers to M/s.

Kingspen Ltd.

Hence, X1 > 3, X2 > 2, X3 > 5

Since the company wants to maximize the profit, hence the objective function is given by: Maximize Z = 1000X1 + 1000X2 + 7000X3- (Rs. 15000 + Rs. 3000 + Rs. 1500) The LP formulation of the given problem is as follow:

Maximize Z = 1000 X1 + 1000X2 + 7000 X3 – (Rs. 15000 + Rs.15000) Subject to the constraints:

20X1 + 15X2 + 12X3 < 1000

5X1 + 4X2 + 3X3 < 1500

2000 X1 + 4000 x2 + 8000 X3 < Rs. 1,40,500

X1 > 3, X2 > 2, X3 > 5

X1, X2 and X3 can take only positive integral values.

Question 16

A manufacturing company produces two types of product the SUPER and REGULAR. Resource requirements for production are given below in the table. There are 1,600 hours of assembly worker hours available per week. 700 hours of paint time and 300 hours of inspection time. Regular customers bill demand at least 150 units of the REGULAR type and 90 units of the SUPER type.

(8 Marks)

Table

Product	*Profit/contribution Rs.*	*Assembly time*	*Paint time*	*Inspection time*

		Hrs.	*Hrs.*	*Hrs.*
REGULAR	*50*	*1.2*	*0.8*	*0.2*
SUPER	*75*	*1.6*	*0.9*	*0.2*

Formulate and solve the given Linear programming problem to determine product mix on a weekly basis.

Answer

Let x_1 and x_2 denote the number of units produced per week of the product 'REGULAR' and 'SUPER' respectively.

Maximise $Z = 50x_1 + 75x_2$

Subject to

$1.2x_1 + 1.6x_2 \leq 1{,}600$ or $12x_1 + 16x_2 \leq 16{,}000$ -(i)

$0.8x_1 + 0.9x_2 \leq 700$ or $8x_1 + 9x_2 \leq 7{,}000$ -(ii)

$0.2x_1 + 0.2x_2 \leq 300$ or $2x_1 + 2x_2 \leq 3{,}000$ -(iii)

$X_1 \geq 150$ -(iv)

$x_2 \geq 90$ -(v)

Let

$x_1 = y_1 + 150$

$x_2 = y_2 + 90$ where $y_1, y_2 \geq 0$

Maximize $Z = 50(y_1 + 150) + 75(y_2 + 90)$ or , $Z = 50y_1 + 75y_2 + 14{,}250$

Subject to :

$12(y_1 + 150) + 16(y_2 + 90) \leq 16{,}000$

$8(y_1 + 150) + 9(y_2 + 90) \leq 7{,}000$

$2(y_1 + 150) + 2(y_2 + 90) \leq 3{,}000$

and $y_1, y_2 \geq 0$

Adding slack variables s_1, s_2, s_3, we get

Maximize $Z = 50y_1 + 75y_2 + 14{,}250$ subject to

$12y_1 + 16y_2 + s_1 = 12{,}760$

$8y_1 + 9y_2 + s_2 = 4{,}990$

$2y_1 + 2y_2 + s_3 = 2{,}520$

Table -1

C_j			50	75	0	0	0	
			y_1	y_2	s_1	s_2	s_3	
C_b								
0	s_1	12,760	12	16	1	0	0	12760/16
0	s_2	4,990	8	9	0	1	0	4990/9
0	s_3	2,520	2	2	0	0	1	2520/2
			-50	-75	0	0	0	
Δ_j								

Table II

C_j			50	75	0	0	0
C_b			y_1	y_2	s_1	s_2	s_3
0	s_1	3889	-20/9	0	1	-16/9	0
75	y_2	554.44	8/9	1	0	1/9	0
0	s_3	1411	2/9	0	0	-2/9	1
Δ_j			50/3	0	0	75/9	0

Since all the elements in the index row are either positive or equal to zero , table II gives an optimum solution which is $y_1 = 0$ and $y_2 = 554.44$

Substituting these values we get

$x_1 = 0+150 = 150$

$x_2 = 90+554.44 = 644.44$ and the value of objective function is

$Z = 50 \times 150 + 75 \times 644.44$

$= \text{Rs. } 55,833$

Question 17

A company manufactures two products A and B, involving three departments – Machining, Fabrication and Assembly. The process time, profit/unit and total capacity of each department is given in the following table:

	Machining (Hours)	*Fabrication (Hours)*	*Assembly (Hours)*	*Profit (Rs).*
A	*1*	*5*	*3*	*80*
B	*2*	*4*	*1*	*100*
Capacity	*720*	*1,800*	*900*	

Set up Linear Programming Problem to maximise profit. What will be the product Mix at Maximum profit level ?

Answer

Maximize $z = 80x + 100y$ subject to $x + 2y \le 720$

$5x + 4y \le 1800$

$3x + y \le 900$

$x \ge 0$ $y \ge 0$

where x = No. of units of A

y = No. of units of B

By the addition of slack variables s1, s2 and s3 the inequalities can be converted into equations. The problems thus become

$z = 80x + 100y$ subject to $x + 2y + s_1 = 720$

$5x + 4y + s_2 = 1800$

$3x + y + s_3 = 900$

and $x \geq 0, \quad y \geq 0, \quad s_1 \geq 0, \quad s_2 \geq 0, \quad s_3 \geq 0$

Table I:

	Profit/unit	Qty.	80 X	100 Y	0 S_1	0 S_2	0 S_3	
S_1	0	720	I	2	1	0	0	$\frac{720}{2} = 360$
S_2	0	1800	5	4	0	1	0	1800/4 = 450
S_3	0	900	3	I	0	0	1	900/1 = 900
Net evaluation row			80	100	0	0	0	

$1800 - 720 \times 4/2 = 360$	$900 - 720 \times 1/2 = 540$
$5 - I \times 2 = 3$	$3 - 1 \times ½ = 5/2$
$4 - 2 \times 2 = 0$	$I - 2 \times 1/2 = 0$
$0 - I \times 2 = -2$	$0 - I \times 1/2 = -1/2$
$I - 0 \times 2 = I$	$0 - 0 \times 1/2 = 0$
$0 - 0 \times 2 = 0$	$I - 0 \times 1/2 = I$

Table 2:

Program	Profit/unit	Qty.	80 X	100 Y	0 S_1	0 S_2	0 S_3	
Y	100	360	½	I	½	0	0	360÷1/2=720
S2	0	360	3	0	–2	1	0	360÷3=120
S3	0	540	5/2	0	–1/2	0	I	540÷5/2=216
Net evaluation row			30	0	–50	0	0	

$360 - 360 \times 1/6 = 300$	$540 - 360 \times 5/6 = 240$
$½ - 3 \times 1/6 = 0$	$5/2 - 3 \times 5/6 = 0$
$1 - 0 \times 1/6 = 1$	$0 - 0 \times 5/6 = 0$
$½ - -2 \times 1/6 = 5/6$	$-1/2 - -2 \times 5/6 = 7/6$
$0 - 1 \times 1/6 = -1/6$	$0 - 1 \times 5/6 = -5/6$
$0 - 0 \times 1/6 = 0$	$1 - 0 \times 5/6 = 1$

Table 3:

Program	Profit/unit	Qty.	80 X	100 Y	0 S_1	0 S_2	0 S_3
Y	100	300	0	I	5/6	-1/6	0
X	80	120	I	0	–2/3	1/3	0
S3	0	240	0	0	7/6	-5/6	I
Net evaluation row			0	0	-500/6	+100/6	
					+160/3	-80/3	0

$$= \frac{180}{6} \quad = -\frac{60}{6}$$

All the values of the net evaluation row of Table 3 are either zero or negative, the optimal program has been obtained.

Here X = 120, y = 300 and the maximum profit

$= 80\times120 + 100\times 300 = 9600 + 30{,}000$

= Rs. 39,600.

Question 18

Three grades of coal A, B and C contains phosphorus and ash as impurities. In a particular industrial process, fuel up to 100 ton (maximum) is required which could contain ash not more than 3% and phosphorus not more than .03%. It is desired to maximize the profit while satisfying these conditions. There is an unlimited supply of each grade. The percentage of impurities and the profits of each grade are as follows:

Coal	*Phosphorus (%)*	*Ash (%)*	*Profit in Rs. (per ton)*
A	*.02*	*3.0*	*12.00*
B	*.04*	*2.0*	*15.00*
C	*.03*	*5.0*	*14.00*

You are required to formulate the Linear-programming (LP) model to solve it by using simplex method to determine optimal product mix and profit.

Answer

Let X_1, X_2 and X_3 respectively be the amounts in tons of grades A, B, and C used. The constraints are

(i) Phosphorus content must not exceed 0.03%

$.02 X_1 + .04X_2 + 0.3 X_3 \leq .03 (X_1 + X_2 + X_3)$

$2X_1 + 4 X_2 + 3X_3 \leq 3 (X_1 + X_2 + X_3)$ or $– X_1 + X_2 \leq 0$

(ii) Ash content must not exceed 3%

$3X_1 + 2 X_2 + 5 X_3 \leq 3 (X_1 + X_2 + X_3)$ or $– X_2 + 2X_3 \leq 0$

(iii) Total quantity of fuel required is not more than 100 tons. $X_1 + X_2 + X_3 \leq 100$

The Mathematical formulation of the problem is

Maximize $Z = 12 X_1 + 15X_2 + 14 X_3$

Subject to the constraints:

$- X_1 + X_2 \leq 0$

$- X_2 + X_3 \leq 0$

$X_1 + X_2 + X_3 \leq 100$

$X_1, X_2, X_3 > 0$

Introducing slack variable $X_4 >0$, $X_5>0$, $X_6>0$

			12	15	14	0	0	0
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
0	Y_4	0	-1	1*	0	1	0	0
0	Y_5	0	0	-1	2	0	1	0
0	Y_6	100	1	1	1	0	0	1

	Z		-12	-15	-14	0	0	0
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
15	Y_2	0	-1	1	0	1	0	0
0	Y_5	0	-1	0	2	1	1	0
0	Y_6	100	2*	0	1	-1	0	1
	Z		-27		-14	15	0	0
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
15	Y_2	50	0	1	1/2	1/2	0	1/2
0	Y_5	50	0	0	5/2*	1/2	1	1/2
12	Y_1	50	1	0	1/2	-1/2	0	1/2
	Z		0	0	-1/2	3/2	0	27/2
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
15	Y_2	40	0	1	0	2/5	-1/5	2/5
14	Y_3	20	0	0	1	1/5	2/5	1/5
12	Y_1	40	1	0	0	-3/5	-1/5	2/5
	Z		0	0	0	8/5	1/5	68/5

The optimum solution is $X_1 = 40$, $X_2 = 40$ and $X_3 = 20$ with maximum Z = 1360.

16
THE TRANSPORTATION PROBLEM

Question 1

A particular product is manufactured in factories A, B, and D: and is sold at centers 1, 2 and 3. The cost in Rs. of product per unit and capacity in kgms per unit time of each plant is given below:

Factory	*Coast (Rs.) per unit*	*Capacity (kgms) per unit*
A	*12*	*100*
B	*15*	*20*
C	*11*	*60*
D	*13*	*80*

The sale price in Rs. Per unit and the demand is kgms per unit time are as follows:

Sale Centre	*Sale price (Rs.) per unit*	*Demand (Kgms) per unit*
1	*15*	*120*
2	*14*	*140*
3	*16*	*60*

Find the optimal sales distribution. *(Nov 1997)*

Answer

The given problem is a transportation problem. The profit matrix for various factories and sales counters is calculated below:

Factory	*Sales Centres*			*Capacity (kgms)*
	1	*2*	*3*	
A	3	2	4	100
B	0	-1	1	20
C	4	3	5	60
D	2	1	3	80
Demand (kgms)	120	140	60	

Since this is an unbalanced transportation problem (demand > capacity), let us introduce a dummy factory with profit as Rs.0 per unit for various sales centres and capacity equal to sixty units. The resulting matrix would be as below:

Factory	*Sales Centres*			*Capacity (kgms)*
	1	*2*	*3*	
A	3	2	4	100
B	0	-1	1	20

C	4	3	5	60
D	2	1	3	80
Dummy	0	0	0	60
Demand (kgms)	120	140	60	

The above profit matrix can be converted into a loss matrix by subtracting all its elements from the highest payoff of the matrix i.e. 5. The loss matrix so obtained is given below:

Factory	*Sales Centres*			*Capacity (kgms)*
	1	*2*	*3*	
A	2	3	1	100
B	5	6	4	20
C	1	2	0	60
D	3	4	2	80
Dummy	5	5	5	60
Demand (kgms)	120	140	60	

The initial solution is obtained by applying Vogel's approximation method.

Factory	*Sales Centres*			*Capacity*	*Difference*
	1	*2*	*3*		
A	100 2	3	1	100/0	1 1 -
B	5	20 6	4	20/0	1 1 1
C	1	2	60 0	60/0	1 - -
D	20 3	60 4	2	80/60/0	1 1 1
Dummy	5	60 5	5	60/0	0 0 0
Demand	120/20/0	140/120/60/0	60/0		
Difference	1	1	1		
	1	1	-		
	2	1	-		

The solution obtained by VAM is as given below:

Factory	*Sales Centres*				*Ui*
	1		*2*	*3*	
A	100		0	E	

	2	3	1	3
B	0 5	20 6	0 4	6
C	0 1	0 2	60 0	2
D	20 3	60 4	0 2	4
Dummy	1 5	60 5	2 5	5
Vj	-1	0	2	

Since all $\Delta_{ij} \geq 0$ for the non allocated cells, hence the solution given by above matrix is optimal. The optional solution for the given problem is given below:

From Factory	*To Sales Centre*	*Quantity*	*Profit per unit (Rs.)*	*Total Profit (Rs.)*
A	1	100	3	300
B	2	20	-1	-20
C	3	60	5	300
D	1	20	2	40
D	2	60	1	60
Dummy	2	60	0	0
			Total Profit =	660

(Note: since some of the $\Delta_{ij's}$ are equal to zero, alternative solutions also exist.)

Question 2

A Company has four factories F_1, F_2, F_3 and F_4, manufacturing the same product. Production and raw material costs differ from factory to factory and are given in the first two rows of the following table. The Transportation costs from the factories to sales depots S_1, S_2 and S_3 are given in the next three rows of the table. The production capacity of each factory is given in the last row.

The last two columns in the table given the sales price and the total requirement at each depot:

Item	*Factory*				*Sales price*	*Requirement*
Per unit	*F_1*	*F_2*	*F_3*	*F_4*	*Per unit*	
Production cost	*15*	*18*	*14*	*13*	-	-
Raw material cost	*10*	*9*	*12*	*9*	-	-
Transportation cost	*3*	*9*	*5*	*4*	*34*	*80*
	1	*7*	*4*	*5*	*32*	*120*
	5	*8*	*3*	*6*	*31*	*150*
Production capacity	*10*	*150*	*50*	*100*	-	-

Determine the most profitable production and distribution schedule and the corresponding profit. The surplus should be taken to yield zero profit.

Answer

Profit = Sales Price – Production cost – Raw Material cost – Transportation cost.

The profit table, therefore, is:

Sales Depots	*Factory*				*Requirement*
	F_1	F_2	F_3	F_4	
S_1	6	-2	3	8	80
S_2	6	-2	2	5	120
S_3	1	-4	2	3	150
Available	10	150	50	100	

Since availability is less than the total requirement, introduce a dummy factory with transportation cost from this dummy factory to sales depots as zero.

The availability at dummy factory is : 350 – 310, i.e. 40 units.

Using now the modified Vogel's approximation method, i.e. by taking differences between highest and next to highest unit profit, we get

	F_1	F_2	F_3	F_4	Dummy	Requirements	Difference
S_1	6	-2	3	[80] 8	0	80	2
S_2	[10] 6	[90] -2	2	[20] 5	0	120	1 1 3 2
S_3	1	[60] -4	[50] 2	3	[40] 0	150	1 1 1 2
Availability	10	150	50	100	40		
Difference	0/5	0/2	1/0	3/2	0		

Using now, MODI method for optimum solution, we have

	F_1	F_2	F_3	F_4	Dummy	u_i
S_1	[3] 6	[3] -2	[4] 3	[80] 8	[5] 0	3
S_2	[10] 6	[90] -2	2 2	[20] 5	2 0	0
S_3	3 1	[60] -4	[50] 2	0 3	[40] 0	-2
v_j	6	-2	4	5	2	

Since, all the net evaluation of unoccupied cells are positive, an optimum solution is reached. Hence, the most profitable production and distribution schedule is to transport from F_1 to S_2 : 10 units, F_2 to S_2 : 90 units, F_2 to S_3 : 60 units, F_3 to S_3 : 50 units, F_4 to S_1 : 80 units & F_4 to S_2 : 20 units.

Profit associated with the optimum Program is Rs. 480.

Alternative Solution:

Profit = Sales Price – Production cost – Raw material cost – Transportation cost.

The Profit matrix is given below:

Factory

Sales Depot	*F_1*	*F_2*	*F_3*	*F_4*	*Requirement*
S_1	6	-2	3	8	80
S_2	6	-2	2	5	120
S_3	1	-4	2	3	150
Availability	10	150	50	100	

Since the requirement (=350) is greater than the availability (=310 units), one dummy factory is added with production = 350 – 310 = 40 units and profit as 0 per unit.

Let us now convert this profit matrix into opportunity loss matrix so that standard minimisation transportation algorithm can be applied to it. This is done b subtracting all the elements of the above matrix from the highest element (=8). The resultant matrix is given below. We now apply Vogel's approximation method to find the initial feasible solution.

	F_1	*F_2*	*F_3*	*F_4*	*Dummy*	*Requirements*	*Difference*
S_1	2	10	5	80 0	8	80/0	2 _ _ _
S_2	10 2	50 10	6	20 3	40 8	120/110/90/ 50/0	1 1 3 2
S_3	7	100 12	50 6	5	8	150/100/0	1 1 1 4
Availability	10/0	150/100/0	50/0	100/20/0	40		
Difference	0	2	1	3	0		
	5	2	0	2	0		
	-	-	0	2	0		
	-	2	0	-	0		

Let us now apply the optimality test to the above initial solution. The number of allocations is 7 which is equal to (m + n – 1) allocations. Let us now find u_is and v_js such that Δ_{ij} = cij – (u_i + v_j) where (i = 1, 2, 3) and (j = 1, 2, , …..5) for non basic cells. Let us assume u_2 = 0. Remaining u_is, v_js and Δ_{ij}'s are calculated below

	F_1	*F_2*	*F_3*	*F_4*	*Dummy*	*u_i*
S_1	3 2	3 10	4 5	80 0	3 8	-3
S_2	10 2	50 0 10	2 6	20 3	40 - 8	0
S_3	3	100 -	50	0	-2 +θ	2

	7	12	6	5	8
v_j	2	10	4	3	8

Since some of the Δ_{ij} is negative, the above solution is not optimal. Including the cell with most negative Δ_{ij} as basic allocation, the modified solution is given below which is tested for optimality.

	3 2	3 10	4 5	80 0	5 8	-3
	10 2	90 10	2 6	20 3	2 8	0
	3 7	60 12	50 6	0 5	40 8	2
v_j	2	10	4	3	6	

Since all $\Delta_{ij} \geq 0$, the above initial feasible solution is the optimal solution. The allocations are as given below:

Factory	*Sales Depot*	*Units*	*Profit/units*	*Total profit (Rs.)*
F_1	S_2	10	6	60
F_2	S_2	90	-2	-180
F_2	S_3	60	-4	-240
F_3	S_3	50	2	100
F_4	S_1	80	8	640
F_4	S_2	20	5	<u>100</u>
				<u>480</u>

Total profit = Rs.480

Since on of the Δ_{ij} = 0, alternative solution exists.

Question 3

A product is manufactured by four factories A, B, C and D. The Unit production costs are Rs.2, Rs.3, Re.1 and Rs.5 respectively. Their daily production capacities are 50, 70, 30 and 50 units respectively. These factories supply the product to four P, Q, R and S. The demand made by these stores are 25, 35, 105 and 20 Units transportation cost in rupees from each factory to each store is given in the following table;

		Stores			
		P	*Q*	*R*	*S*
	A	*2*	*4*	*6*	*11*
Factory	*B*	*10*	*8*	*7*	*5*
	C	*13*	*3*	*9*	*12*
	D	*4*	*6*	*8*	*3*

Determine the extent of deliveries from each of the factories to each of the stores so that the total cost (production and transportation together) is minimum. *(May 2002)*

Answer

The new transportation costs table, which consists of both production and transportation costs, is given in following table.

		Store				
		P	*Q*	*R*	*S*	*Supply*
	A	2+2=4	4+2=6	6+2=8	11+2=13	50
	B	10+3=13	8+3=11	7+3=10	5+3=8	70
Factories	C	13+1=14	3+1=4	9+1=10	12+1=13	30
	D	4+5=9	6+5=11	8+5=13	3+5=8	50
	Demand	25	35	105	20	200 185

Since the total supply of 200 units exceeds the total demand of 185 units by 200-185 =15 units of product, there fore a dummy destination (store) is added to absorb the excess supply. The associated cost coefficients in dummy store are taken as zero as the surplus quantity remains lying in the respective factories and is, in fact, not shipped at all. The modified table is given below. The problem now becomes a balanced transportation one and it is a minimization problem. We shall now apply Vogel's Approximation method to fine an initial solution.

	P	*Q*	*R*	*S*	*Dummy*	*Supply*	*Difference*
A	25	5	20	13	0	50/25/20/0	4 2 2 2 5
	4	6	8				
B	13	11	70	8	0	70/0	8 2 2 2 2 2
			10				
C	14	30	10	13	0	30/0	4 6 _ _ _ _
		4					
D	9	11	15	20	15	50/35/15/0	8 1 1 3 3 5
			13	8	0		
Demand	25/0	35/5/0	105/85/15/0	20/0	15/0	200	
Difference	5	2	2	0	0		
	5	2	2	0	-		
	5	5	2	0	-		
	-	5	2	0	-		
	-	-	2	0	-		

The initial solution is shown in above table. It can be seen that 15 units are allocated to dummy store from factory D. This means that the company may cut down the production by 15 units at the factory where it is uneconomical. We will now test the optimality of the solution. The total number of allocations is 8 which is equal to the required m+n-1 (=8) allocation. Introduce $u_{i's}$, $v_{j'}$ s, i= (1,2,- - - - -4) and $_j$ =(1,2,- - - -5) $\Delta_{ij}=c_{ij}-(u_i+v_j)$ for allocated cells. We assume that u_4 =0 and remaining u_j's, v_j's and Δ_{ij}'s are calculated below"

P	*Q*	*R*	*S*	*Dummy*	*Supply*	*U_i*

						Supply	U_i
A	25 / 4	5 / 6	20 / 8	13 / +10	0 / +5	50	U_1= -5
B	13 / +7	11 / +3	70 / 10	8 / +3	0 / +3	70	U_2 =
C	14 / +1	30 / 4	10 / +4	13 / +12	0 / +7	30	U_3 = -7
D	9 / 0	11 / 0	15 / 13	20 / 8	15 / 0	50	U_4 = 0
Demand	25	35	105	20	15		
V_j	V_1=9	2	2	0	0		

Please not that figures in top left hand corners of the cell represent the cost and the one in the bottom right hand corner of the non basic cell are the values of Δ_{ij}=c_{ij}-[(u_i+v_j)]

Since opportunity cost in all the unoccupied cells is positive, therefore initial solution is an optimal solution also. The total cost (transportation and production together) associated with this solution is

Total cost = 4×25+6×5+8×20+10×70+4×30+13×15+8×20+0×15

= 100+30+160+700+120+195+160

= Rs.1,465/-

Question 4

A compressed Natural Gas (CNG) company has three plants producing gas and four outlets. The cost of transporting gas from different production plants to the outlets, production capacity of each plant and requirement at different outlets is shown in the following cost-matrix table:

Plants	*Outlets*				*Capacity of Production*
	A	*B*	*C*	*D*	
X	*4*	*6*	*8*	*6*	*700*
Y	*3*	*5*	*2*	*5*	*400*
Z	*3*	*9*	*6*	*5*	*600*
Requirement	*400*	*450*	*350*	*500*	*1,700*

Determine a transportation schedule so that the cost is minimized.

The cost in the cost-matrix is given in thousand of rupees. *(Nov 2001)*

Answer

The given problem is a balanced minimization transportation problem. The objective of the company is to minimize the cost. Let us find the initial feasible solution using Vogel's Approximation method (VAM)

Outlets

Plants	*A*	*B*	*C*	*D*	*Capacity*	*Difference*
X	4	400 / 6	8	300 / 6	700/300/0	2 2 0 0
Y	3	50 / 5	350 / 2	5	400/50/0	1 2 0 0

Z	400 3	9	6	200	600/200/0	2 2 4 0
Requirement	400/0	450/400/0	350/0	500/300/0		
Difference	0	1	4	0		
	0	1	-	0		
	-	1	-	0		

The initial feasible solution obtained by VAM is given below:

Outlets

Plants	*A*	*B*	*C*	*D*	*Capacity*
X	4	400 6	8	300 6	700
Y	3	50 5	350 2	5	400
Z	400 3	9	6	200 5	600
Requirement	400	450	350	500	

Since the number of allocations = 6= (m+n-1), let us test the above solution for optimality. Introduce u_i (i=1,2,3) and v_j (1,2,3,4) such that $\Delta_{ij}= C_{ij} - (u_i+v_j)$ for allocated cells. We assume u_1=0, and rest of the u_i's, vj's and Δi_j's are calculated as below:

Outlets

Plants	*A*	*B*	*C*	*D*	U_i
X	0 4	400 6	5 8	300 6	0
Y	0 3	50 5	350 2	0 5	-1
Z	400 3	4 9	4 6	200 5	-1
V_j	4	6	3	6	

On calculating Δi_j's for non-allocated cells, we found that all the $\Delta i_j \geq 0$, hence the initial solution obtained above is optimal.

The optimal allocations are given below.

Plants	*Outlet*	*Units*		*Cost*		*Total Cost*
X	→B	400	×	6	=	2,400
X	→D	300	×	6	=	1,800
Y	→B	50	×	5	=	250
Y	→C	350	×	2	=	700
Z	→A	400	×	3	=	1,200
Z	→D	200	×	5	=	1,000

						7,350

The minimum cost = 7,350 thousand rupees.

Since some of the Δi_j's = 0, the above solution is not unique. Alternative solutions exist.

Question 5

A company has 3 plants and 3 warehouses. The cost of sending a unit from different plants to the warehouses, production at different plants and demand at different warehouses are shown in the following cost matrix table:

Plants	*Warehouses*			*Production*
	A	*B*	*C*	
X	*8*	*16*	*16*	*152*
Y	*32*	*48*	*32*	*164*
Z	*16*	*32*	*48*	*154*
Demand	*144*	*204*	*82*	

Determine a transportation schedule, so that the cost is minimized. Assume that the cost in the cost matrix is given in thousand of rupees.

Answer

The given problem is unbalanced transportation problem since the demand (=430 units) is 40 units less than the production (=470). It is converted into a balanced problem by adding a dummy warehouse as given below:

Plants	*Warehouses*				*Production*
	A	*B*	*C*	*Dummy*	
X	8	16	16	0	152
Y	32	48	32	0	164
Z	16	32	48	0	154
Demand	144	204	82	40	

The objective of the company is to minimize the transportation cost. Let us apply vogel's approximation method for finding the initial feasible solution:

Ware House

Plants	*A*	*B*	*C*	*Dummy*	*Production*	*Difference*
X	8	152 16	16	0	152/0	8 8 _ _
Y	32	42 48	82 32	40 0	164/124/42/0	32 0 0 16
Z	144 16	10 32	48	0	154/10/0	16 16 16 16
Demand	144/0	204/52/42/0	82/0	40/0		
Difference	8	16	16	0		
	8	16	16	-		

16	16	16	-
-	16	16	-

The solution obtained by VAM is given below

Ware House

Plants	*A*	*B*	*C*	*Dummy*	*Production*
X	8	152 16	16	0	152
Y	32	42 48	82 32	40 0	164
Z	144 16	10 32	48	0	154
Demand	144	204	82	40	

The initial solution is tested for optimality. There are 6(m+n-1) independent allocations. Let us introduce u_i, v_j, i=(1,2,3,4) such that $\Delta_{ij} = c_{ij} - (u_i+v_j)$ for allocated cells.

We assume u_2 = 0 and remaining u_1's vj's and Δi_j's are calculated as below:

Ware House

Plants	*A*	*B*	*C*	*Dummy*	U_i
X	8 8	152 16	16 16	32 0	-32
Y	0 32	42 48	82 32	40 0	0
Z	144 16	10 32	32 48	16 0	-16
V_j	32	48	32	0	

On calculating Δi_j's=0, the solution is not unique. Alternate solution exists.

Question 6

Following is the profit matrix based on four factories and three sales depots of the company:

		S_1	S_2	S_3	*Availability*
	F_1	6	6	1	10
Towns	F_2	-2	-2	-4	150
	F_3	3	2	2	50
	F_4	8	5	3	100
Requirement		80	120	150	

Determine the most profitable distribution schedule and the corresponding profit, assuming no profit in case of surplus production.

Answer

The given transportation problem is an unbalanced one and it is a maximization problem. As a first stem, we will balance this transportation problem, by adding a dummy factory, assuming no profit in case of surplus production

Sales Depots

		S_1	S_2	S_3	*Availability*
	F_1	6	6	1	10
Factories	F_2	-2	-2	-4	150
	F_3	3	2	2	50
	F_4	8	5	3	100
	Dummy	0	0	0	40
Requirement		80	120	150	

We shall now convert the above transportation problem (a profit matrix) into a loss matrix by subtracting all the elements form the highest value in the table i.e. 8. Thereafter, we shall apply the VAM to find an initial solution.

Sales Depots

		S_1	S_2	S_3	*Availability*	*Difference*
	F_1	2	10 (2)	7	10/0	0 5 _ _
	F_2	10	40 (10)	110 (12)	150/110/0	0 2 2 2
Factories	F_3	5	50 (6)	6	50/0	1 0 0 0
	F_4	80 (0)	20 (3)	5	100/20/0	3 2 2 _
	Dummy	8	8	40 (8)	40/0	0 0 0 0
	Requirement	80/0	120/110/90/40/0	150		
	Difference	2	1	1		
		-	1	1		
		-	3	1		
		-	2	2		

The initial solution obtained by VAM is given below:

Sales Depots

		S_1	S_2	S_3
	F_1	2	10 (2)	7
	F_2	10	40 (10)	110 (12)
Factories	F_3		50	

	5	6	6
F4	80 0	20 3	5
Dummy	8	8	40 8

The initial solution is tested for optimality. The total number of independent allocations is 7 which is equal to the desired (m+n-1) allocations. We introduce u_i's (i=1, 2- - - 5) and v_{js} (j=1,2,3) such that $\Delta_{ij}= c_{ij} –(u_{i+}v_{j})$. Let us assume u_2=0, remaining $u_{i'}$s, $v_{j'}$s and $\Delta_{ij'}$s are calculated below:

Sales Depots

		S_1	S_2	S_3	U_j
	F1	3 2	10 2	3 7	-8
	F2	3 10	40 +θ 10	110 12	0
Factories	F3	2 5	50 -θ 6	-2 +θ 6	-4
	F4	80 0	20 3	5	-7
	Dummy	11 8	2 8	40 8	-4
	V_j	7	10	12	

Since one of the Δ_{ij} negative, the initial solution is not optimal. Let us introduce in the cell with –ve Δ_{ij} { i.e. the cell (F_3, S_3)}, an assignment θ. The value of θ an the reallocated solution as obtained from about is given below. The values of u_i's, v_j's and $\Delta_{ij'}$s are also calculated.

Θ = min {(50-0) = 0 (110-θ)=0} = 50

Sales Depots

		S_1	S_2	S_3	U_j
	F1	3 2	10 2	3 7	-8
	F2	3 10	90 10	60 12	0
Factories	F3	2 5	50 -θ 6	-2 +θ 6	-4
	F4	80 0	20 3	5	-7
	Dummy	11 8	2 8	40 8	-4
	V_j	7	10	12	

Since all $\Delta_{ij'}$s for non basic cells are positive, the solution as calculated in the above table is optimal solution. The distribution schedule from factories to sales depots along with profit is given below:

Factory	Sales Depot	No. of units	Profit per unit	Total Profit
F_1	S_2	10	6	60
F_2	S_2	90	-2	-180
F_2	S_3	60	-4	-240
F_3	S_3	50	2	100
F_4	S_1	80	8	640
F_4	S_2	20	5	100
				480

(Note : Since one of the Δ_{ij}'s=0 alternate schedule with a profit of Rs.480 exists)

Question 7

A company produces a small component for all industrial products and distributes it to five wholesalers at a fixed prices of Rs.2.50 per unit. Sales forecasts indicate that monthly deliveries will be 3,000, 3,000, 10,000, 5,000 and 4,000 units to wholesalers 1,2,3,4 and 5 respectively. The monthly production capabilities are 5,000, 10,000, 12,500 at plants 1, 2 and 3 respectively. The direct costs of production of each unit are Rs.1.00 and Rs.0.80 at plants 1, 2 and 3 respectively. The transportation costs of shipping a unit from a plant to a wholesaler are given below:

		1	2	3	4	5
	1	0.05	0.07	0.10	0.15	0.15
Plant	2	0.08	0.06	0.09	0.12	0.14
	3	0.10	0.09	0.08	0.10	0.15

Find how many components each plant supplies to each wholesaler in order to maximize profit.

(May 2000)

Answer

Since the total capacity of plants is more than the supply to the wholesalers by a quantity 27500 units- 25000 units = 2500 units, so the problem is an unbalanced transportation problem. Introduce a dummy wholesaler supplying 2500 units such that the transportation costs plus the production cost from various plants to this destination are assumed to be zero. Also, the direct costs of production of each unit are given as Re.1, Re.0.90 and Re.0.80 at plants 1, 2 and 3 respectively. The modified balanced transportation problem is now obtained as follows:

		1	2	3	4	5	Dummy	Capacity
	1	0.05	1.07	1.10	1.15	1.15	0	5000
Plant	2	0.98	0.96	0.99	1.02	1.04	0	10000
	3	0.90	0.89	0.88	0.90	0.95	0	12500
		3000	3000	10000	5000	4000	2500	

For simplicity in computation, multiply all direct cost plus transportation costs in the above table by 100, and consider 100 units =1 unit of items. Hence, the simplified cost table becomes:

		1	2	3	4	5	Dummy	Capacity
	1	105	107	110	115	115	0	50
Plant	2	98	96	99	102	104	0	100
	3	90	89	88	90	095	0	125

Supply	30	30	100	50	40	25

Let us now apply Vogel's Approximation method to find the initial basic feasible solution

Wholesaler

		1	2	3	4	5	Dummy	Capacity	Difference
	1	25 105	107	110	115	115	25 0	50/25/0	105/2/2/2/5/10
Plant	2	5 98	30 96	25 99	102	40 104	0	100/70/45/5	96/2/2/2/1/6
	3	90	89	75 88	50 90	95	0	125/75/0	88/1/1/_
Supply		30/25/0	30/0	100/25/0	50/0	40	25/0		
Difference		8	7	11	12	9	0		
		8	7	11	12	9	-		
		8	7	11	-	9	-		
		7	11	11	-	11	-		
		7	-	11		11			

The initial basic feasible solution as obtained by VAM is given below:

		1	2	3	4	5	Dummy	Capacity
	1	25 105	107	110	115	115	25 0	50
Plant	2	5 98	30 96	25 99	102	40 104	0	100
	3	90	89	75 88	50 90	95	0	125
Supply		30	30	100	50	40	25	

We now apply the optimality test to find whether the initial solution found above is optimal or not. The number of allocations is 8 which is equal to the required m+n-1 (=8) allocations. Also, these allocations are independent. Hence, both the conditions of optimality test are satisfied.

Let us now introduce u_i's, (i=1,2,3) and v_j's, (j= 1,2,3……6) such that $\Delta_{ij}=c_{ij}-(u_i+v_j)$ for allocated cells. We assume that u_2 =0 and remaining u_i 's, $v_{j'}$ s and Δ_{ij}'s are calculated as below:

		1	2	3	4	5	Dummy	U_i's
	1	25 105	4 107	4 110	7 115	4 115	25 0	7
Plant	2	5 98	30 96	25 99	1 102	40 104	7 0	0
	3	3	4	75	50	2	18	-11

	90	89	88	90	95	0
V_j's	98	96	99	101	104	-7

Since all Δ_{ij}'s for non-basic cells are positive, therefore, the solution obtained above is an optimal one. The allocation of plant to wholesaler and their (transportation cost + direct production cost) is given below:

Plant	*Warehouse*	*No. of units*	*Cost per unit (Rs.)*	*Total cost (Rs.)*
1	→ 1	2500	1.05	2625
2	→ 1	500	0.98	490
2	→ 2	3000	0.96	2880
2	→ 3	2500	0.99	2475
2	→ 5	4000	0.104	4160
3	→ 3	7500	0.88	6600
3	→ 4	5000	0.90	4500
				23730

Since the company distributes the component at a fixed price of Rs.2.50 per unit to all five wholesalers, the profit is given by

Profit = Rs.2.50 × 22500 – Rs.23,730

= Rs.56,250 – Rs.23,730

= Rs.32,520

(**Note:** The problem has been solved using the cost matrix. However, it can be solved using the profit matrix first and then converting it to minimization problem).

Question 8

The following table shows all the necessary information on the available supply to each warehouse, the requirement of each market and the unit transportation cost from each warehouse to each market:

		Market				
		I	*II*	*III*	*IV*	*Supply*
	A	*5*	*2*	*4*	*3*	*22*
Warehouse	*B*	*4*	*8*	*1*	*6*	*15*
	C	*4*	*6*	*7*	*5*	*8*
Requirement		*7*	*12*	*17*	*9*	

The shipping clerk has worked out the following schedule from his experience:

12 Units from A to II

1 Unit from A to III

9 Units fro A to IV

15 Units from B to III

7 Units from C to I and

1 Unit from C to III

You are required to answer the following:

(i) Check and see if the clerk has the optimal schedule;

(ii) Find the optimal schedule and minimum total shipping cost; and

(iii) If the clerk is approached by a carrier of route C to II, who offers to reduce his rate in the hope of getting some business, by how much should the rate be reduced before the clerk should consider giving him an order? *(Nov 1999)*

Answer

(i) The shipping clerk has worked out the following schedule as initial solution:

Market

		I	II	III	IV	Supply
Warehouse	A	5	$\boxed{12}$ 2	$\boxed{1}$ 4	$\boxed{9}$ 3	22
	B	4	8	$\boxed{15}$ 1	6	15
	C	$\boxed{7}$ 4	6	$\boxed{1}$ 7	5	8
Requirement		7	12	17	9	

The initial solution is tested for optimality. The total number of independent allocations is 6 which is equal to the desired (m+n-1) allocations. We introduce u_i's (i=1,2,3) and v_j's (j= 1,2,3,4) such that $\Delta_{ij} = c_{ij} – (u_i + v_j)$. Let us assume $u_1 = 0$, remaining u_i's and v_j's are calculated as below:

	I	II	III	IV	U_i
A	4 5	$\boxed{12}$ 2	$\boxed{1}$ +θ 4	$\boxed{9}$ -θ 3	0
B	6 4	9 8	$\boxed{15}$ 1	6 6	-3
C	$\boxed{7}$ 4	1 6	$\boxed{1}$ -θ 7	-1 θ 5	3
V_j	1	2	4	3	

Since on of the Δ_{ij} 's is negative, the schedule worked out by the clerk is not the optimal solution.

(ii) Introduce in the cell with – ve Δ_{ij} [i.e. the cell (C, IV)] , an assignment θ and the reallocated solution as obtained from above is given below. The value of u_i s, v_j's are also calculated.

θ = min (9 – θ = =0 & 1- θ = 0) =1

	I	II	III	IV	U_i
A	3 5	$\boxed{12}$ 2	$\boxed{2}$ 4	$\boxed{8}$ 3	0
B	5 4	9 8	$\boxed{15}$ 1	6 6	-3
C	$\boxed{7}$ 4	2 6	1 7	$\boxed{1}$ 5	2

V_j	2	2	4	3

Since all Δ_{ij}'s for non basic cells are positive, the solution as calculated in the above table is optimal solution. The supply of units from each warehouse to markets, along with the transportation cost is given below:

Warehouse	*Market*	*Units*	*Cost per unit (Rs.)*	*Total Cost (Rs.)*
A	II	12	2	24
A	III	2	4	8
A	IV	8	3	24
B	III	15	1	15
C	I	7	4	28
C	IV	1	5	5
		Minimum total shipping cost =		104

(iii) if the clerk wants to consider the carrier of route C to II for giving an order, then his transportation cost must be less than the cost of carrier of routes C to I and C to IV i.e. his transportation cost should be at the most Rs.3 per unit. If the carrier C to II brings down his cost to Rs.3, he will get an order for 1 unit, and the schedule will be :

Warehouse	*Market*	*Units*	*Cost per unit (Rs.)*	*Total Cost (Rs.)*
A	II	11	2	22
A	III	2	4	8
A	IV	9	3	27
B	III	15	1	15
C	I	7	4	28
C	II	1	3	3
		Minimum total shipping cost =		103

and the total shipping cost will be Rs.103.

Question 9

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. There 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 customer:

		Warehouse		
		W_1	*W_2*	*W_3*
	A	*5*	*7*	*8*
Customer	*B*	*4*	*4*	*6*

C	*6*	*7*	*7*

Find the optimal transportation route. *(May 1999)*

Answer

Let us first formulate the given problem into a transportation problem as given below:

		W_1	W_2	W_3	Customer requirements
	A	5	7	8	70
Customer	B	4	4	6	30
	C	6	7	7	50
	Stock	65	42	43	

Since stock = customer requirements (=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.

Warehouse

		W_1	W_2	W_3	Requirements	Difference
	A	65 / 5	5 / 7	8	70/5/0	2 2 1 7
Customer	B	4	30 / 4	6	30/0	0 _ _ _
	C	6	7 / 7	43 / 7	50/7/0	1 1 0 0
	Stock	65/0	42/12/7/0	43/0		
	Difference	1	3	1		
		1	0	1		
		-	0	1		
		-	0	-		

The initial solution obtained by VAM is given below:

Warehouse

		W_1	W_2	W_3	Requirements
	A	65 / 5	5 / 7	8	70
Customer	B	4	30 / 4	6	30
	C	6	7 / 7	43 / 7	50
	Stock	65	42	43	

The total number of allocations is 5 which is equal to the required m+n-1(=5) allocations. Let us now test the optimality of the initial solution obtained above. Introduce u_i, v_j ; i= (1,2,3) and j = (1,2,3) such that $\Delta_{ij} = c_{ij} – (u_i+v_j)$ for allocated cells. We assume that u1 = 0 and remaining u_1's , v_j's and Δ_{ij}'s are calculated below:

Warehouse

		W_1	W_2	W_3	u_i's
	A	$\boxed{65}$ 5	$\boxed{5}$ 7	1 8	0
Customer	B	2 4	$\boxed{30}$ 4	2 6	-3
	C	1 6	$\boxed{7}$ 7	$\boxed{43}$ 7	50
	v_j's	5	7	7	

Since all Δ_{ij}'s for non basic cells are positive, therefore, the solution obtained above is an optimal one. The allocation of units from warehouses to customer and their cost are given below:

Warehouse	Customer	Unit	Cost per unit	Total Cost
W_1	A	65	Rs.5	Rs.325
W_2	A	5	Rs.7	Rs.35
W_2	B	30	Rs.4	Rs.120
W_2	C	7	Rs.7	Rs.49
W_3	C	43	Rs.7	Rs.301
			Total	Rs.830

Question 10

Consider the following data for the transportation problem:

Factory	*Destination*			*Supply to be exhausted*
	(1)	*(2)*	*(3)*	
A	*5*	*1*	*7*	*10*
B	*6*	*4*	*6*	*80*
C	*3*	*2*	*5*	*15*
Demand	*75*	*20*	*50*	

Since there is not enough supply, some of the demands at the three destinations may not be satisfied. For the unsatisfied demands, let the penalty costs be rupees 1, 2 and 3 for destinations (1), (2) and (3) respectively.

Answer

The initial solution is obtained below by vogel's method.

Since demand (=75+20+50=145) is greater than supply (=10+80+15=105) by 40 units, the given problem is an unbalanced one. We introduce a dummy factory with a supply of 40 units. It is given that for the unsatisfied demands, the penalty cost is rupees 1, 2, and 3 for destinations (1), (2) and (3) respectively. Hence, the transportation problem becomes

Factory	*Destination*			*Supply to be exhausted*
	(1)	*(2)*	*(3)*	
A	*5*	*1*	*7*	*10*
B	*6*	*4*	*6*	*80*
C	*3*	*2*	*5*	*15*
Dummy	*1*	*2*	*3*	*40*

Demand	*75*	*20*	*50*	*145*

Destination

		(1)	(2)	(3)	Supply	Difference
	A	5	[10] 1	7	100	4 _ _
Factory	B	[20] 6	[10] 4	[50] 6	80/70/50/0	2 2 2
	C	[15] 3	2	5	15/0	1 1 1
	Dummy	[40] 1	2	3	40/0	1 1 _
	Demand	75/35/20/0	20/10/0	50/0		
	Difference	2	1	2		
		2	0	2		
		3	2	1		

The initial solution is given in the table below.

Destination

		(1)	(2)	(3)	Supply
	A	5	[10] 1	7	10
Factory	B	[20] 6	[10] 4	[50] 6	80
	C	[15] 3	2	5	15
	Dummy	[40] 1	2	3	40
	Demand	75	20	50	

We now apply the optimality test to find whether the initial solution found above is optimal or not.

The number of allocations is 6 which is equal to the required m+n -1 (=6) allocations. Also, these allocations are in dependent. Hence, both the conditions are satisfied.

Let us now introduce u_i , and v_j' I = (1,2,3,4) and j = (1,2,3) such that $\Delta_{ij} = C_{ij} - (u_i+v_j)$ for allocated cells. We assume that u_2 =0 and remaining u_i's, v_j's and Δ_{ij}'s are calculated as below:-

	(1)	(2)	(3)	u_i's
A	2 5	[10] 1	4 7	-3

		1	2	3	u_i's
Factory	B	20 / 6	10 / 4	50 / 6	0
	C	15 / 3	1 / 2	2 / 5	-3
	Dummy	40 / 1	3 / 2	2 / 3	-5
	vj's	6	4	6	

Since all Δ_{ij}'s for non basic cells are positive, therefore, the solution obtained above is an optimal one. The allocation of factories to destinations and their cost is given below:-

Factory	Destination	Units	Cost	Total Cost	
A	(2)	10	Re 1	Rs,10	
B	(1)	20	Rs.6	Rs.120	Transportation
B	(2)	10	Rs.4	Rs.40	Cost
B	(3)	50	Rs.6	Rs.300	
C	(1)	15	Rs.3	Rs.45	
Dummy	(1)	40	Re 1	Rs.40	Penalty Cost
				Rs.555	

Question 11

A company has four factories situated in four different locations in the country and four sales agencies located in four other locations in the country. The cost of production (Rs. Per unit), the sales price (Rs. per unit), and shipping cost (Rs. Per unit) in the case of matrix, monthly capacities and monthly requirements are given below:

Factory	*Sales Agency*				*Monthly Capacity (Units)*	*Cost of production*
	1	*2*	*3*	*4*		
A	*7*	*5*	*6*	*4*	*10*	*10*
B	*3*	*5*	*4*	*2*	*15*	*15*
C	*4*	*6*	*4*	*5*	*20*	*16*
D	*8*	*7*	*6*	*5*	*15*	*15*
Monthly Requirement (Units)	*8*	*12*	*18*	*22*		
Sales Price	*20*	*22*	*25*	*18*		

Find the monthly production and distribution schedule which will maximize profit. *(May 1996)*

Answer

The given information can be tabulated following transportation problem

Profit Matrix

Factory	*Sales Agency*				*Monthly Capacity (Units)*
	1	*2*	*3*	*4*	

A	*3*	*7*	*9*	*4*	*10*
B	*2*	*2*	*6*	*1*	*15*
C	*0*	*0*	*5*	*-3*	*20*
D	*-3*	*0*	*4*	*-2*	*15*
Monthly Requirement (Units)	*8*	*12*	*18*	*22*	

Where entries in the cells of the above table indicate profit per unit received by selling one unit of item from factory i (I = A, B, C, D) to j[th] sales agency (j=1, 2, 3, 4). The profit per unit is calculated using the following formula:

Profit=Sales Price – (Cost of Production + Shipping Cost)

The objective of the company is to maximize the profit. For achieving this objective, let us convert this maximization problem into minimisation problem by subtracting all the elements of the above pay off matrix from the highest payoff i.e. Rs.9.

Loss Matrix

Factory	*Sales Agency*				*Monthly Capacity (Units)*
	1	*2*	*3*	*4*	
A	*6*	*2*	*0*	*5*	*10*
B	*7*	*7*	*3*	*8*	*15*
C	*9*	*9*	*4*	*12*	*20*
D	*12*	*9*	*5*	*11*	*15*
Monthly Requirement (Units)	*8*	*12*	*18*	*22*	

Now, let us apply Vogel's Approximation Method to the above matrix for finding the initial feasible solution.

Factory	*Sales Agency*				Monthly Capacity	Difference
	1	*2*	*3*	*4*		
A	6	[10] 2	0	5	10/0	2 3 _ _
B	7	7	3	[15] 8	15/0	4 0 0 _
C	[2] 9	9	[18] 4	12	20/2/0	5 0 0 0
D	[6] 12	[2] 9	5	[7] 11	15/13/6/0	4 2 2 2
Monthly requirement	8/6/0	12/2/0	18/0	22/7		
Difference	1 1 2 3	5 5 2 0	3 _ _ _	3 3 3 1		

The initial solution is an given below which is tested for optimality. There are m+n -1 = 7 independent allocations.

Let us introduce u_i v_j , i = (1,2,3,4); j=(1,2,3,4) such that $\Delta_{ij} = c_{ij}-(u_i+v_j)$ for allocated cells. We assume $u_4 = 0$ and remaining u_i's, v_j's and Δ_{ij}'s are calculated as below:

Factory	*Sales Agency*				u_i's
	1	*2*	*3*	*4*	
A	1 6	10 2	0 0	1 5	-7
B	-2 7	1 7	-1 3	15 8	-3
C	2 +θ 9	3 9	18 -θ 4	4 12	-3
D	6 -θ 12	2 9	-2 +θ 5	7 11	0
	12	9	7	11	

Since some of the Δ_{ij}'s are negative, therefore, the above solution is not optimal. Introduce in the cell (D, 3) with the most negative $\Delta_{ij,}$ assignment θ. The value of θ and the reallocated solution as obtained from above is given below. The value of u_i's, v_j's are also calculated. The solution satisfies the conditions of optimality. The condition $\Delta_{ij} = c_{ij} - (u_i + v_j) \geq 0$ for non allocated cells is also satisfied.

Factory	*Sales Agency*				u_i's
	1	*2*	*3*	*4*	
A	3 6	10 2	2 0	1 5	-7
B	0 7	1 7	1 3	15 8	-3
C	8 9	1 9	12 4	2 12	-1
D	2 12	2 9	6 5	7 11	0
v_j's	10	9	5	11	

Since all Δ_{ij}'s for non basic cells are positive, therefore the solution obtained above is an optimal one. The allocation of factories to sales agencies and their profit amount is given below:

Factory	*Sales Agency*	*Profit*	
A	2	10 × Rs.7	= Rs.70
B	4	15 × Rs.1	= Rs.15
C	1	8 × Rs.0	= Rs.0
C	3	12 × Rs.5	= Rs.60
D	2	2 × Rs.0	= Rs.0

D	3	6 × Rs.4	= Rs.24
D	4	7 × Rs.(-2)	= -Rs.14
			= Rs.155

Since one of the Δ_{ij}s is Zero, the optimal solution obtained above is not unique. Alternate solution also exists.

Question 12

XYZ and Co. has provided the following data seeking your advice on optimum investment strategy.

Investment made at the Beginning of year	*Net Return Data (in Paise) of Selected Investment*				*Amount available (Lacs)*
	P	*Q*	*R*	*S*	
1	*95*	*80*	*70*	*60*	*70*
2	*75*	*65*	*60*	*50*	*40*
3	*70*	*45*	*50*	*40*	*90*
4	*60*	*40*	*40*	*30*	*30*
Maximum Investment (Lacs)	*40*	*30*	*60*	*60*	

The following additional information are also provided

- *P, Q, R and S represent the selected investments,*
- *The company has decided to have four years investment plan.*
- *The policy of the company is that amount invested in any year will remain so until the end of the fourth year.*
- *The values (Paise) in the table represent net return on investment of one Rupee till he end of the planning horizon (for example, a Rupee investment in Investment P at the beginning of year 1 will grow to Rs.1.95 by the end of the fourth year, yielding a return of 95 paise)*

Using the above determine the optimum investment strategy. *(Nov 1996)*

Answer

The given problem is an unbalanced transportation problem which is converted into a balanced on by adding a dummy investment as given below:

Year	*Net Return data (in paise) of Investment*				*Dummy*	*Amount Payable*
	P	*Q*	*R*	*S*		
1	95	80	70	60	0	70
2	75	65	60	50	0	40
3	70	45	50	40	0	90
4	90	40	40	30	0	30
Maximum Investment	40	50	60	60	20	

The values in the table represent net return on investment of one rupee till the end of the fourth year. The objective of the company is to maximize the net return. For achieving this objective, let us convert this maximization problem into minimization problem by subtracting all the elements of the above payoff matrix from the highest payoff i.e. 95, and apply Vogel's approximation method for finding the initial feasible solution.

Year	*Loss Matrix – Investment type*	*Dummy*	*Amount*	*Difference*

	P	Q	R	S		Available	
1	40 0	30 15	25	35	95	70/30/0	15/10 _ _
2	20	20 30	20 35	45	95	40/20/0	10/5/5/10
3	25	50	40 45	50 55	95	90/50/0	10/40/20 /0/0
4	35	55	55	10 65	20 95	30/20/0	10/3/0
Maximum Investment	40/0	50/20/0	60/40/0	60/10/0	20/0		
Difference	20	15	10	10	0		
	-	15	10	10	0		
	-	20	10	10	0		
	-	-	10	10	0		

solution obtained by VAM is as given below

Year	*Loss Matrix – Investment type*				*Dummy*	*Amount Available*
	P	*Q*	*R*	*S*		
1	40 0	30 15	25	35	95	70
2	20	20 30	20 35	45	95	40
3	25	50	40 45	50 55	95	90
4	35	55	55	10 65	20 95	30
Maximum Investment	40/0	50/20/0	60/40/0	60/10/0	20/0	

This initial solution is tested for optimality. There are 8 (=m+n-1) independent allocations. Let us introduce u_i, v_j, i=(1,2,3,4); = (1,2,3,4,5 such that Dij = cij = (u_i+v_j) for allocation cell. We assume u1 = 0 and remaining u1's vj's and Dij's are calculated.

Year	*Loss Matrix – Investment type*				*Dummy*	*Amount Available*
	P	*Q*	*R*	*S*		
1	40 0	30 15	5 25	5 35	35 95	0
2	5 20	20 30	20 35	0 45	20 95	15
3	0 25	10 50	40 45	50 55	10 95	25
4	0 35	5 55	55	10 65	20 95	35
v_j's	0	15	20	30	60	

On calculating A_{ij}s for non-allocated cells, we found that their values are positive, hence the initial solution obtained above is optimal. The optimal allocations are given below:

Year	Invest in	Net Return
1	Invest Rs 40 lacs in investment P	0.95xRs.40 lacs = Rs. 38,00,000
	Rs 30 lacs in investment Q	0.80xRs.30 lacs = Rs. 24,00,000
2	Invest Rs 20 lacs in investment Q	0.65xRs.20 lacs = 13,00,000
	Rs 20 lacs in investment R	0.60xRs.20 lacs = 12,00,000
3	Invest Rs 40 lacs in investment R	0.50xRs.40 lacs = Rs. 20,00,000
	Rs 50 lacs in investment S	0.40xRs.50 lacs = Rs. 20,00,000
4	Invest Rs.10 lacs in investment S	0.30xRs.10 lacs = Rs.3,00,000
	Total Rs.130,00,000	

Question 13

A company has four terminals U, V, W and X. At the start of a particular day 10, 4, 6 and 5 trailers respectively are available at these terminals. During the previous night 13, 10 , 6 and 6 trailers respectively were loaded at plants A, B, C and D. The company dispatcher has come up with the costs between the terminals and plants as follows:

Plants

		A	*B*	*C*	*D*
Terminals	*U*	*20*	*36*	*10*	*28*
	V	*40*	*20*	*45*	*20*

W	*75*	*35*	*45*	*50*
X	*30*	*35*	*40*	*25*

Find the allocation of loaded trailers from plants to terminals in order to minimize transportation cost. (May 1997)

Answer

The given problem is an unbalanced transportation problem since the availability of trailers (= 10+4+6+5=25) is less than the requirement (=13+10+6+6=35). Therefore, it is first converted into a balanced problem by adding a dummy terminal with an availability of 10 trailers and cost elements for various plants as zero. The problem becomes as given below.

Plants

Terminals	A	B	C	D	Availability
U	20	36	10	28	10
V	40	20	45	20	4
W	75	35	45	50	6
X	30	45	40	25	5
Dummy	0	0	0	0	10
Requirement	13	10	6	6	

The objective of the company is to minimize transportation cost. To achieve this objective, let us find an initial feasible solution by applying Vogel's Approximation Method to the above matrix.

Plants

Terminals	A	B	C	D	Availability	Difference
U	3 20	36	6 10	1 28	10/4/1/0	10/10/8/8
V	40	4 20	45	20	4/0	0/0/0/-
W	75	6 35	45	50	6/0	10/10/15/15
X	30	35	40	5 25	5/0	5/5/5/5
Dummy	10 0	0	0	0	10/0	0/-/-/-
Requirement	13/3/0	10/6/0	6/0	6/1/0		
Difference	20	20	10	20		
	10	15	30	5		
	10	15	0	5		
	10	0	-	5		

The initial solution is as given below which is tested for optimality.

Plants

Terminals	A	B	C	D	Availability
U	3 20	 36	6 10	1 28	10
V	 40	4 20	 45	 20	4
W	 75	6 35	 45	 50	6
X	 30	 35	 40	5 25	5
Dummy	10 0	 0	 0	 0	10
Requirement	13	10	6	6	

The number of allocation is 7 which is one less than the required m+n-1 (=8) allocations. Introduce a very small quality e in the least cost independent cell (Dummy, B0. Let us also introduce u_j, v_j; I- (1,2 – 5) j = (1,2,3,4) such that $\Delta_{ij} = c_{ij}-(u1+v_j)$ for allocation cells. We assume that u1=0 and remaining u_i's, v_j's and Δ_{ij}'s are calculated as below:

Terminals	A	B	C	D	u_i's
U	3 +θ 20	16 36	6 10	1 -θ 28	0
V	20 40	4 -θ 20	35 45	-8 +θ 20	0
W	40 75	6 35	20 45	7 50	15
X	13 30	18 35	33 40	5 25	-3
Dummy	10 -θ 0	e +θ 0	10 0	-8 0	-20
vj's	20	20	10	28	

Since some of the Δ_{ij}'s are negative, the above solution is not optimal. Introduce in the cell (V,D) with the most negative Δ_{ij} an assignment θ. And the reallocated solution as obtained from above is given below. The values of u_i's and v_j's and Δ_{ij}'s also calculated.

Terminals	A	B	C	D	u_i's
U	4 20	16 36	6 10	8 28	0
V	20 40	3 20	35 45	1 20	0
W	40 75	6 35	20 45	15 50	15
X	5	10	25	5	

	30	35	40	25	5
Dummy	9	1	10	0	
	0	0	0	0	-20
v_j's	20	20	10	20	-20

Since all Δ Ij's for non basic cells are positive, therefore, the solution obtained above is an optimal one. The allocation of terminals to plants and their cost is given below.

Terminal	Plant	Cost	
U	A	4 × Rs.20	= Rs.80
U	C	6 × Rs.10	= Rs.60
V	B	3 × Rs.20	= Rs.60
V	D	1 × Rs.20	= Rs.20
W	B	6 × Rs.35	= Rs.210
X	D	5 × Rs.25	= Rs.125
			= Rs.555

Question 16

A manufacturing company produces two types of product the SUPER and REGULAR. Resource requirements for production are given below in the table. There are 1,600 hours of assembly worker hours available per week. 700 hours of paint time and 300 hours of inspection time. Regular customers bill demand at least 150 units of the REGULAR type and 90 units of the SUPER type.

(8 Marks)

Table

Product	*Profit/contribution Rs.*	*Assembly time Hrs.*	*Paint time Hrs.*	*Inspection time Hrs.*
REGULAR	*50*	*1.2*	*0.8*	*0.2*
SUPER	*75*	*1.6*	*0.9*	*0.2*

Formulate and solve the given Linear programming problem to determine product mix on a weekly basis.

Answer

Let x_1 and x_2 denote the number of units produced per week of the product 'REGULAR' and 'SUPER' respectively.

Maximise $Z = 50x_1 + 75x_2$

Subject to

$1.2x_1 + 1.6x_2 \le 1{,}600$ or $12x_1 + 16x_2 \le 16{,}000$ -(i)

$0.8x_1 + 0.9x_2 \le 700$ or $8x_1 + 9x_2 \le 7{,}000$ -(ii)

$0.2x_1 + 0.2x_2 \le 300$ or $2x_1 + 2x_2 \le 3{,}000$ -(iii)

$X_1 \ge 150$ -(iv)

$x_2 \ge 90$ -(v)

Let

$x_1 = y_1 + 150$

$x_2 = y_2 + 90$ where $y_1, y_2 \ge 0$

Maximize $Z = 50(y_1 + 150) + 75(y_2 + 90)$ or , $Z = 50y_1 + 75y_2 + 14{,}250$

Subject to :

$12(y_1 + 150) + 16(y_2 + 90) \leq 16{,}000$

$8(y_1 + 150) + 9(y_2 + 90) \leq 7{,}000$

$2(y_1 + 150) + 2(y_2 + 90) \leq 3{,}000$

and $y_1, y_2 \geq 0$

Adding slack variables s_1, s_2, s_3, we get

Maximize $Z = 50y_1 + 75y_2 + 14{,}250$ subject to

$12y_1 + 16y_2 + s_1 = 12{,}760$

$8y_1 + 9y_2 + s_2 = 4{,}990$

$2y_1 + 2y_2 + s_3 = 2{,}520$

Table -1

C_j			50	75	0	0	0	
			y_1	y_2	s_1	s_2	s_3	
C_b								
0	s_1	12,760	12	16	1	0	0	12760/16
0	s_2	4,990	8	9	0	1	0	4990/9
0	s_3	2,520	2	2	0	0	1	2520/2
Δ_j			-50	-75	0	0	0	

Table II

C_j			50	75	0	0	0
C_b			y_1	y_2	s_1	s_2	s_3
0	s_1	3889	-20/9	0	1	-16/9	0
75	y_2	554.44	8/9	1	0	1/9	0
0	s_3	1411	2/9	0	0	-2/9	1
Δ_j			50/3	0	0	75/9	0

Since all the elements in the index row are either positive or equal to zero , table II gives an optimum solution which is $y_1 = 0$ and $y_2 = 554.44$

Substituting these values we get

$x_1 = 0+150 = 150$

$x_2 = 90+554.44 = 644.44$ and the value of objective function is

$Z = 50 \times 150 + 75 \times 644.44$

=Rs. 55,833

Question 17

A company manufactures two products A and B, involving three departments – Machining, Fabrication and Assembly. The process time, profit/unit and total capacity of each department is given in the following table:

	Machining (Hours)	*Fabrication (Hours)*	*Assembly (Hours)*	*Profit (Rs).*
A	*1*	*5*	*3*	*80*
B	*2*	*4*	*1*	*100*
Capacity	*720*	*1,800*	*900*	

Set up Linear Programming Problem to maximise profit. What will be the product Mix at Maximum profit level ?

Answer

Maximize $z = 80x + 100y$ subject to

$x + 2y \le 720$

$5x + 4y \le 1800$

$3x + y \le 900$

$x \ge 0 \; y \ge 0$

where x = No. of units of A

y = No. of units of B

By the addition of slack variables s1, s2 and s3 the inequalities can be converted into equations. The problems thus become

$z = 80x + 100y$ subject to

$x + 2y + s_1 = 720$

$5x + 4y + s_2 = 1800$

$3x + y + s_3 = 900$

and $x \ge 0, \quad y \ge 0, \quad s_1 \ge 0, \quad s_2 \ge 0, \quad s_3 \ge 0$

Table I:

			80	100	0	0	0	
	Profit/unit	Qty.	X	Y	S_1	S_2	S_3	
S_1	0	720	I	2	1	0	0	$\frac{720}{2} = 360$
S_2	0	1800	5	4	0	1	0	1800/4 = 450
S_3	0	900	3	I	0	0	1	900/1 = 900
Net evaluation row			80	100	0	0	0	

$1800 - 720 \times 4/2 = 360$	$900 - 720 \times 1/2 = 540$
$5 - I \times 2 = 3$	$3 - 1 \times ½ = 5/2$
$4 - 2 \times 2 = 0$	$I - 2 \times 1/2 = 0$
$0 - I \times 2 = -2$	$0 - I \times 1/2 = -1/2$
$I - 0 \times 2 = I$	$0 - 0 \times 1/2 = 0$
$0 - 0 \times 2 = 0$	$I - 0 \times 1/2 = I$

Table 2:

			80	100	0	0	0
Program	Profit/unit	Qty.	X	Y	S_1	S_2	S_3

Y	100	360	½	I	½	0	0	360÷1/2=720
S2	0	360	3	0	–2	1	0	360÷3=120
S3	0	540	5/2	0	–1/2	0	I	540÷5/2=216
Net evaluation row			30	0	–50	0	0	

360 – 360 × 1/6 = 300	540 – 360 × 5/6 = 240
½ - 3 ×1/6 = 0	5/2 –3 × 5/6 = 0
1- 0× 1/6=1	0 – 0 × 5/6 = 0
½ - -2 × 1/6 = 5/6	-1/2 - -2 ×5/6 = 7/6
0 – 1 ×1/6 = - 1/6	0 – 1 × 5/6 = -5/6
0 – 0 ×1/6 = 0	1-0 × 5/6 = 1

Table 3:

			80	100	0	0	0
Program	Profit/unit	Qty.	X	Y	S_1	S_2	S_3
Y	100	300	0	I	5/6	-1/6	0
X	80	120	I	0	–2/3	1/3	0
S3	0	240	0	0	7/6	-5/6	I
Net evaluation row			0	0	-500/6 +160/3 $= \frac{180}{6}$	+100/6 -80/3 $= -\frac{60}{6}$	0

All the values of the net evaluation row of Table 3 are either zero or negative, the optimal program has been obtained.

Here X = 120, y = 300 and the maximum profit

= 80×120 + 100× 300 = 9600 + 30,000

= Rs. 39,600.

Question 18

Three grades of coal A, B and C contains phosphorus and ash as impurities. In a particular industrial process, fuel up to 100 ton (maximum) is required which could contain ash not more than 3% and phosphorus not more than .03%. It is desired to maximize the profit while satisfying these conditions. There is an unlimited supply of each grade. The percentage of impurities and the profits of each grade are as follows:

Coal	*Phosphorus (%)*	*Ash (%)*	*Profit in Rs. (per ton)*
A	*.02*	*3.0*	*12.00*
B	*.04*	*2.0*	*15.00*
C	*.03*	*5.0*	*14.00*

You are required to formulate the Linear-programming (LP) model to solve it by using simplex method to determine optimal product mix and profit.

Answer

Let X_1, X_2 and X_3 respectively be the amounts in tons of grades A, B, and C used. The constraints are

(i) Phosphorus content must not exceed 0.03%

$.02 X_1 + .04X_2 + 0.3 X_3 \leq .03 (X_1 + X_2 + X_3)$

$2X_1 + 4 X_2 + 3X_3 \leq 3 (X_1 + X_2 + X_3)$ or $– X_1 + X_2 \leq 0$

(ii) Ash content must not exceed 3%

$3X_1 + 2 X_2 + 5 X_3 \leq 3 (X_1 + X_2 + X_3)$ or $– X_2 + 2X_3 \leq 0$

(iii) Total quantity of fuel required is not more than 100 tons. $X_1 + X_2 + X_3 \leq 100$

The Mathematical formulation of the problem is

Maximize $Z = 12 X_1 + 15X_2 + 14 X_3$

Subject to the constraints:

$- X_1 + X_2 \leq 0$

$- X_2 + X_3 \leq 0$

$X_1 + X_2 + X_3 \leq 100$

$X_1, X_2, X_3 > 0$

Introducing slack variable $X_4 >0$, $X_5>0$, $X_6>0$

			12	15	14	0	0	0
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
0	Y_4	0	-1	1*	0	1	0	0
0	Y_5	0	0	-1	2	0	1	0
0	Y_6	100	1	1	1	0	0	1
	Z		-12	-15	-14	0	0	0
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
15	Y_2	0	-1	1	0	1	0	0
0	Y_5	0	-1	0	2	1	1	0
0	Y_6	100	2*	0	1	-1	0	1
	Z		-27		-14	15	0	0
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
15	Y_2	50	0	1	1/2	1/2	0	1/2
0	Y_5	50	0	0	5/2*	1/2	1	1/2
12	Y_1	50	1	0	1/2	-1/2	0	1/2
	Z		0	0	-1/2	3/2	0	27/2
C_b	Y_b	X_b	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
15	Y_2	40	0	1	0	2/5	-1/5	2/5
14	Y_3	20	0	0	1	1/5	2/5	1/5
12	Y_1	40	1	0	0	-3/5	-1/5	2/5
	Z		0	0	0	8/5	1/5	68/5

The optimum solution is $X_1 = 40$, $X_2 = 40$ and $X_3 = 20$ with maximum Z = 1360.

17

THE ASSIGNMENT PROBLEM

Question 1

An Electronic Data Processing (ED) centre has three expert Software professionals. The Centre wants three application software programs to be developed. The head of EDP Centre estimates the computer time in minutes required by the experts for development of Application Software Programs as follows:

Software programs	*Computer time (in minutes) required by software Professionals*		
1	*100*	*85*	*70*
2	*50*	*70*	*110*
3	*110*	*120*	*130*

Assign the software professionals to the application software programs to ensure minimum usage of computer time. *(May 2002)*

Answer

The given problem is a balanced minimization assignment problem.

Step 1 & II : The minimum time elements in row 1, 2 and 3are 70, 50 and 110 respectively. We subtract these elements from all elements in their respective row. The reduced matrix is shown in Table 1.

Table 1

Software Programs	A	B	C
1	30	15	0
2	0	20	60
3	0	10	20

The minimum time elements in columns A, B and C are 0, 10, and 0 respectively. Subtract these elements from all the elements in their respective columns to get the reduced time matrix as shown in table 2.

Table 2

Software Programs	A	B	C
1	30	5	0
2	0	10	60
3	0	0	20

Step 3(a) : The minimum number of horizontal and vertical lines to cover all zeros is 3, which is equal to the order of the matrix. Examine all rows one by one starting from row 1 until a row containing only single zero element is located. Assign this zero. All zero in the assigned column are crossed off as shown in table 3.

Table 3

Software Programs	A	B	C
1	30	5	0
2	0	10	60
3	~~0~~	0	20

Step 3(b): Now examine each column starting from A. There is only one zero in column. B Assign this cell as shown in table 4

Table 4

Software Programs	A	B	C
1	30	15	$\boxed{0}$
2	$\boxed{0}$	20	60
3	~~0~~	$\boxed{0}$	20

Step 3(c) : Since the number of assignments (=3) equals the number of rows, the optimal solution is obtained. This Pattern of assignments among software professionals and programs with their respective time (in minutes) is given below:

Program	Software Professionals	Time (in Minutes)
1	C	70
2	A	50
3	B	120
	Total	240

Question 2

A Production supervisor is considering, how he should assign five jobs that are to be performed, to five mechanists working under him. He wants to assign the jobs to the mechanists in such a manner that the aggregate cost to perform the jobs is the least. He has following information about the wages paid to the mechanists for performing these jobs:

Jobs

Mechanist	*1*	*2*	*3*	*4*	*5*
A	*10*	*3*	*3*	*2*	*8*
B	*9*	*7*	*8*	*2*	*7*
C	*7*	*5*	*6*	*2*	*4*
D	*3*	*5*	*8*	*2*	*4*
E	*9*	*10*	*9*	*6*	*10*

Assign the jobs to the mechanists so that the aggregate cost is the least. *(Nov 2001)*

Answer

The given problem is a standard minimization problem.

Subtracting minimum element of each row from all the elements of that row, the given problem reduces to

Jobs

Mechanist	*1*	*2*	*3*	*4*	*5*
A	8	1	1	0	6
B	7	5	6	0	5
C	5	3	4	0	2
D	1	3	6	0	2
E	3	4	3	0	4

Subtract the minimum element of each column from all the elements of that column. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

Jobs

Mechanist	*1*	*2*	*3*	*4*	*5*
A	7	0	0	0	4
B	6	4	5	0	3
C	4	2	3	0	0
D	0	2	5	0	0
E	2	3	2	0	2

Since the minimum number of lines covering all zeros is equal to 4 which is less than the number of columns/rows (=5), the above table will not provide optimal solution. Subtract the minimum uncovered element (=2) from all uncovered elements and add to the elements lying on the intersection of two lines, we get the following matrix.

Jobs

Mechanist	*1*	*2*	*3*	*4*	*5*
A	7	0	0	2	6
B	4	2	3	0	3
C	2	0	1	0	0
D	0	2	5	2	2
E	0	1	0	0	2

Since the minimum number of horizontal and vertical lines to cover all zeros is equal to five which is equal to the order of the matrix, the above table will give the optimal solution. The optimal assignment is made below:

Jobs

Mechanist	*1*	*2*	*3*	*4*	*5*
A	7	$\boxed{0}$	$\cancel{0}$	2	6
B	4	2	3	$\boxed{0}$	3
C	2	$\cancel{0}$	1	$\cancel{0}$	$\boxed{0}$
D	$\boxed{0}$	2	5	2	2
E	$\cancel{0}$	1	$\boxed{0}$	$\cancel{0}$	2

The optimal assignment is given below:

Mechanist	Job	Wages
A	2	3

B	4	2
C	5	4
D	1	3
E	3	9
		21

The total least cost associated with the optimal mechanist-job assignment = 21

Question 3

A project consist of four (4) major jobs, for which four (4) contractors have submitted tenders. The tender amounts, in thousands of rupees, are given below.

Jobs

Contractors	*A*	*B*	*C*	*D*
1	*120*	*100*	*80*	*90*
2	*80*	*90*	*110*	*70*
3	*110*	*140*	*120*	*100*
4	*90*	*90*	*80*	*90*

Find the assignment, which minimizes the total cost of the project. Each contractor has to be assigned one job.
(May 2001)

Answer

The given problem is a standard minimization problem. Subtracting the minimum element of each row from all its elements in turn, the given problem reduces to

Jobs

Contractors	*A*	*B*	*C*	*D*
1	40	20	0	10
2	10	20	40	0
3	10	40	20	0
4	10	10	0	10

Now subtract the minimum element of each column from all its elements in turn. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

Jobs

Contractors	*A*	*B*	*C*	*D*
1	30	10	0	10
2	0	10	40	0
3	0	30	20	0
4	0	0	0	10

Since the minimum number of lines to cover all zeros is equal to 4(=order of the matrix), this matrix will give optimal solution. The optimal assignment is made in the matrix below:

Jobs

Contractors	*A*	*B*	*C*	*D*
1	30	10	$\boxed{0}$	10
2	$\boxed{0}$	10	40	$\cancel{0}$
3	$\cancel{0}$	30	20	0
4	$\cancel{0}$	$\boxed{0}$	$\cancel{0}$	10

The optimal assignment is

Contractor	*Job*	*Cost (in thousands of rupees)*
1	C	80
2	A	80
3	D	100
4	B	90

Hence, total minimum cost of the project will be Rs.3,50,000.

Question 4

A Car hiring company has one car at each of the five depots A,B,C,D and E. A customer in each of the five towns V,W,X,Y and requires a car. The distance in kms, between depots (origin) and the towns (destination) are given in the following table:

Depots

		A	*B*	*C*	*D*	*E*
	V	*3*	*5*	*10*	*15*	*8*
	W	*4*	*7*	*15*	*18*	*8*
Towns	*X*	*8*	*12*	*20*	*20*	*12*
	Y	*5*	*5*	*8*	*10*	*6*
	Z	*10*	*10*	*15*	*25*	*10*

Find out as to which car should be assigned to which customer so that the total distance traveled is a minimum. How much is the total traveled distance?

Answer

The given problem is a balanced minimization assignment problem. Let us apply the assignment algorithm to find the optimal assignment. Subtracting the smallest element of teach row from all the elements of that row, we get the following table:

Depots

		A	*B*	*C*	*D*	*E*
	V	0	2	7	12	5
	W	0	3	11	14	4
Towns	X	0	4	12	12	4
	Y	0	0	3	5	1
	Z	0	0	5	15	0

Subtracting the smallest element of each column from the elements of that column, wet get the following:

Depots

		A	B	C	D	E
	V	0	2	4	7	5
	W	0	3	8	9	4
Towns	X	0	4	9	7	4
	Y	0	0	0	0	1
	Z	0	0	2	10	0

Draw the minimum number of lines to cover all zeros. Since the number of lines (=3) is not equal to the order of the matrix (which is 5), the above matrix will not give the optimal solution. Subtract the minimum uncovered element (=2) from all uncovered elements and add it to the elements lying on the intersection of two lines, we get the following matrix.

Depots

		A	B	C	D	E
	V	0	0	2	5	3
	W	0	1	6	7	2
Towns	X	0	2	7	5	2
	Y	2	0	0	0	1
	Z	2	0	2	10	0

Again, the minimum number of lines to cover all zeros is 4, which is less than the order of the matrix. Subtract the uncovered element (=2) from all the uncovered elements and add it to the elements lying on the intersection of two lines, we get.

Depots

		A	B	C	D	E
	V	0	0	0	3	1
	W	0	1	4	5	0
Towns	X	0	2	5	3	0
	Y	4	2	0	0	1
	Z	4	2	2	10	0

Since the minimum number of lines to cover all zeros is 4 which is less than the order of the matrix, hence, the above matrix will not give the optimal solution. Subtracting the uncovered element (=1) from all the uncovered elements and adding it to the elements lying on the intersection of two lines, we get.

Depots

		A	B	C	D	E
	V	1	0	0	3	2
	W	0	0	3	4	0
Towns	X	0	1	4	2	0
	Y	5	2	0	0	2
	Z	4	1	1	9	0

Since the minimum number of lines to cover all zeros is 5 which is equal to the order of the matrix, the above table will give the optimal assignment. The optimal assignment is made below:

Depots

		A	B	C	D	E
	V	1	$\cancel{0}$	$\boxed{0}$	3	2
	W	$\cancel{0}$	$\boxed{0}$	3	4	$\cancel{0}$
Towns	X	$\boxed{0}$	1	4	2	$\cancel{0}$
	Y	5	2	$\cancel{0}$	$\boxed{0}$	2
	Z	4	1	1	9	$\boxed{0}$

The optimal assignment is

Town	*Depot*	*Distance (in kms)*
V	C	10
W	B	7
X	A	8
Y	D	10
Z	E	<u>10</u>
	Total	<u>45</u>

Hence the minimum total traveled distance = 45 kms.

Question 5

ABC airline operating 7 days a week has given the following time-table. Crews must have minimum layover of 5 hours between flights. Obtain the pairing flights that minimize the layover time away from home. For any given pairing the crew will be based at the city that results in the smaller layover.

Hyderabad-Delhi			*Delhi-Hyderabad*		
Flight No.	*Depart.*	*Arrive*	*Flight No.*	*Depart.*	*Arrive*
A1	*6 AM*	*8 AM*	*B1*	*8 AM*	*10 AM*
A2	*8 AM*	*10 AM*	*B2*	*9 AM*	*11 AM*
A3	*2 PM*	*4 PM*	*B3*	*2 PM*	*4 PM*
A4	*8 PM*	*10 PM*	*B4*	*7 PM*	*9 PM*

(May 2000)

Answer

To begin with, let us first assume that the crew is based at Hyderabad. The flight A1 that starts from Hyderabad at 6 A.M, reaches Delhi at 8 A.M. The schedule time for the flight at Delhi is 8 A.M. Since the minimum layover time for crew is 5 hours, this flight can depart only on the next day i.e. the layover time will be 24 hours. Similarly, layover times for other flights are also calculated and given in the following table:

Flight No.	*Crew based at Hyderabad*			
	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	15	21

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

Flight No.	*Crew based at Hyderabad*			
	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

Since the crew can be based at either of the places, minimum layover times can be obtained for different flight numbers by selecting the corresponding lower value out of the above two tables. The resulting table is as given below;

Flight No.	*Crew based at Hyderabad*			
	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	23

A* with an entry in the above table indicates that it corresponds to layover time when the crew is based at Delhi. We will now apply the assignment algorithm to find the optimal solution. Subtracting the minimum element of each row from all the elements of that row, we get the following matrix:

Flight No.	*Crew based at Hyderabad*			
	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 a Zero in each column, there is no need to perform column reduction. The minimum number of lines to cover all zeros 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.	*Crew based at Hyderabad*			
	B_1	B_2	B_3	B_4
A_1	14	13	$\boxed{0}$	3
A_2	13	12	7	$\boxed{0}$
A_3	$\boxed{0}$	1	6	1
A_4	1	$\boxed{0}$	7	12

The optimal assignment is

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

Question 6

Solve the assignment problem represented by the following effective matrix:

	a	*b*	*c*	*d*	*e*	*f*
A	*9*	*22*	*58*	*11*	*19*	*27*
B	*43*	*78*	*72*	*50*	*63*	*48*
C	*41*	*28*	*91*	*37*	*45*	*33*
D	*74*	*42*	*27*	*49*	*39*	*32*
E	*26*	*11*	*57*	*22*	*25*	*18*
F	*3*	*56*	*53*	*31*	*17*	*28*

(Nov 1999)

Answer

The given problem is a balanced minimization assignment problem. Let us apply the assignment algorithm. Subtracting the smallest element of each row from all the elements of that row, we get the following table:

	a	*b*	*c*	*d*	*e*	*f*
A	0	13	49	2	10	18
B	0	35	29	7	20	5
C	13	0	63	9	17	5
D	47	15	0	22	12	5
E	25	0	46	11	14	7
F	0	53	50	28	14	25

Subtracting the smallest element of each column from all the elements of that column, we get the following:

	a	*b*	*c*	*d*	*e*	*f*
A	0	13	49	0	0	10
B	0	35	29	5	10	0
C	13	0	63	7	7	0
D	47	15	0	20	2	0
E	25	0	46	9	4	2
F	0	53	50	26	4	20

Draw the minimum number of lines to cover all zeros. Since the number of lines (=5) is not equal to the order of the matrix (which is 6), the above matrix will not give the optimal solution. Subtract the minimum uncovered element (=2) from all uncovered elements and add it to the elements lying on the intersection of twc lines, we get the following matrix:

	a	*b*	*c*	*d*	*e*	*f*
A	2	15	51	0	0	15
B	0	35	29	3	8	0
C	13	0	63	5	5	0
D	47	15	0	18	0	0
E	25	0	46	7	2	2
F	0	53	50	24	2	20

Again, the minimum number of lines to cover all zeros is 5, which is less than the order of the matrix. Subtract the minimum uncovered element (=2) from all uncovered elements and add it to elements lying on the intersection of two lines, we get

	a	*b*	*c*	*d*	*e*	*F*
A	4	17	51	0	0	17
B	0	35	27	1	6	0
C	13	0	61	3	3	0
D	49	17	0	18	0	2
E	25	0	44	5	0	2
F	0	53	48	22	0	20

Since the minimum number of lines to cover all zero is 6 which is equal to the order of the matrix, hence, the above matrix will give the optimal solution. The optimal assignment are given below:

	a	*b*	*c*	*d*	*e*	*f*
A	2	17	51	$\boxed{0}$	0	17
B	0	35	27	1	6	$\boxed{0}$
C	13	$\boxed{0}$	61	3	3	$\cancel{0}$
D	49	17	$\boxed{0}$	18	0	2
E	25	$\cancel{0}$	44	5	$\boxed{0}$	2
F	$\boxed{0}$	53	48	22	$\cancel{0}$	20

The assignment is

(i) A→d, B→f, C→b, D→c, E→e, F→a

And total effect = 11+48+28+27+25+3=142

Alternate solutions exist. One of the alternate solutions is given by

(ii) A→d, B→a, C→f, D→c, E→b and F→e with total effect = 142

Question 7

To stimulate interest and provide an atmosphere for intellectual discussion, a finance faculty in a management school decides to hold special seminars on four contemporary topics: leasing, portfolio management, private mutual funds, swaps and options. Such seminars should be held once in a week in the afternoons. However, scheduling these seminars (one for each topic, and not more than one seminar per afternoon) has to be done *carefully so that the number of students unable to attend is kept to a minimum. A careful study indicates that the number of students who cannot attend a particular seminar on a specific day is as follows:*

	Leasing	*Portfolio Management*	*Private Mutual Fund*	*Swaps & Options*
Monday	*50*	*40*	*60*	*20*
Tuesday	*40*	*30*	*40*	*30*
Wednesday	*60*	*20*	*30*	*20*
Thursday	*30*	*30*	*20*	*30*
Friday	*10*	*20*	*10*	*30*

Find an optimal schedule of the seminars. Also find out the total number of students who will be missing at least one seminar. *(May 1999)*

Answer

This is an unbalanced minimization assignment problem. We, first of all balance the given problem by adding a dummy seminar:

	Leasing	*Portfolio Management*	*Private Mutual Fund*	*Swaps & Options*	*Dummy*
Monday	50	40	60	20	0
Tuesday	40	30	40	30	0
Wednesday	60	20	30	20	0
Thursday	30	30	20	30	0
Friday	10	20	10	30	0

Subtracting the minimum element of each column from all elements of that column, we get the following matrix:

	Leasing	*Portfolio Management*	*Private Mutual Fund*	*Swaps & Options*	*Dummy*
Monday	40	20	50	0	0
Tuesday	30	10	30	10	0
Wednesday	50	0	20	0	0
Thursday	20	10	10	10	0
Friday	0	0	0	10	0

The minimum number of lines to cover all zeros is 4 which is less than the order of the square matrix (i.e.5) the above matrix will not give the optimal solution. Subtract the minimum uncovered element (=10) from all uncovered elements and add it to the elements lying on the intersection of two lines, we get the following matrix.

	Leasing	*Portfolio Management*	*Private Mutual Fund*	*Swaps & Options*	*Dummy*
Monday	30	20	40	0	0
Tuesday	20	10	20	10	0
Wednesday	40	0	10	0	0

Thursday	10	10	0	10	0
Friday	0	10	0	20	10

Since the minimum number of lines to cover all zeros is 5 which is equal to the order of the matrix, the above matrix will give the optimal solution which is given below:

	Leasing	*Portfolio Management*	*Private Mutual Fund*	*Swaps & Options*	*Dummy*
Monday	30	20	40	$\boxed{0}$	$\cancel{0}$
Tuesday	20	10	20	10	$\boxed{0}$
Wednesday	40	$\boxed{0}$	10	$\cancel{0}$	$\cancel{0}$
Thursday	10	10	$\boxed{0}$	10	$\cancel{0}$
Friday	$\boxed{0}$	10	$\cancel{0}$	20	10

And the optimal schedule is

		No. of Students Missing
Monday	: Swaps and options	20
Tuesday	: No Seminar	0
Wednesday	: Portfolio Management	20
Thursday	: Pvt. Mutual funds	20
Friday	: Leasing	10
		70

Thus, the total number of students who will be missing at least one seminar = 70

Question 8

A manufacturing company has four zones A, B, C, D and four sales engineers P, Q, R, S respectively for assignment. Since the zones are not equally rich in sales potential, therefore it is estimated that a particular engineer operating in a particular zone will bring the following sales;

Zone A	*:*	*4,20,000*
Zone B	*:*	*3,36,000*
Zone C	*:*	*2,94,000*
Zone D	*:*	*4,62,000*

The engineers are having different sales ability. Working under the same conditions, their yearly sales are proportional to 14, 9, 11 and 8 respectively. The criteria of maximum expected total sales is to be met by assigning the best engineer to the richest zone, the next best to the second richest zone and so on.

Find the optimum assignment and the maximum sales. *(May 1998)*

Answer

It is given that the yearly sales of four sales engineers are proportional to 14, 9, 11 and respectively. The sum of proportion is 14+9+11+8=42

Let us assume that Rs.1,000 is equivalent to one unit. The sales units of four engineers in four different zones have been calculated as in the following table:

Zones

Sales Engineer	A	B	C	D
P	(14/42)×420=140	(14/42)×336=112	(14/42)×294=98	(14/42)×462=154
Q	(9/42)×420=90	(9/42)×336=72	(9/42)×294=63	(9/42)×462=99
R	(11/42)×420=110	(11/42×336=88	(11/42)×294=77	(11/42)×462=121
S	)8/42)×420=80	(8/42)×336=64	(8/42)×294=56	(8/42)×462=88

The problem here is to find the optimum assignment in the following sales table so as to maximize the total sales of the company.

Zones (Sales in thousands of rupees)

Sales Engineer	A	B	C	D
P	140	112	98	154
Q	90	72	63	99
R	110	88	77	121
S	80	64	56	88

In order to apply the assignment algorithm, we will first convert this maximization problem into a minimization problem by subtracting all elements of the above matrix from the highest element i.e. 154. The resultant loss matrix is given below:-

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D
P	14	42	56	0
Q	64	82	91	55
R	44	66	77	33
S	74	90	98	66

Now perform the row operations with each of the row i.e. from all the elements of a row, subtract the minimum element of that row. The reduced matrix is as given below:

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D
P	14	42	56	0
Q	9	27	36	0
R	11	33	44	0
S	8	24	32	0

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:

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D
P	6	18	24	0
Q	1	3	4	0
R	3	9	12	0
S	0	0	0	0

The minimum number of lines drawn to cover all zeros is 2 which is less than the order of the matrix (i.e. 4), hence we can't not make assignments. Subtract the minimum uncovered element from all the uncovered elements and add it to the elements lying at the intersection of two lines, we get:

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D
P	5	17	23	0
Q	0	2	3	0
R	2	8	11	0
S	0	0	0	1

The minimum number of lines drawn again to cover all the zeros is 3 which is one less than the order of the matrix. Repeat the above step which gives the following table:

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D
P	5	15	21	0
Q	0	0	1	0
R	2	6	9	0
S	2	0	0	3

The minimum number of lines to cover all zeros is still one less then the order of the matrix. Repeat the above step again, which gives the following table:

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D
P	3	13	19	0
Q	0	0	1	2
R	0	4	7	0
	2	0	0	5

The minimum number of lines drawn to cover all the zeros is 4 which is equal to the order of the matrix. Hence, the above table will give the optimum assignment. The assignments are as follows:

Zones (Loss in thousands of rupees)

Sales Engineer	A	B	C	D

P	3	13	19	0
Q	0	0	1	2
R	0	4	7	0
S	2	0	0	5

Engineers	Zones	Sales (in Rs.)
P	D	1,54,000
Q	B	72,000
R	A	1,10,000
S	C	56,000
		3,92,000

It can be seen from the above assignments that the best engineer P is assigned to the richest Zone D, the next best engineer R is assigned to second richest zone A, the next best engineer Q is assigned to zone B and so on. Hence, the optimum assignment matches the company's criteria of achieving the maximum expected total sales.

Question 9

An organization is producing 4 different products viz. A, B, C, and D having 4 operators viz. P, Q, R and S, who are capable of producing any of the four products, works effectively 7 hours a day. The time (in minutes) required for each operator for producing each of the product are given in the cells of the following matrix along profit (Rs. per unit):

Operator	*Product*			
	A	*B*	*C*	*D*
P	*6*	*10*	*14*	*12*
Q	*7*	*5*	*3*	*4*
R	*6*	*7*	*10*	*10*
S	*20*	*10*	*15*	*15*
Profit (Rs./Units)	*3*	*2*	*4*	*1*

Find out the assignment of operators to products which will maximize the profit. *(May 1996)*

Answer

Using the information that the factory works effectively 7 hours (=420 minutes) a day and the time required by each operator for producing each of the products, we obtain the following production and profit matrices:

Production Matrix (units)				
Operator	*Product*			
	A	*B*	*C*	*D*
P	70	42	30	35
Q	60	84	140	105
R	70	60	42	42
S	21	42	28	28

Profit Matrix (in Rs.)				
Operator	*Product*			
	A	*B*	*C*	*D*
P	210	84	120	35
Q	180	168	560	105
R	210	120	168	42
S	63	84	112	28

In order to apply the assignment algorithm for minimizing losses, let us first convert this profit matrix to a loss matrix by subtracting all the elements of the given matrix from its highest element which is equal to Rs.560. The matrix so obtained is given below:

Operator	*Product*			
	A	*B*	*C*	*D*
P	350	476	440	525
Q	380	392	0	455
R	350	440	392	518
S	497	476	448	532

Now apply the assignment algorithm to the above loss matrix. Subtracting the minimum element of each row from all elements of that row, we get the following matrix:

Operator	*Product*			
	A	*B*	*C*	*D*
P	0	126	90	175
Q	380	392	0	455
R	0	90	42	168
S	49	28	0	84

Now subtract the minimum element of each column from the elements of that column to get the following matrix:

Operator	*Product*			
	A	*B*	*C*	*D*
P	0	98	90	91
Q	380	364	0	371
R	0	62	42	84
S	49	0	0	0

Draw the minimum number of lines to cover all zeros. The minimum number of lines to cover all zeros is three which is less than the order of the square matrix (i.e.4) thus the above matrix will not give the optimal solution. Subtract the minimum uncovered element (=62) from all uncovered elements and add it to the elements lying on the intersection of two lines, we get the following matrix:

Operator	*Product*			
	A	*B*	*C*	*D*
P	0	36	90	29
Q	380	302	0	309
R	0	0	42	22
S	111	0	62	0

The minimum number of lines which cover all zeros is 4 which is equal to the order of the matrix, hence, the above matrix will give the optimal solution. Specific assignments in this case are as below:

Operator	*Product*			
	A	*B*	*C*	*D*

P	0	36	90	29
Q	380	302	0	309
R	0	0	42	22
S	111	0	62	0

Operator	Product	Profit (Rs.)
P	A	210
Q	C	560
R	B	120
S	D	28
Total	Profit (Rs.)	918

Question 10

A private firm employs typists on hourly piece rate basis for their daily work. Five typists are working in that firm and their charges and speeds are different. On the basis of some earlier understanding, only one job is given to one typist is paid for full hours even when he or she works for a fraction of an hour. Find the least cost allocation for the following when he or she works for a fraction of an hour. Find the least cost allocation for the following data:

Typist	*Rate per hour (Rs.)*	*Number of pages typed hour*	*Job*	*No. of pages*
A	*5*	*12*	*P*	*199*
B	*6*	*14*	*Q*	*175*
C	*3*	*8*	*R*	*143*
D	*4*	*10*	*S*	*298*
E	*4*	*11*	*T*	*178*

(Nov 1996)

Answer

The following matrix gives the cost incurred if the typist (i = A, B, C, D, E) executes the job (j = P, Q, R, S, T).

Job

Typist	*P*	*Q*	*R*	*S*	*T*
A	85	75	65	125	75
B	90	78	66	132	78
C	75	66	57	114	69
D	80	72	60	120	72
E	76	64	56	112	68

Subtracting the minimum element of each row from all its elements in turn, the above matrix reduces to

Job

Typist	*P*	*Q*	*R*	*S*	*T*
A	20	10	0	60	10
B	24	12	0	66	12

C	18	9	0	57	12
D	20	12	0	60	12
E	20	8	0	56	12

Now subtract the minimum element of each from all its elements in turn, and draw minimum number of lines horizontal or vertical so as to cover all zeros . All zeros can be covered by four lines as given below:

2	2	0	4	0
6	4	0	10	2
0	1	0	1	2
2	4	0	4	2
2	0	0	0	2

Since there are only 4 lines (<5) to cover all zeros, optimal assignments cannot be made. The minimum uncovered element is 2.

We subtract the value 2 from all uncovered elements. Add this value to al junction values and leave the other elements undisturbed. The revised matrix to obtained is given below:

2	2	2	4	0
4	2	0	8	0
0	1	2	1	2
0	2	0	2	0
2	0	2	0	2

Since the minimum no. of lines required to cover al the zeros is only 4(<5), optimal assignment cannot be made at this stage also.

The minimum uncovered element is 1, repeating the usual process again, we get the following matrix.

2	1	2	8	0
4	1	0	7	0
0	0	2	0	2
0	1	0	1	0
3	0	3	0	3

Since the minimum number of lines to cover all zeros is equal to 5, is this matrix will give optimal solution? The optimal assignment is made in the matrix below:

Typist	*P*	*Q*	*R*	*S*	*T*
A	2	1	2	3	$\boxed{0}$
B	4	1	$\boxed{0}$	7	0
C	0	$\boxed{0}$	2	0	2
D	$\boxed{0}$	1	0	1	0
E	3	0	0	$\boxed{0}$	3

Cost (Rs.)

Thus typist A is given job 75	T	:
Thus typist B is given job 66	R	:
Thus typist C is given job 66	Q	:

Thus typist D is given job 80	P	:
Thus typist E is given job	S	112
	Total	Rs.399

Note: In case the above solution is not unique. Alternate solution also exists.

Question 11

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

Chennai Mumbai			*Mumbai - Chennai*		
Flight Number	*Depart.*	*Arrive*	*Flight Number*	*Depart.*	*Arrive*
A1	*6 AM*	*8 AM*	*B1*	*8 AM*	*10 AM*
A2	*8 AM*	*10 AM*	*B2*	*9 AM*	*11 AM*
A3	*2 PM*	*4 PM*	*B3*	*2 PM*	*4 PM*
A4	*8 PM*	*10 PM*	*B4*	*7 PM*	*9 PM*

(May 1997)

Answer

To begin with, let us first assume that the crew is based at Chennai. The flight A1, which starts from Chennai at 6 A.M, reaches Mumbai at 8 AM. The schedule time for the flight at Mumbai is 8 AM. Since the minimum layover time for crew is 5 hours, this flight can depart only on the next day i.e. the layover time will be 24 hours. Similarly, layover times for other flights are also calculated and given in the following table.

Crew based at Chennai

Flight No.	B1	B2	B3	B4
A1	24	25	6	11
A2	22	23	28	9
A3	16	17	22	27
A4	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 following table.

Crew based at Chennai

Flight No.	B1	B2	B3	B4
A1	20	19	14	9
A2	22	21	16	11
A3	238	27	22	17
A4	10	9	28	23

Now since the crew can be based at either of the laces, minimum layover times can be obtained for different flight numbers by selecting the corresponding lower value out of the above two tables. The resulting table is as given below:

Crew based at Chennai

Flight No.	B1	B2	B3	B4

A1	20*	19*	6	9
A2	22	21*	16*	9
A3	16	17	22	17*
A4	10	9*	16	21

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

Flight No.

Flight No.	B1	B2	B3	B4
A1	14	13	0	3
A2	13	12	7	0
A3	0	1	6	1
A4	1	0	7	12

Since there is a zero in each column, there is no need to perform column reduction. The minimum number of lines to cover all zeros 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.	B1	B2	B3	B4
A1	14	13	0	3
A2	13	12	7	0
A3	0	1	6	1
A4	1	0	7	12

The optimal assignment is

From Flight No.	*To Flight No.*	*Layover*
A1	B3	6
A2	B4	9
A3	B1	16
A4	B2*	9
		40 hours

Question 12

A firm produces four products.. There are four operators who are capable of producing any of these four products. The processing time various 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 products are given below:

Operators	*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 (Rs.) p. u.	*8*	*6*	*5*	*4*

Find the optimal assignment of products to operators. *(Nov 1997)*

Answer

The firm methods 8 hours a day and allows 30 minutes for lunch, hence the net working time available per day is 7 hours and 30 minute 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	30	50	45	75
2	45	75	50	75
3	18	30	30	50
4	30	50	45	45
Profit (Rs.) p. u.	8	6	5	4

Since we are given the profit per unit of each product, the profit matrix is computed as given below:

Operators	*Profit matrix in Rs. of products*			
	A	*B*	*C*	*D*
1	240	300	225	300
2	360	450	250	300
3	144	180	150	200
4	24	300	225	180

The above profit matrix is converted into a loss matrix by subtracting all the elements of the profit matrix form its highest payoff Rs.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

Let us now apply the assignment algorithm that is 'Hungarian Rule' to the above loss matrix. Accordingly, subtract the minimum element of each row from all its elements in turn, the above matrix thus reduces to :

Operators	*Loss Matrix - Products*			
	A	*B*	*C*	*D*
1	60	0	75	0
2	90	0	200	150
3	56	20	50	0
4	60	0	75	120

Subtract the minimum element of each column form all the elements of the Column in turn. Draw the minimum number of lines in the resultant matrix so as to cover all zeros, we get.

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

Since the minimum number of lines to cover all zeros is three which is one less then the order of the matrix, we subtract the minimum uncovered element (=4) from all uncovered elements and add it to the element lying at the intersection of two lines. The matrix so obtained is given below:

Operators	*Profit matrix in Rs. of 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 minimum number of lines to cover all zeros is 4 which is equal to the order of the matrix, the above will give the optimal solution. The optimal assignments are given below:

Operators	*Profit matrix in Rs. of products*			
	A	*B*	*C*	*D*
1	9	0	21	0
2	30	$\boxed{0}$	146	150
3	0	0	$\boxed{0}$	4
4	$\boxed{0}$	0	21	120

The optimal assignment is as shown below:

Operator	*Product*	*Profit (Rs.)*
1	D	300
2	B	450
3	C	150
4	A	240
	Rs.	1140

Question 13

A project consists of four (4) major jobs, for which four (4) contractors have submitted tenders. The tender amounts, in thousands of rupees, area given below:

Jobs

Contractors	*A*	*B*	*C*	*D*
1	*120*	*100*	*80*	*90*

2	*80*	*90*	*110*	*70*
3	*110*	*140*	*120*	*100*
4	*90*	*90*	*80*	*90*

Final the assignment, which minimizes the total cost of the project . Each contractor has to be assigned one job.
(May 2001)

Answer

The given problem is a standard minimization problem. Subtracting the minimum element of each row from all its elements in turn, the given problem reduces to

Jobs

Contractors	*A*	*B*	*C*	*D*
1	40	20	0	10
2	10	40	20	0
3	10	40	20	0
4	10	10	0	0

Now subtract the minimum element of each column from all it elements in turn. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

Jobs

Contractors	*A*	*B*	*C*	*D*
1	30	40	0	10
2	0	10	40	0
3	0	30	20	0
4	0	0	0	10

Since the minimum number of lines to cover all zeros is equal to 4 (= order of the matrix), this matrix will give optimal solution. The optimal assignment is made in the matrix below.

Contractors	*A*	*B*	*C*	*D*
1	30	40	$\boxed{0}$	10
2	$\boxed{0}$	10	40	0
3	0	30	20	$\boxed{0}$
4	0	$\boxed{0}$	0	10

The optimal assignment is:

Contractor	Job	Cost (in thousands of rupees)
1	C	80
2	A	80
3	D	100
4	B	90

Hence, total minimum cost of the project will be Rs. 3,50,000.

Question 14

A Marketing Manager has 4 subordinates and 4 tasks. The subordinates differ in efficiency. The tasks also differ in their intrinsic difficulty. His estimates of the time each subordinate would take to perform each task is given in the matrix below. How should the task be allocated one to one man so that the total man-hours are minimised ? (7 Marks)

	I	*II*	*III*	*IV*
1	*16*	*52*	*34*	*22*
2	*26*	*56*	*8*	*52*
3	*76*	*38*	*36*	*30*
4	*38*	*52*	*48*	*20*

Answer

	I	II	III	IV
1	16	52	34	22
2	26	56	8	52
3	76	38	36	30
4	38	52	48	20

Step 1:

Subtract the smallest element of each row from every element of the corresponding row

	I	II	III	IV
1	0	36	18	6
2	18	48	0	44
3	46	8	6	0
4	18	32	28	0

Step 2: Subtract the smallest element of each column from every element in that column

	I	II	III	IV
1	0	28	18	6
2	18	40	0	44
3	46	0	6	0
4	18	24	28	0

Step 3: Drew minimum number of horizontal and vertical lines to cover all the zeros

	I	II	III	IV
1	0	28	18	6
2	18	40	0	44
3	46	0	6	0
4	18	24	28	0

The optimal assignment is

1	—	I	=	16
2	—	III	=	8
3	—	II	=	38
4	—	IV	=	20

<u>82 hours</u>

Minimum time taken = 82 hours

Question 15

A BPO company is taking bids for 4 routes in the city to ply pick-up and drop cabs. Four companies have made bids as detailed below:

Bids for Routes (Rs.)

Company/Routes	R_1	R_2	R_3	R_4
C_1	4,000	5,000	–	–
C_2	–	4,000	–	4,000
C_3	3,000	–	2,000	–
C_4	–	–	4,000	5,000

Each bidder can be assigned only one route. Determine the minimum cost that the BPO should incur.

Answer

Reducing minimum from each column element (figure in '000s)

Step 1

	R_1	R_2	R_3	R_4
C_1	1	1	–	–
C_2	–	0	–	0
C_3	0	–	0	–
C_4	–	–	2	1

Step 2

	R_1	R_2	R_3	R_4
C_1	0	0	–	–
C_2	–	0	–	0
C_3	0	–	0	–
C_4	–	–	1	0

Number of lines to connect all zeros nos. is 4 which is optional.

Alternatively you may also reduce the minimum from each row.

Step 1

	R_1	R_2	R_3	R_4
C_1	0	1	–	–
C_2	–	0	–	0
C_3	1	–	0	–
C_4	–	–	0	1

Step 2

	R_1	R_2	R_3	R_4
C_1	0	1	–	–
C_2	–	0	–	0
C_3	0		0	
C_4	–	–	0	0

Number of lines to connect all zeros nos. is 4 which is optional.

All diagonal elements are zeros and are chosen. The minimum cost is Rs.15,000 $C_1 – R_1$ 4,000; $C_2 – R_2$ 4,000; $C_3 – R_3$ 2,000; $C_4 – R_4$ 5,000; (Total) = 15,000.

Question 1

A small maintenance project consists of the following twelve jobs whose precedence relations are identified with their node numbers.

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.

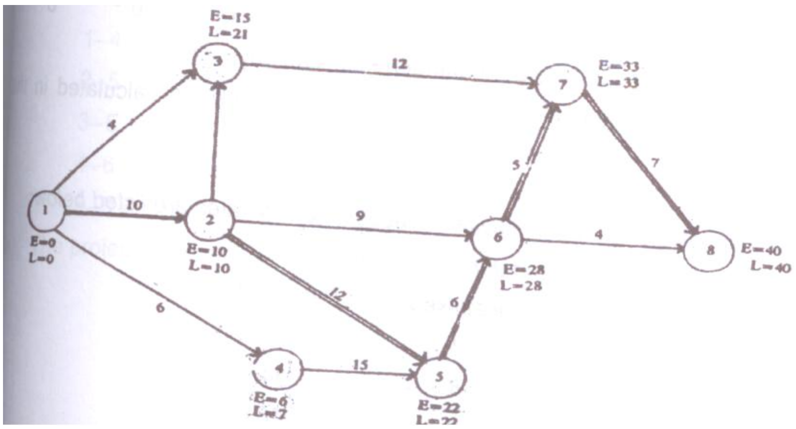
(ii) Calculate earliest start, earliest finish, latest start and latest finish time for al the jobs.

(iii) Find the critical path and project duration.

(iv) Tabulate total float, free float and independent float. *(Nov 1997)*

Answer

(i) The required arrow diagram is drawn below:



(ii) The latest start, earliest finish, latest start and latest finish time for all the jobs ae calculated in the table given below:

Job	*Dura-*	*Earliest time*		*Latest time*		*Stock of*		*Total*	*Free*	*Indep.*
(I, j)	*ation*	*Start*	*Finish*	*Start*	*Finish*	*Tail*	*Head*	*Float = (TF)*	*Float*	*Float*
	(in days)	*EST (E_1)*	*EFT*	*LST*	*LFT (L_1)*	*Event (L_1-E)*	*Event (L_1-E)*	*=(LST-EST)*	*=(TF-S1 of head event)*	*(FF-S1 of tail event)*
1-2	10	0	10	0	10	0	0	0	0	0
1-3	4	0	4	17	21	0	6	17	11	11
1-4	6	0	6	1	7	0	1	1	0	0

2-3	5	10	15	21	21	0	6	6	0	0
2-5	12	10	22	22	22	0	0	0	0	0
2-6	9	10	19	28	28	0	0	0	0	0
3-7	12	15	27	33	33	6	0	6	6	0
4-5	15	6	21	22	22	1	0	1	1	0
5-6	6	22	28	28	28	0	0	0	0	0
6-7	5	28	33	33	33	0	0	0	0	0
6-8	4	28	32	36	40	0	0	0	0	0
7-8	7	33	40	33	40	0	0	0	0	0

(iii) The critical path s 1 → 2 → 5 → 6 → 7 → 8 and the project is 40 days.

(iv) Total float, free float and independent float for various activities are calculated in the above table.

Question 2

An Engineering Project has the following activities, whose time estimates are listed below:

Activity	*Estimated duration (in months)*		
(i – j)	*Optimistic*	*Most likely*	*Pessimistic*
1-2	*2*	*2*	*14*
1-3	*2*	*8*	*14*
1-4	*4*	*4*	*16*
2-5	*2*	*2*	*2*
3-5	*4*	*10*	*28*
4-6	*4*	*10*	*16*
5-6	*6*	*12*	*30*

(i) Draw the project network and find the critical path.

(ii) Find the expected duration and variance for each activity. What is the expected project length?

(iii) Calculate the variance and standard deviation of the project length.

(iv) What is the probability that the project will be completed at least eight months earlier than expected time?

(v) If the project due date is 38 months, what is the probability of not meeting the due date? Given:

Z :	*0.50*	*0.67*	*1.00*	*1.33*	*2.00*
Prob. :	*0.3085*	*0.2514*	*0.1587*	*0.0918*	*0.0228*

(Nov 2001)

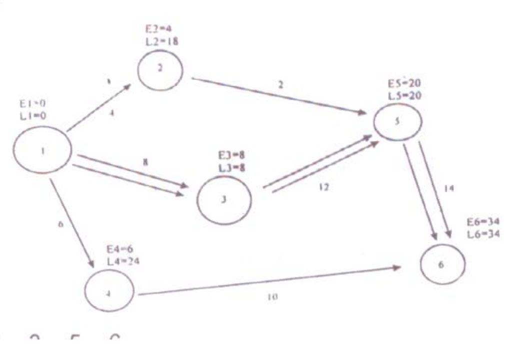
Answer

The earliest and latest expected time for each event is calculated by considering the expected time of each activity as shown in the table below:

Activity (i – j)	t_0	t_m	t_p	$t_e = (t_0 + 4t_m + t_p) / 6$	$\sigma^2 = \left(\frac{t_p - t_0}{6}\right)^2$
1-2	2	2	14	4	4
1-3	2	8	14	8	4

1-4	4	4	16	6	4
2-5	2	2	2	2	0
3-5	4	10	28	12	16
4-6	4	10	16	10	4
5-6	6	12	30	14	16

(a) The project network is drawn below:



(i) Critical Path is : 1 – 3- 5 – 6

(ii) The expected duration and variance of each activity is shown in the table above.

The expected project length is the sum of the duration of critical activities. Hence,

Expected project Length = 8 + 12 + 14 = 34 months

(iii) Variance of the project length is the sum of the variances of critical activities.

Variance of project length = σ^2 = 4 + 16 + 16 = 36 months

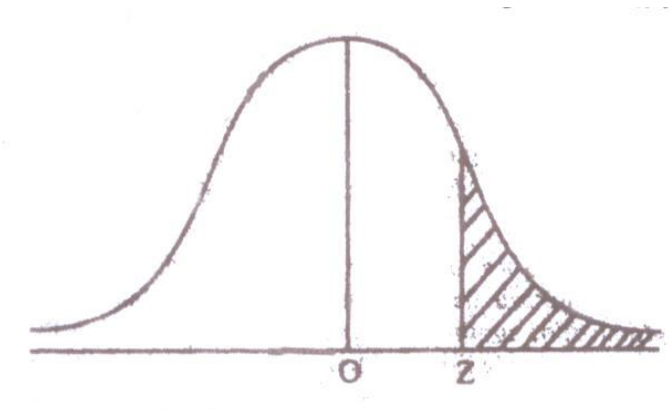
Therefore, Standard Deviation = $\sigma = \sqrt{36} = 6$

(iv) Probability that the project will be completed at lest 8 months earlier than the expected time of 34 months is given by

Prob. $\left[Z \le \frac{T_s - T_e}{\sigma_e} = \frac{(34-8)-34}{6} \right]$ = Prob.[Z ≤ - 1.33]

But Z = -1.33 from the normal distribution table is 0.0918.

Students may please note that the values for the Prob. For a Z value correspond tot e shaded area as shown in the diagram below:



Thus, the probability of completing the project within 26 months is 9.18%.

(v) If the project due date is 38 months, then the probability of not meeting the due date is given by

$$\text{Prob.}\left[Z > \frac{T_s - T_e}{\sigma_e} = \frac{(38-34)}{6}\right] = \text{Prob.}[Z > 0.67]$$

But Z = 0.67 from the normal distribution is 0.2514.

Thus, the probability of not meeting the due date is 25.14%.

Question 3

Consider the schedule of activities and related information as given below, for the construction of a Plant:

Activity	*Expected Time (Months)*	*Variance*	*Expected Cost (Millions of Rs.)*
1-2	*4*	*1*	*5*
2-3	*2*	*1*	*3*
3-6	*3*	*1*	*4*
2-4	*6*	*2*	*9*
1-5	*2*	*1*	*2*
5-6	*5*	*1*	*12*
4-6	*9*	*5*	*20*
5-7	*7*	*8*	*7*
7-8	*10*	*16*	*14*
6-8	*1*	*1*	*4*

Assuming that the cost and time required for one activity is independent of the time and cost of any other activity and variations are expected to follow normal distribution.

Draw a network based on the above data and calculate:

(i) Critical path

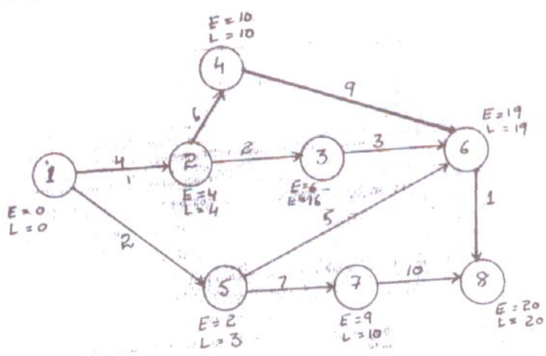
(ii) Expected cost of construction of the plant

(iii) Expected time required to build the plant

(iv) The standard deviation of the expected time. *(May 2001)*

Answer

The required network is drawn below:



(i) From the above network, it can be noted that the critical path is 1 – 2 – 4 – 6 – 8.

(ii) Expected cost of construction of the plant = (5 + 3 + 4 + 9 + 2 + 12 + 20 + 7 + 14 + 4) millions of Rs.

= Rs.80 million

(iii) Expected time required to build the plant = 4 + 6 + 9 + 1 = 20 months.

(iv) It is given that the time required for one activity is independent of the time and cost of any other activity and variations are expected to follow normal distribution, the S.D.

Hence, the variance of the expected time is determined by summing the variance of critical activities and is = 1 + 2 + 5 + 1 = 9.

Standard Deviation of the expected time = $\sqrt{9}$ = 3 months.

Question 4

The time schedule for different activities of a project is given below:

Activity (i – j)	*Time in days*
1-2	*8*
1-3	*10*
1-4	*8*
2-3	*10*
2-6	*16*
3-5	*17*
4-5	*18*
4-6	*14*
5-6	*9*

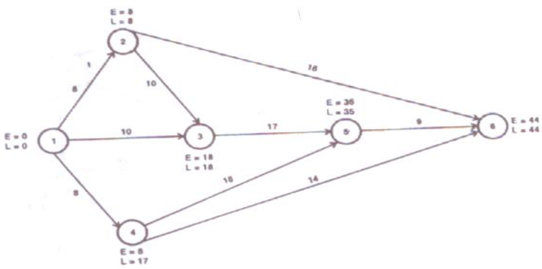
Construct the PERT network and compute.

(i) Critical path and its duration.

(ii) Total and free float for each activity. *(Nov 2000)*

Answer

The required network is drawn below:



(i) From the diagram, it may be noted that the critical path is given by 1 – 2 – 3 – 5 – 6. The path represents the minimum possible time to complete the project.

The project duration = 8 + 10 + 17 + 9 = 44 days.

(ii) Total floats and free floats for various activities are calculated in the table given below:

Activity	Duration	Start		Finish		Total	Free
		Earliest (EST)	Latest (LST)	Earliest (EFT)	Latest (LFT)	Float (TF) (LST-EST) or (LFT-EFT)	Float (TF-Head event slack)
1-2	8	0	0	8	8	0	0

1-3	10	0	8	10	18	8	8
1-4	8	0	9	8	17	9	0
2-3	10	8	8	18	18	0	0
2-6	16	8	28	24	44	20	20
3-5	17	18	18	35	35	0	0
4-5	18	8	17	26	35	9	9
4-6	14	8	30	22	44	22	22
5-6	9	35	35	44	44	0	0

Question 5

A project has the following time schedule:

Activity	*Time in weeks*	*Activity*	*Time in weeks*
1-2	*4*	*5-7*	*8*
1-3	*1*	*6-8*	*1*
2-4	*1*	*7-8*	*2*
3-4	*1*	*8-9*	*1*
3-5	*6*	*8-10*	*8*
4-9	*5*	*9-10*	*7*
5-6	*4*		

Construct a PERT network and compute:

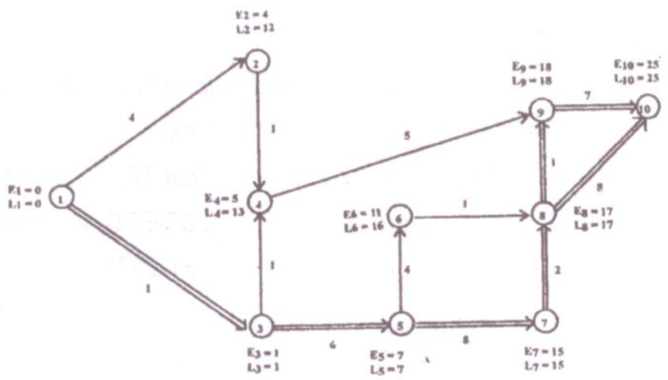
(i) T_E and T_L for each event;

(ii) Float for each activity; and

(iii) Critical path and its duration. *(May 2000)*

Answer

The network is constructed as given in figure below:



(i) The T_E's and T_L's for various events computed on the network are as follows:

Event No.:	1	2	3	4	5	6	7	8	9	10
T_E	0	4	1	5	7	11	15	17	18	25
T_L	0	12	1	13	7	17	15	17	18	25

(ii) Activity floats are computed using the following formula:

Float = T_L (Head event) – T_E (Tail event) – Duration

Activity	*Duration*	*T_E (Tail Event)*	*T_L(Head Event)*	*Float*
1-2	4	0	12	8
1-3	1	0	1	0
2-4	1	4	13	8
3-4	1	1	13	11
3-5	6	1	7	0
4-9	5	5	18	8
5-6	4	7	16	5
5-7	8	7	15	0
6-8	1	11	17	5
7-8	2	15	17	0
8-9	1	17	18	0
8-10	8	17	25	0
9-10	7	18	25	0

Critical path is given by all those activities which have zero floats. Along the zero float activities, there are two such critical paths:

(i) 1 → 3 → 5 → 7 → 8 → 9 → 10

(ii) 1 → 3 → 5 → 7 → 8 → 10

The project duration is 25 weeks.

Question 6

A project has the following time schedule:

	Time in Weeks	*Activity*	*Time in Weeks*
1-2	*2*	*4-6*	*3*
1-3	*2*	*5-8*	*1*
1-4	*1*	*6-9*	*5*
2-5	*4*	*7-9*	*4*
3-6	*8*	*8-9*	*3*
4-7	*5*		

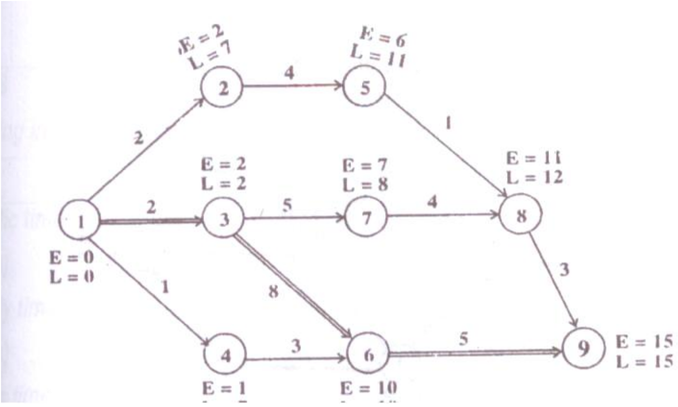
Construct PERT network and compute:

(i) total float for each activity; and

(ii) critical path and its duration. *(Nov 1999)*

Answer

The required PERT network is given below:



(ii) Total float of ach activity is calculated below:

Activity	*Duration (in weeks)*	*Start*		*Finish*		*Total*
		Earliest (EST)	*Latest (LST)*	*Earliest (EST)*	*Latest (LFT)*	*(LST-EST)*
1-2	2	0	5	2	7	5
1-3	2	0	0	2	2	0
1-4	1	0	6	1	7	6
2-5	4	2	7	6	11	5
3-6	8	2	2	10	10	0
3-7	5	2	3	7	8	1
4-6	3	1	7	4	10	6
5-8	1	6	11	7	12	5
6-9	5	10	10	15	15	0
7-8	4	7	8	11	12	1
8-9	3	11	12	14	15	1

(ii) The critical path is given by 1-3-6-9 and the project duration is 15 weeks.

Question 7

Given the following information:

Activity:	*0-1*	*1-2*	*1-3*	*2-4*	*2-5*	*3-4*	*3-6*	*4-7*	*5-7*	*6-7*	
Duration:	*2*	*8*	*10*	*6*	*3*	*3*	*7*	*5*	*2*	*8*	*(in days)*

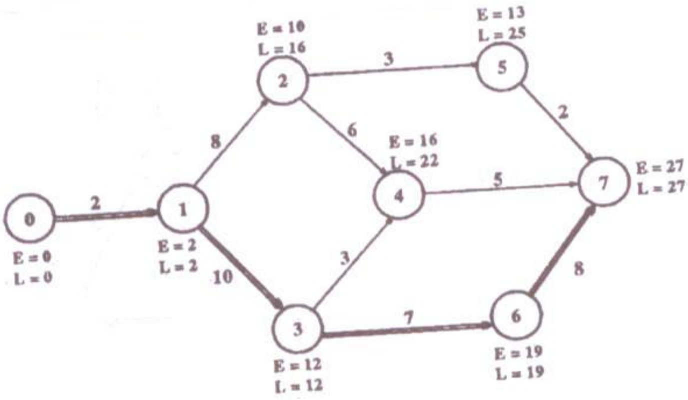
(i) Draw the arrow diagram.

(ii) Identify critical path and find the total project duration.

(iii) Determine total, free and independent floats. *(May 1999)*

Answer

(i) The arrow diagram for the given data is drawn below:



(ii) The critical path is - 0→1→3→6→7

Total project duration = 27 days.

(iii) The total, free and independent floats are computed in the following table:

Activity	Duration (Hours)	Earliest Start (EST)	Earliest Finish (EFT)	Latest Start (EST)	Latest Finish (LFT)	Floats		
						Total (LST-EST) or (LFT-EFT)	Free (Total Float – Slack of Head event)	Indepe-ndent (Free Float – Stack of tail event)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0-1	2	0	2	0	2	0	0	0
1-2	8	2	10	8	16	6	0	0
1-3	10	2	12	2	12	0	0	0
2-4	6	10	16	16	22	6	0	0
2-5	3	10	13	22	25	12	0	0
3-4	3	12	15	19	22	7	1	1
3-6	7	12	19	12	19	0	0	0
4-7	5	16	21	22	27	6	6	0
5-7	2	13	15	25	27	12	12	0
6-7	8	19	27	19	27	0	0	0

Question 8

The following information is given:

Activity	*(1-2)*	*(2-3)*	*(2-4)*	*(3-5)*	*(4-6)*	*(5-6)*	*(5-7)*	*(6-7)*
Pessimistic time (in weeks)	*3*	*9*	*6*	*8*	*8*	*0*	*5*	*8*
Most likely time (in weeks)	*3*	*6*	*4*	*6*	*6*	*0*	*4*	*5*
Optimistic time (in weeks)	*3*	*3*	*2*	*4*	*4*	*0*	*3*	*2*

Draw the Network diagram for the above. Calculate:

(i) Variance to each activity.

(ii) Critical path and expected project length.

(iii) The probability that the project will be completed in 23 weeks.

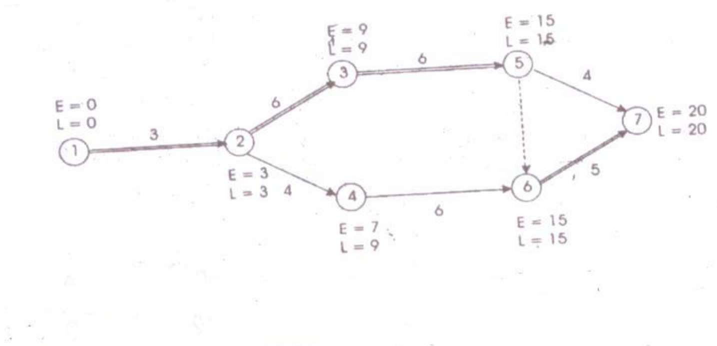
Given that:

Z value :	*1.90*	*1.91*	*1.92*	*1.93*	*1.94*
Probability :	*0.9713*	*0.9719*	*0.9726*	*0.9732*	*0.9738*

(May 1998)

Answer

The required network is drawn below:



The expected time marked in the above network diagram for various activities is calculated in the table below:

Activity	*Time (in weeks)*			*Expected time (weeks)* Γ	*Variance* Γ
	Optimistic (t_o)	*Most likely (t_m)*	*Pessimistic (t_p)*		
1-2	3	3	3	3	0
2-3	3	6	9	6	1
2-4	2	4	6	4	4/9
3-5	4	6	8	6	4/9
4-6	4	6	8	6	4/9
5-6	0	0	0	0	0
5-7	3	4	5	4	1/9
6-7	2	5	8	5	1

(i) Variance of each of the activities has been calculated in the last column of the above table.

(ii) Critical path is given by 1 – 2 – 3 – 5 – 6 – 7 and the expected project length is 20 weeks.

(iii) Variance of the critical path = σ^2 = 0 + 1 + 4/9 + 0 + 1 = 22/9 = 2.444

Man = ┌ = 20 weeks.

To calculate the probability of completing the project in 23 weeks, we will first calculate the normal variate Z as below:

Z = ┌

P (x ≤ 23) = P (z ≤ 1.92) = 0.9726 (from the given table)

Thus, the probability that the project will be completed in 23 weeks is 97.26%.

Question 9

A project consists of eight activities with the following relevant information:

Activity	*Immediate Predecessor*	*Estimated Duration (Days)*		
		Optimistic	*Most Likely*	*Pessimistic*
A	—	*1*	*1*	*7*
B	—	*1*	*4*	*7*
C	—	*2*	*2*	*8*
D	*A*	*1*	*1*	*1*
E	*B*	*2*	*5*	*14*
F	*C*	*2*	*5*	*8*
G	*D, E*	*3*	*6*	*15*
H	*F, G*	*1*	*2*	*3*

(i) Draw the PERT network and find out the expected project completion time.

(ii) What duration will have 95% confidence for project completion?

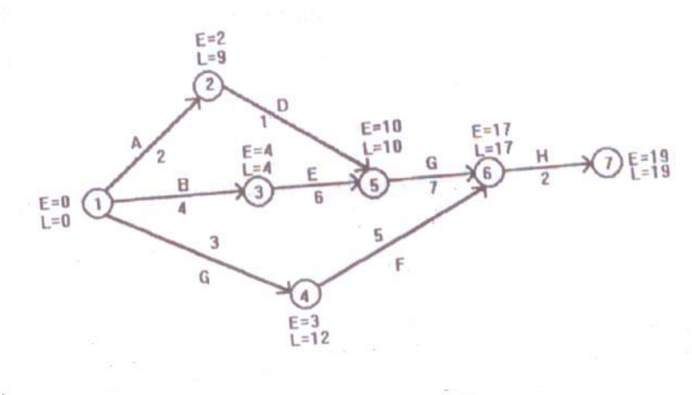
(iii) If the average duration for activity F increases to 14 days, what will be its effect on the expected project completion time which will have 95% confidence?

(For standard normal Z = 1.645, area under the standard normal curve from 0 to Z = 0.45)

(May 1996)

Answer

(i) The required network is drawn below:



The expected time for each activity shown in the network above is calculated in the following table:

Activity	Estimated Duration (Days			Expected duration Γ	Variance Γ
	Optimistic a	Most likely m	Pessimistic b		
A 1-2	1	1	7	2	1
B 1-3	1	4	7	4	1
C 1-4	2	2	8	3	1

D 2-5	1	1	1	1	0
E 3-5	2	5	14	6	4
F 4-6	2	5	8	5	1
G 5-6	3	6	15	7	4
H 6-7	1	2	3	2	1/9

The critical path is given by 1 – 3 – 5 – 6 – 7 or B – E – G – H and the expected project completion time is 19 days.

(ii) The variance for critical path is 1 + 4 + 4 + 1/9 = 82/9

Standard deviation of critical path = = σ1 ┌ = 3.02 (approx.).

To calculate the project duration which will have 95% chances of its completion, we utilse the given value of Z corresponding to 95% confidence which is 1.645.

Thus, ┌ = 1,645

or X = 1,645 × 3.02 + 19 = 23.97 days = 24 days

Hence, 24 days of project completion time will have 95% probability of its completion.

(iii) If the average duration for activity F increases to 14 days, then the path 1 – 4 – 6 – 7 i.e. C –F – H will also become critical path with expected project completion time of 19 days. Now, activities C and F are also critical activities. Since we are given only the average duration for activity F, It is assumed that the variance for this activity is zero. Further, since PERT analysis is based on the assumption that the activities are independent in terms of their variance, therefore, standard deviation of critical paths can be computed as:

σ = ┌

We now wish to calculate the expected project completion time that will have 95% confidence level,

P 9Z < 1.645) = 0.95

or X = 19 + 1.645 × 3.18 = 24.23 days.

Hence the project duration of 24.23 days will have 95% confidence of completion.

Question 10

A small project consists of seven activities for which the relevant data are given below:

Activity	*Preceding activities*	*Activity Duration (Days)*
A	--	*4*
B	--	*7*
C	--	*6*
D	*A, B*	*5*
E	*A, B*	*7*
F	*C, D, E*	*6*
G	*C, D, E*	*5*

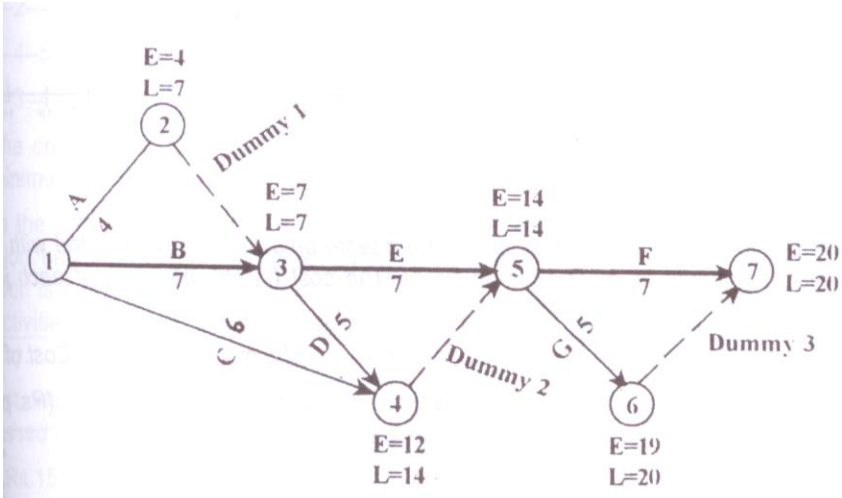
(i) Draw the network and find the project completion time.

(ii) Calculate total float for each of the activities.

(iii) Draw the time scaled diagram. *(Nov 1996)*

Answer

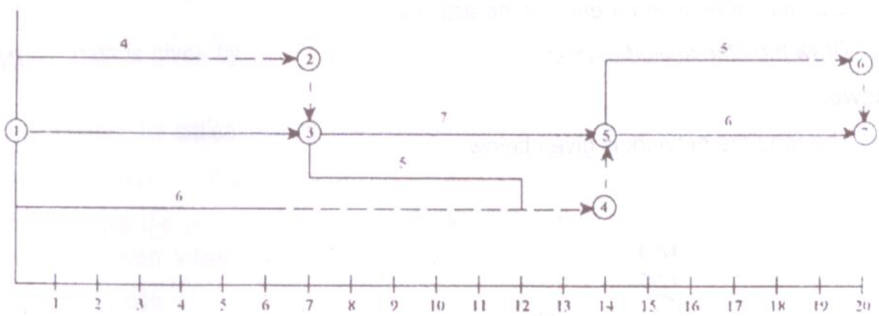
(i) The required network is given below:



(ii) The total float for various activities is calculated as below:

Activity		Duration	Start		Finish		Total float
			Earliest	Latest	Earliest	Latest	
A	1-2	4	0	3	4	7	3
B	1-3	7	0	0	7	7	0
Dummy 1	2-3	0	4	7	4	7	3
D	3-4	5	7	9	12	14	2
E	3-5	7	7	7	14	14	0
Dummy 2	4-5	0	12	14	12	14	2
F	5-7	6	14	14	20	20	10
G	5-6	5	14	15	19	20	1
Dummy 3	6-7	0	19	20	19	20	1

(iii) The required time scale diagram is drawn below:



Question 11

A small project consists of jobs as give in the table below. Each job is listed with tits normal time and a minimum or crash time (in days). The cost (in Rs. per day) of each job is also given:

Job (i – j)	*Normal duration*	*Minimum (crash)*	*Cost of Crashing*

	(in days)	*Duration (in days)*	*(Rs. per day)*
1-2	*9*	*6*	*20*
1-3	*8*	*5*	*25*
1-4	*15*	*10*	*30*
2-4	*5*	*3*	*10*
3-4	*10*	*6*	*15*
4-5	*2*	*1*	*40*

(i) What is the normal project length and the minimum project length?

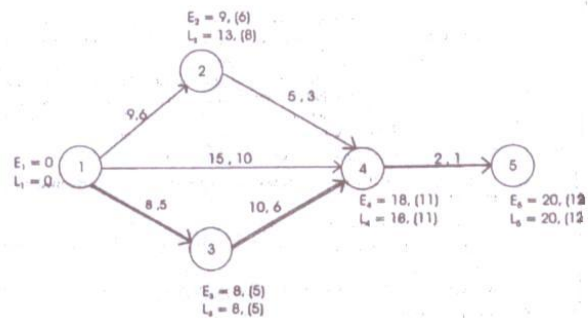
(ii) Determine the minimum crashing cost of schedules ranging from normal length down to, and including the minimum length schedule. That is, if L = Length of the schedule, find the costs of schedules which are L, L – 1, L – 2 and so on.

(iii) Overhead costs total Rs.60 per day. What is the optimum length schedule in terms of both crashing and overhead cost? List the schedule duration of each job for your solution.

(May 2002)

Answer

(i) The required network is given below:



The various paths in the network are:

1 – 2 – 4 – 5 with project duration = 16 days

1 – 4 – 5 with project duration = 17 days

1 – 3 – 4 – 5 with project duration = 20 days

The critical path is 1 → 3 → 4 → 5. The normal length of the project is 20 days and minimum project length is 12 days.

(ii) Since the present schedule consumers more time than the minimum project length, the duration can be reduced by crashing some of the activities. Also, since the project duration is controlled by the activities lying on the critical path, the duration of some of the activities lying on critical path can be reduced. It is given that overhead cost is Rs.60 per day.

Step I: First, the crashing cost of activity (3, 4) being minimum, the duration of this activity can be compressed from 10 days to 9 days. The total cost for 19 day's schedule

= Rs.15 + Rs.19 × 60 = Rs.1,155

Step II: Since the critical path remains unchanged, the duration of activity (3, 4) can be further reduced from 9 days to 8 days resulting in an additional cost of Rs.15 so that total cost for 18 days schedule = Rs.30 + Rs.60 × 18 = Rs.30 + Rs.1,080 = Rs.1,110.

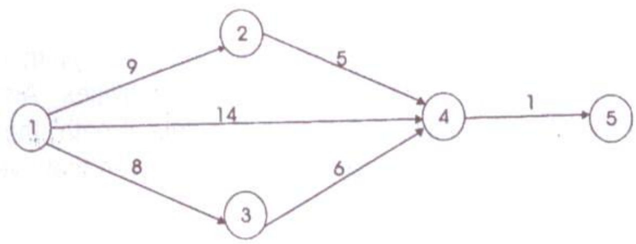
Step III: Continue this procedure till the minimum project length schedule. The calculations are given below:

Normal Project length (days)	*Job crashed*	*Crashing Cost (Rs.)*	*Overhead cost @ Rs.60 / day*	*Total Cost. (Rs.)*
20	--	--	20×60	1,200
19	3–4	1 × 15 = 15	19×60	1,155
18	3–4	2 × 15 = 30	18×60	1,110
17	3–4	3 × 15 = 45	17×60	1,065
16	4–5	3×15+1×40 = 85	16×60	1,045
15	3–4, 1–4	4×15+1×40+1×30= 130	15×60	1,030
14	1–3, 1–4, 2–4	130+1×30+1×25+1×10=195	15×60	1,035
13	1–3, 1–4, 2–4	195+1×25+1×30+1×10=260	13×60	1,040
12	1–3, 1–4, 1–2	260+25+30+20=335	12×60	1,055

(iii) Since the total cost starts increasing from 14 days duration onwards, the minimum total cost of Rs.1,030 for the optimum project duration of 15 days occurs for optimum duration of each job as given below:

Job:	(1,2)	(1,3)	(1,4)	(2,4)	(3,4)	(4,5)
Optimum:	9	8	14	5	6	1

Duration (day)



Path 1 → 2 → 4 → 5 = 9 + 5 + 1= 15 days

Path 1 → 4 → 5 = 14 + 1 = 15 days

Path 1 → 3 → 4 → 5 = 8 + 6 + 1 = 15 days.

Hence, the optimum duration of the project is 15 days.

Question 12

Write short notes on Distinction between PERT and CPM. (Nov 2000)

Answer

Distinction between PERT and CPM: The PERT and CPM models are similar in terms of their basic structure, rationale and mode of analysis. However, there are certain distinctions between PERT and CPM networks which are enumerated below:

(1) CPM is activity oriented i.e. CPM network is built on the basis of activities. Also results of various calculations are considered in terms of activities of the project. On the other hand, PERT is even oriented.

(2) CPM is a deterministic model i.e. it does not take into account the uncertainties involved in the estimation of time for execution of a job or an activity. It completely ignores the probabilistic element of the problem. PERT, however, is a probabilistic model. It uses three estimates of the activity time; optimistic, pessimistic and most likely, with a view to take into account time uncertainty. Thus, the expected duration for each activity is probabilistic and expected duration indicates that there is fifty per probability of getting the job done within that time.

(3) CPM laces dual emphasis on time and cost and evaluates the trade-off between project cost and project item. By deploying additional resources, it allows the critical path project manager to manipulate project duration within certain limits so that project duration can be shortened at an optimal cost. On the other hand, PERT is primarily concerned with time. It helps the manger to schedule and coordinate various activities so that the project can be completed on scheduled time.

(4) CPM is commonly used for those projects which are repetitive in nature and where one has prior experience of handling similar projects. PERT is generally used for those projects where time required to complete various activities are not known as prior. Thus, PERT is widely used for planning and scheduling research and development project.

Question 13

Define a project and briefly explain the four common implications which characterize a project, and state the five steps of the working methodology of critical path analysis. (May 1997)

Answer

A project can be defined as a set of activities or jobs that are performed in a certain sequence determined logically or technologically and it has to be completed within (i) a specified time, (ii) a specified cost and (iii) meeting the performance standards. Examples of a project from fairly diverse fields could be cited. Some of them are given below:

1. Introducing a new product in the market.
2. Construction of a new bridge over a river or construction of a 25 – storied building.
3. Executing a large and complex order on jobbing production.
4. Sending a spacecraft to the mars.

All these projects are characterized by the following set of common implications, although they pertain to widely different fields.

(i) The Large-scale characteristic: These projects are generally unusually large and complex. Thousands of suppliers, workers and other categories of persons are involved and their efforts have to be coordinated for completion of the project.

(ii) The non-recurring characteristic: These projects are generally of a one-time nature. Neither in the past, nor in the future they are likely to undertaken substantially in the same form.

(iii) Uncertain and critical dates: During of the various activities involved in such projects are usually uncertain. Further in such type of projects, many critical dates exits by which operations must be completed in order to complete the entire project on schedule.

(iv) completion dead line: The fourth distinct feature of these projects is that there is dead line for the completion of the entire project. In case of any delay in the completion of the project, some penalty is levied for such delay beyond the dead line.

The working methodology of Critical Path Analysis (CPA) which includes both CPM and PERT, consists of following five steps:

1. Analyse and breakdown the project in terms of specific activities and / or events.
2. Determine the interdependence and sequence of specific activities and prepare a network,
3. Assign estimates of time, cost or both to all the activities of the network.
4. Identify the longest or critical path through the network.
5. Monitor, evaluate and control the progress of the project by re-planning, rescheduling and reassignment of resources.

Question 14

A product comprised of 10 activities whose normal time and cost are given as follows:

Activity	*Normal Time (days)*	*Normal cost*
1-2	*3*	*50*
2-3	*3*	*5*
2-4	*7*	*70*
2-5	*9*	*120*
3-5	*5*	*42*
4-5	*0*	*0*
5-6	*6*	*54*
6-7	*4*	*67*
6-8	*13*	*130*
7-8	*10*	*166*

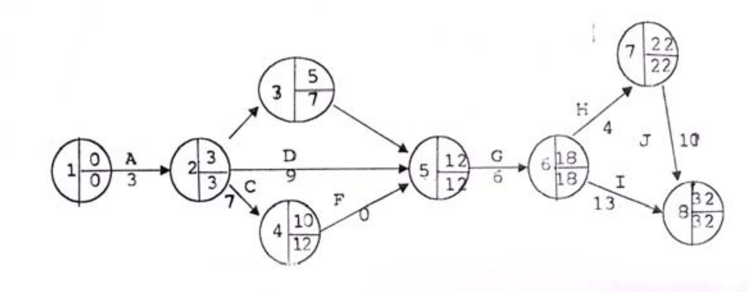
Indirect cost Rs. 9 per day.

(i) Draw the network and identify the critical path.

(ii) What are the project duration and associated cost ?

(iii) Find out the total float associated with each activity.

Answer



Critical path A D G H J

1------2-------5-------6---------7---------8

(ii) A D G H J is the critical path having normal project duration

$3 + 9 + 6 + 4 + 10 = 32$ days

Normal project cost:- Direct cost = Rs. 704

Indirect cost (32×9) = 288

992

(iii) Calculation of total float

Activity	*Nt(days)*	E_F	L_F	*Float* (L_F–E_F)
1-2	3	3	3	0
2-3	3	6	7	1
2-4	7	10	12	2
2-5	9	12	12	0
3-5	5	11	12	1
4-5	0	10	12	2
5-6	6	18	18	0
6-7	4	22	22	0
6-8	13	31	32	1
7-8	10	32	32	0

Question 15

A small project is composed of seven activities, whose time estimates are listed below. Activities are identified by their beginning (i) and ending (j) node numbers.

Activity	*Estimated durations (in days)*		
(I-j)	*Optimistic*	*Most likely*	*Pessimistic*
1-2	*2*	*2*	*14*
1-3	*2*	*8*	*14*
1-4	*4*	*4*	*16*
2-5	*2*	*2*	*2*
3-5	*4*	*10*	*28*
4-6	*4*	*10*	*16*
5-6	*6*	*12*	*30*

(a) Draw the project network.

(b) Find the expected duration and variance for each activity. What is the expected project length?

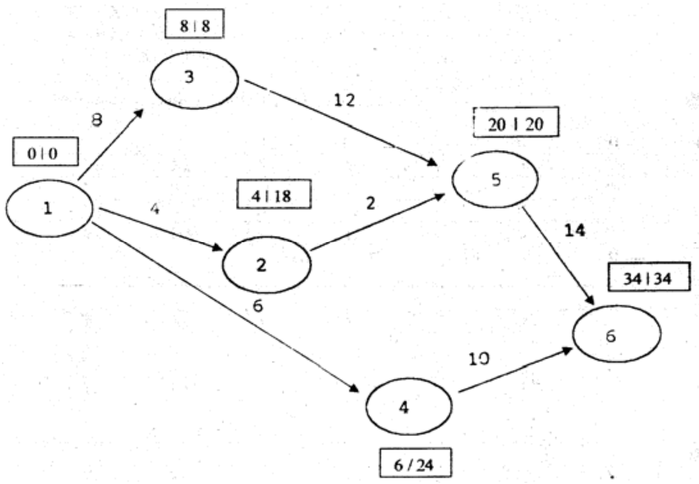
(c) If the project due date is 38 days, what is the probability of meeting the due date ?

Given:	*z*	*0.50*	*0.67*	*1.00*	*1.33*	*2.00*
	P	*0.3085*	*0.2514*	*0.1587*	*0.0918*	*0.0228*

Answer

Activity	*Estimated durations (in days) =*			$\frac{a+4m+b}{6}$	$\sigma^2 = \left(\frac{b-a}{6}\right)^2$
(I – j)	a	m	b		
1-2	2	2	14	4	4
1-3	2	8	14	8	4
1-4	4	4	16	6	4

2-5	2	2	2	2	0
3-5	4	10	28	12	16
4-6	4	10	16	10	4
5-6	6	12	30	14	16



The critical path is 1-----3----5----6

(b) The expected duration of the project 8+12+14 = 34 days

(c) Variance of project length is $\sigma^2 = 4 + 16 + 16 = 36$

The standard normal deviate is:

$$Z = \frac{\text{due date - expected date of completion}}{\sqrt{\text{variance}}}$$

$Z = \frac{26-34}{6} = \frac{8}{6} = -1.33$ probability of meeting the due date is 0.0918 or 9.18%

(d) When due date is 38 days

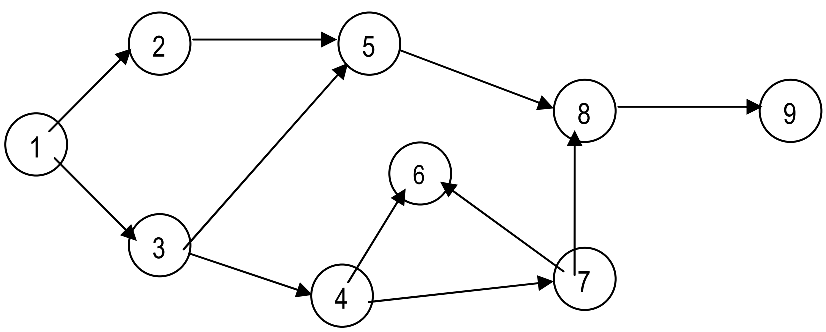
$Z = \frac{38-34}{6} = \frac{4}{6} = 0.67$ Probability meeting the date is 0.2514 or 25.14%.

Question 16

A network is given below:

(i) Name the paths and give their total duration.

(ii) Give three different ways of reducing the project above duration by four days.



Answer

(i) Assuming that the duration of activity 3 – 5 is 4 weeks.

The various critical paths are:

1-2-5-8-9	15 weeks
1-3-4-7-8-9	15 weeks
1-3-4-6-7-8-9	15 weeks
1-3-5-8-9	15 weeks

(ii) Note: Since the duration for activity 3-5 is not specified it is open for you to assume the duration. Depending upon the duration assume three possibilities emerge.

1. If the duration assumed is more than 4 weeks then that path (13, 35, 58, 89) alone will be critical. In that case you can choose any of the activity in the critical path.
2. If the duration assumed is exactly 4 weeks then it will be one of the 4 critical paths and the various possibilities are given below.
3. If the duration assumed is less than 4 weeks then the solution should be based on 3 of the critical paths namely 12,589, 1346789 and 134789. This has 16 combinations.

Reduce in the following ways, the project duration is. Since all the paths are critical, reduction is possible by combining activities. The activities can be independent, common to few paths and common to all the paths. The various categories are as follows:

1. Common to all the paths. 8-9
2. Independent : Combination 1. 1-2,3-5,4-6 and 4-7.

Combination	2.	2-5,3-5,4-6 and 4-7.
Combination	3.	1-2,3-5,4-7, 6-7.
Combination	4.	2-5,3-5,4-7, 6-7.

3. Activities common to two of the paths.

Combination	1.	1-2,1-3.
Combination	2.	1-3,2-5.
Combination	3.	3-4,5-8.
Combination	4.	5-8,7-8.

4. Activities common to two of the paths and two independent activities.

Combination	1.	1-2,3-4,3-5.
Combination	2.	1-2,3-5,7-8.
Combination	3.	2-5,3-4,3-5.
Combination	4.	2-5,3-5,7-8.
Combination	5.	4-6,4-7,5-8.
Combination	6.	4-7,5-8,6-7.

(Any three of the above combination.)

20

SIMULATION

Question 1

An investment company wants to study the investment projects based on market demand profit and the investment required, which are independent of each other. Following probability distributions are estimated for each of these three factors.

Annual demand

(units in thousands)	*25*	*30*	*35*	*40*	*45*	*50*	*55*
Probability	*0.05*	*0.10*	*0.20*	*0.30*	*0.20*	*0.10*	*0.05*

Profit per unit	*3.00*	*5.00*	*7.00*	*9.00*	*10.00*
Probability	*0.10*	*0.20*	*0.40*	*0.20*	*0.10*

Investment Required

(In thousand of rupees)	*2,750*	*3,000*	*3,500*
Probability	*0.25*	*0.50*	*0.25*

Using simulation process, repeat the time 10 times, compute the investment on each that taking these factors into trial. What is the most likely return?

Use the following random numbers:

(30, 12, 16)	*(50, 09, 69)*	*(63, 94, 26)*	*(27, 08, 74)*
(64, 60, 61)	*(28, 28, 72)*	*(31, 23, 57)*	*(54, 85, 20)*
(64, 68, 18)	*(32, 31, 87)*		

In the bracket above, the first random number is for annual demand, the second one is for profit and the last one is for the investment required.

Answer

The yearly return can be determined by the formula:

$$\text{Return (\%)} = \frac{\text{Profit} \times \text{Number of units demanded}}{\text{Investment}} \times 100$$

First of all, random numbers 00 – 99 are allocated in proportion to the probabilities associated with each of three variables as given under.

Annual Demand

Units in thousands	*Probability*	*Cum. Probability*	*Random Numbers Assigned*
25	0.05	0.05	00-04
30	0.10	0.15	05-14
35	0.20	0.35	15-34
40	0.30	0.65	35-64

45	0.20	0.85	65-84
50	0.10	0.95	85-94
55	0.02	1.00	95-99

Profit per unit

Profit	*Probability*	*Cum. Probability*	*Random Numbers Assigned*
3.00	0.10	0.10	00-99
5.00	0.20	0.30	10-29
7.00	0.40	0.70	30-69
9.00	0.20	0.90	70-89
10.00	0.10	1.00	90-99

Investment required (in thousands of rupees)

Investment	*Probability*	*Cum. Probability*	*Random Numbers Assigned*
2,750	0.25	0.25	00-24
3,000	0.50	0.75	25-74
3,500	0.25	1.00	75-99

Let us now simulate the process for 10 trials. The results of the simulation are shown in the tables given below:

Trials	*Random number of demand*	*Simulated demand (0'000) units*	*Random No. for profit per unit*	*Simulated profit per unit*	*Random number for investment*	*Simulated investment ('000) Rs.*	*Simulated return (%) (Demand × profit per unit × 1,000) ÷ Investment*
1	30	35	12	5.00	16	2750	6.36
2	59	40	09	3.00	69	3000	4.00
3	63	40	94	10.00	26	3000	13.33
4	27	35	08	3.00	74	3000	3.50
5	64	40	60	7.00	61	3000	9.33
6	28	35	28	5.00	72	3000	5.83
7	31	35	23	5.00	57	3000	5.83
8	54	40	85	9.00	20	2750	13.09
9	64	40	68	7.00	18	2750	10.18
10	32	35	31	7.00	87	3500	7.00

The above table shows that the highest likely return is 13.33% which is corresponding to the annual demand of 40,000 units resulting a profit of Rs.10/- per unit and the required investment will be Rs.30,00,000.

Question 2

Param and Karam are workers on a two-station assembly line. The distribution of activity times at their stations is as follows:

Time	*Time Frequency*	*Time frequency*

(in sec.)	*For Param*	*For Karam*
10	*4*	*4*
20	*6*	*5*
30	*10*	*6*
40	*20*	*7*
50	*40*	*10*
60	*11*	*8*
70	*5*	*6*
80	*4*	*4*

(i) Simulate operation of the line for eight times. Use the random numbers given below:

Operation 1		*Operation 2*	
14	*61*	*36*	*97*
01	*82*	*76*	*41*
95	*00*	*55*	*13*
44	*03*	*25*	*34*

(ii) Assuming Karam must wait until Param completes the first item before starting work. Will he have to wait to process any of the other eight items? Explain your answer, based upon your simulation.

Answer

Cumulative frequency distribution for Param is derived below. Also fitted against it are the eight given random numbers. In parentheses are shown the serial numbers of random numbers.

10	4	01 (2)	00 (7)	03 (8)
20	10			
30	20	14 (1)		
40	40			
50	80	44 (4)	61 (5)	
60	91	82 (6)		
70	96	95 (3)		
80	100			

Thus the eight times are: 30, 10, 70, 50, 60, 10 and 10 respectively.

Like wise we can derive eight times for Karam also.

Col-1	Col-2	Col-3	(2× Col-2)		
10	4	8			
20	9	18	13 (7)		
30	15	30	25 (4)		
40	22	44	36 (1)	34 (8)	41 (6)
50	32	64	55 (3)		
60	40	80	76 (2)		
70	46	92			

80 50 100 97 (5)

(Note that cumulative frequency has been multiplied by 2 in column 3 so that all the given random numbers are utilized).

Thus, Karam's times are: 40, 60, 50, 30, 80 40, 20 and 40 seconds respectively.

Param's and Karam's times are shown below to observe for waiting time, if any.

1	2	3	4
Param	Cum. Times	Karam Initial	Karam's cumulative time with 30 seconds included
30	30	40	70
10	40	60	130
70	110	50	180
50	160	30	210
50	210	80	290
60	270	40	330
10	280	20	350
10	290	40	390

Since col. 4 is consistently greater than Co.2, no subsequent waiting is involved.

Question 3

A Car Manufacturing Company manufactures 40 cars per day. The sale of cars depends upon demand which has the following distribution:

Sales of Cars	*Probability*
37	*0.10*
38	*0.15*
39	*0.20*
40	*0.35*
41	*0.15*
42	*0.05*

The production cost and sale price of each car are Rs.4 lakh and Rs.5 lakh respectively. Any unsold car is to be disposed off at a loss of Rs.2 lakh per car. There is a penalty of Re.1 lakh per car, if the demand is not met. Using the following random numbers, estimate total profit/ loss for the company for the next ten days:

9, 98, 64, 98, 94, 01, 78, 10, 15, 19

If the company decides to produce 39 cars per day, what will be its impact on profitability?

(May 2002)

Answer

First of all random numbers 00-99 are allocated in proportion to the probabilities associated with the sales of cars as given below:

Table 1

Sales of Car	*Probability*	*Cumulative probability*	*Range for random numbers*

37	0.10	0.10	00-99
38	0.15	0.25	10-24
39	0.20	0.45	25-44
40	0.35	0.80	45-79
41	0.15	0.95	80-94
42	0.05	1.00	95-98

Based on the given random numbers, we simulate the estimated sales and calculate the profit / loss on the basis of specified units of production.

Table 2

Day	*Random Numbers*	*Estimated Sale*	*Profit (Production 40 cars / day) (Rs. Lakh)*	*Profit (Production 39 cars / day) (Rs. Lakhs)*
1	9	37	37×1-3×2=31	37×1-2×2=33
2	98	42	40×1-2×1=38	39×1-3×1=36
3	64	40	40×1=40	39×1-1×1=38
4	98	42	40×1-2×1=38	39×1-3×1=36
5	94	41	40×1-1×1=39	39×1-2×1=37
6	01	37	37×1-3×2=31	37×1-2×2=33
7	78	40	40×1=40	39×1-1×1=38
8	10	38	38×1-2×2=34	38×1-1×2=36
9	15	38	38×1-2×2=34	38×1-1×2=36
10	19	38	38×1-2×2=34	36×1-1×2=36

There is no additional profit or loss if the company decides to reduce production to 39 cars per day.

Question 4

An investment company wants to study the investment projects based on market demand, profit and the investment required, which are independent of each other. Following probability distributions are estimated for each of these three factors:

Annual Demand							
(Units in thousands)	*25*	*30*	*35*	*40*	*45*	*50*	*55*
Probability	*0.05*	*0.10*	*0.20*	*0.30*	*0.20*	*0.10*	*0.05*

Profit per Unit :	*3.00*	*5.00*	*7.00*	*9.00*	*10.00*
Probability :	*0.10*	*0.20*	*0.40*	*0.20*	*0.10*

Investment required			
(in thousands of Rupees):	*2,750*	*3,000*	*3,500*
Probability :	*0.25*	*0.50*	*0.25*

Using simulation process, repeat the trial 10 times, compute the investment on each trail taking these factors into trail. What is the most likely ret

Use the following random numbers:urn?

(30, 12, 16); (59, 09, 69); (63, 94, 26); (27, 08, 74);

(64, 60, 61); (28, 28, 72); (31, 23, 57); (54, 85, 20);

(64, 68, 18); (32, 31, 87).

In the bracket above, the first random number is for annual demand, the second one is for profit and the last one is for the investment required. *(May 2001)*

Answer

The yearly return can be determined by the formula:

$$\text{Return (\%)} \ \frac{\text{Pr ofit} \times \text{Number of units demanded}}{\text{Investment}} \times 100$$

First of all, random number 00-99 are allocated in proportion tot eh probabilities associated with each of the three variables as given under:

Annual Demand

Units in thousands	*Probability*	*Cum. Probability*	*Random Number assigned*
25	0.05	0.05	00-04
30	0.10	0.15	05-14
35	0.20	0.35	15-34
40	0.30	0.65	35-64
45	0.20	0.85	65-84
50	0.10	0.95	85-94
55	0.05	1.00	95-99

Profit per unit

Profit	*Probability*	*Cum. Probability*	*Random Number assigned*
3.00	0.10	0.10	00-09
5.00	0.20	0.30	10-29
7.00	0.40	0.70	30-69
9.00	0.20	0.90	70-89
10.00	0.10	1.00	90-99

Investment required (in thousands of Rupees)

Units	*Probability*	*Cum. Probability*	*Random Number assigned*
2,750	0.25	0.25	00-24
3,000	0.50	0.75	25-74
3,500	0.25	1.00	75-99

Let us now simulate the process for 10 trails. The results of the simulation are shown in the tables given below:

Trails	*Random Number of*	*Simulated demand ('000)*	*Random No for profit per*	*Simulated profit per unit*	*Random Number for*	*Simulated investment ('000) Rs.*	*Simulated return (%) (Demand × profit*

	Demand	units	unit		investment		per unit × 100) + investment
1	30	35	12	5.00	16	2,750	6.36
2	59	40	09	3.00	69	3,000	4.00
3	63	40	94	10.00	26	3,000	13.33
4	27	35	08	3.00	74	3,000	3.50
5	64	40	60	7.00	61	3,000	9.33
6	28	35	28	5.00	72	3,000	5.83
7	31	35	23	5.00	57	3,000	5.83
8	54	40	85	9.00	20	2,750	13.09
9	64	40	68	7.00	18	2,750	10.18
10	32	35	31	7.00	87	3,500	7.00

The above table shows that the highest likely return is 13.33% which is corresponding to the annual demand of 40,000 units resulting a profit of Rs.10/- per unit and the required investment will be Rs.30,00,000.

Question 5

A retailer deals in a perishable commodity. The daily demand and supply are variables. The data for the past 500 days show the following demand and supply:

Supply		*Demand*	
Availability (kg.)	*No. of days*	*Demand (kg.)*	*No. of days*
10	*40*	*10*	*50*
20	*50*	*20*	*110*
30	*190*	*30*	*200*
40	*150*	*40*	*100*
50	*70*	*50*	*40*

The retailer buys the commodity at Rs.20 per kg and sells it at Rs.30 per kg. Any commodity remains at the end of the day, has no saleable value. Moreover, the loss (unearned profit) on any unsatisfied demand is Rs.8 per kg. Given the following pair of random numbers, simulate 6 days sales, demand and profit.

(31, 18); (63, 84); (15, 79); (07, 32) (43, 75); (81, 27)

The first random number in the pair is for supply and the second random number is for demand viz. in the first pair (31, 18), use 31 to simulate supply and 18 to simulate demand.

(Nov 2000)

Answer

The demand and supply patterns yield the following probability distribution. The numbers 00-99 are allocated in proportion to the probabilities associated with each event.

Availability (Kg.)	*Prob.*	*Cum. Prob.*	*Random Numbers allocated*	*Demand (Kg)*	*Prob.*	*Cum. Prob.*	*Random number allocated*
10	0.08	0.08	00-07	10	0.10	0.10	00-09
20	0.10	0.18	08-17	20	0.22	0.32	10-31
30	0.38	0.56	18-55	30	0.40	0.72	32-71

40	0.30	0.86	56-85	40	0.20	0.92	72-91
50	0.14	1.00	86-99	50	0.08	1.00	92-99

Let us simulate the supply and demand for the next six days using the given random numbers in order to find the profit if the cost of the commodity is Rs.20 per kg, the selling price is Rs.30 per kg, loss on any unsatisfied demand is Rs.8 per kg and unsold commodities at the end of the day have no saleable value.

Day	*Random no.*	*Supply availability*	*Random no.*	*Demand*	*Buying cost Rs.*	*Selling cost Rs.*	*Loss for unsatisfied demand*	*Profit*
1	31	30	18	20	600	600	--	--
2	63	40	84	40	800	1200	--	400
3	15	20	32	40	400	600	160	40
4	07	10	32	30	200	300	160	-60
5	43	30	75	40	600	900	80	220
6	81	40	27	20	800	600	--	-200

During the simulated period of six days, the net profit of the retailer is

= (400 + 40 + 220) – (60 + 200)

= 660 – 260

= Rs.400

Question 6

A book-store wishes to carry Systems Analysis and Design in stock. Demand is probabilistic and replenishment of stock takes 2 days (i.e., if an order is placed in March 1, it will be delivered at the end of the day on March 3). The probabilities of demand are given below:

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

Each time an order is placed, the store incurs an ordering cost of Rs.10 per order. The store also incurs a carrying cost of Rs.0.50 per book per day. The inventory carrying cost is calculated on the basis of stock at the end of each day. The manger of the book-store wishes to compare two options for his inventory decision:

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

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

Currently (beginning of the 1st day) the store has stock of 8 books plus 6 books plus 6 books ordered 2 days ago and expected to arrive next day. Using Monte-Carlo simulation for 10 cycles, recommend which option the manager should choose?

The two digits random numbers are given below:

89, 34, 78, 63, 81, 39, 16, 13, 73 *(May 2000)*

Answer

The question is not happily worded, if we go by the language of the question, the following solution can be worked out:

First of all, random numbers 00-99 are allocated in proportion to the probabilities associated with demand as given below:

Demand	*Probability*	*Cum. Probability*	*Random Nos.*
0	0.05	0.05	00-04
1	0.10	0.15	05-14
2	0.30	0.45	15-44
3	0.45	0.90	45-89
4	0.10	1.00	90-99

Based on the ten random numbers given, we simulate the demand per day in the table given below.

It is given that stock n hand = 8 and stock on order = 6 (expected next day). Let us now consider both the options stated in the question.

Option A: Order 5 Books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books:

Day	*Random No.*	*Sales Demand*	*Op. Stock in hand*	*Qty. Order*	*Qty. Recd. At end of the day*	*Total Qty. on order*	*Closing Stock*
1	89	3	8	-	-	6	5
2	34	2	5	-	6	-	9
3	78	3	9	-	-	-	6
4	63	3	6	5	-	5	3
5	61	3	3	-	-	5	0
6	81	3	0	0			
7	39	2					
8	16	2					
9	13	1					
10	73	3					

Now on day 6, there is stock out position since 5 units will be received at the end of the day and demand occurring during the day can not be met. Hence, it will into be possible to proceed further and we will have to leave the answer at this stage.

	Random No.	*Sales Demand*	*Opening Stock in hand*	*Qty. Order*	*Qty. Recd. At end of the day*	*Total Qty. on order*	*Closing Stock*
1	89	3	8	--	--	6	5
2	34	2	5	--	6	--	9
3	78	3	9	--	--	--	6
4	63	3	6	8	--	8	3
5	61	3	3	--	--	8	0
6	81	3	0	--	8	--	
7	39	2					
8	16	2					

9	13	1					
10	73	3					

Now on day 6, there is stock out position since 8 units will be received at eh end of the day and demand occurring during the day can not be met. Hence, it is not possible to proceed further and we may leave the answer at this stage.

Alternatively, if we assume that the demand occurring during the day can be met out of stock received at the end of the day, the solution will be as follows:

Stock in hand = 8 and stock on order = 6 (expected next day)

	Random No.	*Sales Demand*	*Opening Stock in hand*	*Qty. Order*	*Qty. Recd. At end of the day*	*Total Qty. on order*	*Closing Stock*
1	89	3	8	--	--	6	5
2	34	2	5	--	6	--	9
3	78	3	9	--	--	--	6
4	63	3	6	5	--	5	3
5	61	3	3	--	--	5	0
6	81	3	0	5	5	5	2
7	39	2	2	5	--	10	0
8	16	2	0	--	5	5	3
9	13	1	3	--	5	--	7
10	73	3	7	5	--	5	4

Carrying Cost = 39 × 0.50 = Rs.19.50

Ordering Cost = 4 × 10 = Rs.40.00

Total Cost = Rs.59.50

Option B: Order 8 Books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books:

	Random No.	*Sales Demand*	*Opening Stock in hand*	*Qty. Order*	*Qty. Recd. At end of the day*	*Total Qty. on order*	*Closing Stock*
1	89	3	8	--	--	6	5
2	34	2	5	--	6	--	9
3	78	3	9	--	--	--	6
4	63	3	6	8	--	8	3
5	61	3	3	--	--	8	0
6	81	3	0	--	8	--	5
7	39	2	5	8	--	8	3
8	16	2	3	--	--	8	1
9	13	1	1	--	8	--	8
10	73	3	8	--	--	--	5

Carrying Cost = 45 × 0.50 = Rs.22.50

Ordering Cost = 2 × 10 = Rs.20.00

Total Cost = Rs.42.50

Since Option B has lower cost, Manager should order 8 books.

Question 7

A bakery shop keeps stock of a popular brand of cake. Previous experience indicates the daily demand as given here:

Daily demand :	*0*	*10*	*20*	*30*	*40*	*50*
Probability :	*0.01*	*0.20*	*0.15*	*0.50*	*0.12*	*0.02*

Consider the following sequence of random numbers;

R. No. 48, 78, 19, 51, 56, 77, 15, 14, 68, 09

Using this sequence, simulate the demand for the next 10 days. Find out the stock situation if the owner of the bakery decides to make 30 cakes every day. Also, estimate the daily average demand for the cakes on the basis of simulated data. *(Nov 1999)*

Answer

The numbers 00-99 are allocated in proportion to the probabilities associated with each event as given below:

Daily Demand	*Probability*	*Cumulative Probability*	*Random Numbers Allocated*
0	0.01	0.01	00-00
10	0.20	0.21	01-20
20	0.15	0.36	21-35
30	0.50	0.86	36-85
40	0.12	0.98	86—97
50	0.02	1.00	98-99

Let us simulate the demand for the next 10 days using the given random numbers in order to find out the stock position if the owner of the bakery decides to make 30 breads every day. We will also estimate the daily average demand for the bread on the basis of simulated data.

Day	*Random Number*	*Simulated Demand*	*Stock if 30 breads are prepared every day*
1	48	30	0
2	78	30	0
3	19	10	20
4	51	30	20
5	56	30	20
6	77	30	20
7	15	10	40
8	14	10	60
9	68	30	60

10	9	10	80
	Total	*220*	

Daily average demand of the basis of simulated data = 220

Question 8

Write a short note on the advantages of simulation. *(Nov 1996)*

Answer

Advantages of simulation are enumerated below:

1. Simulation techniques allow experimentation with a model of the system rather than the actual operating system. Sometimes experimenting with the actual system itself could prove to be too costly and, in many cases too disruptive. For example, if you are comparing two ways of providing food service in a hospital, the confusion that would result from operating two different systems long enough to get valid observations might be too great. Similarly, the operation of a large computer central under a number of different operating alternatives might be too expensive to be feasible.
2. The non-technical manage can comprehend simulation more easily than a complex mathematical model. Simulation does not require simplifications and assumptions to the extent required in analytical solutions. A simulation model is easier to explain to management personnel since it is a description of the behaviour of some system or process.
3. Sometimes there is not sufficient time to allow the actual system to operate extensively. For example, if we were studying long-term trends in world population, we simply could not wait the required number of years to see results. Simulation allows the manger to incorporate time into an analysis. In a computer simulation of business operation the manager can compress the result of several years or periods into a few minutes of running time.
4. Simulation allows a user to analyze these large complex problems for which analytical results are not available. For example, in an inventory problem if the distribution for demand and lead time for an item follow a standard distribution, such as the poison distribution, then a mathematical or analytical solution can be found. However, when mathematically convenient distributions are not applicable to the problem, an analytical analysis of the problem may be impossible. A simulation model is a useful solution procedure for such problems.

Question 9

A company trading in motor vehicle spares wishes to determine the level of stock it should carry for the item in its range. Demand is not certain and replenishment of stock takes 3 days. For one item X, the following information is obtained: (7 Marks)

Demand (unit per day)	*Probability*
1	*.1*
2	*.2*
3	*.3*
4	*.3*
5	*.1*

Each time an order is placed, the company incurs an ordering cost of Rs. 20 per order. The company also incurs carrying cost of Rs. 2.50 per unit per day. The inventory carrying cost is calculated on the basis of average stock.

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

(A) Order 12 units when the inventory at the beginning of the day plus order outstanding is less than 12 units.

(B) Order 10 units when the inventory at the beginning of the day plus order outstanding is less than 10 units.

Currently (on first day) the company has a stock of 17 units. The sequence of random number to be used is 08, 91, 25, 18,40, 27, 85, 75, 32, 52 using first number for day one.

You are required to carry out a simulation run over a period of 10 days, recommended which option the manager should chose.

Answer

Allocation of random numbers

Demand	Probability	Cumulative prob.	Random numbers
1	.1	.1	00-09
2	.2	.3	10-29
3	.3	.6	30-59
4	.3	.9	60-89
5	.1	1.0	90-99

Option I

Day	*Random numbers*	*Opening Stock*	*Demand*	*Closing Stock*	*Order placed*	*Order in*	*Average stock*
1	08	17	1	16	-	-	16.5
2	91	16	5	11	12		13.5
3	25	11	2	09	-	-	10.0
4	18	09	2	07	-	-	8.00
5	40	07	3	04	-	12	5.50
6	27	16	2	14	-	-	15.0
7	85	14	4	10	12	-	12.00
8	75	10	4	06	-	-	8.00
9	32	6	3	3	-	-	4.50
10	52	3	3	-	-	12	1.50
							94.5

Carrying cost (94.5 $\times$ 2.50) =Rs.236.25

Ordering cost (2 $\times$ 20) =<u>Rs.40.00</u>

<u>Rs.276.25</u>

Option 11

Day	*Random no.*	*Opening Stock*	*Demand*	*Closing Stock*	*Order placed*	*Order in*	*Average stock*
1	08	17	1	16	-	-	16.5
2	91	16	5	11	-	-	13.5
3	25	11	2	09	10	-	10.0
4	18	09	2	07	-	-	8.00
5	40	07	3	04	-		5.50
6	27	04	2	02	-	10	3.00
7	85	12	4	08	10	-	10.00
8	75	08	4	04	-	-	6.00

9	32	04	3	01	-	-	2.50
10	52	01	3	-	-	10	0.50
							75.5

Carrying cost (75.5 $\times$ 2.50) = Rs.118.75

Ordering cost (2 $\times$ 20) = Rs. 40.00

Rs.228.75

Option II is better.

Question 10

A Publishing house has bought out a new monthly magazine, which sells at Rs. 37.5 per copy. The cost of producing it is Rs. 30 per copy. A Newsstand estimates the sales pattern of the magazine as follows:

Demand Copies	*Probability*
0 $<$ 300	*0.18*
300 $<$ 600	*0.32*
600 $<$ 900	*0.25*
900 $<$ 1200	*0.15*
1200 $<$ 1500	*0.06*
1500 $<$ 1800	*0.04*

The newsstand has contracted for 750 copies of the magazine per month from the publisher.

The unsold copies are returnable to the publisher who will take them back at cost less Rs. 4 per copy for handling charges.

The newsstand manager wants to simulate of the demand and profitability. The of following random number may be used for simulation:

27, 15, 56, 17, 98, 71, 51, 32, 62, 83, 96, 69.

You are required to-

(i) Allocate random numbers to the demand patter forecast by the newsstand.

(ii) Simulate twelve months sales and calculate the monthly and annual profit/loss.

(iii) Calculate the loss on lost sales.

Answer

(i) Allocation of random numbers

Demand	*Probability*	*Cumulative probability*	*Allocated RN*
0<300	0.18	0.18	00—17
300 < 600	0.32	0.50	18—49
600 < 900	0.25	0.75	50—74
900 < 1200	0.15	0.90	75—89
1200 <1500	0.06	0.96	90—95
1500 < 1800	0.04	1.00	96—99

(ii) Simulation: twelve months sales, monthly and annual profit/loss

Month	*RN*	*Demand*	*Sold*	*Return*	*Profit on sales (Rs.)*	*Loss on return (Rs.)*	*Net (Rs.)*	*Loss on lost units*

1	27	450	450	300	3375	12000	2175	
2	15	150	150	600	1125	2400	-1275	
3	56	750	750	--	5625	--	5625	
4	17	150	150	600	1125	2400	-1275	
5	98	1650	750	--	5625	---	5625	900
6	71	750	750	--	5625	--	5625	
7	51	750	750	--	5625	--	2175	
8	32	450	450	300	3375	1200	5625	
9	62	750	750	--	5625	--	5625	300
10	83	1050	750	--	5625	--	5625	900
11	96	1650	750	--	5625	--	5625	
12	69	750	750	--	5625		5625	
					54000	7200	46800	2100

(iii) Loss on lost sale 2100×7.5 = Rs15750.

Question 11

(i) What is simulation?

(ii) What are the steps in simulation?

Answer

(i) Simulation is a quantitative procedure which describes a process by developing a model of that process and then conducting a series of organized trial and error experiments to product the behaviour of the process over time.

(ii) Steps in the simulation process:

(i) Define the problem and system you intend to simulate.

(ii) Formulate the model you intend to use.

(iii) Test the model, compare with behaviour of the actual problem environment.

(iv) Identify and collect data to test the model.

(v) Run the simulation.

(vi) Analyse the results of the simulation and, if desired, change the solution you are evaluating.

(vii) Rerun the simulation to tests the new solution.

(viii) Validate the simulation i.e., increase the chances of valid inferences.

21

LEARNING CURVE THEORY

Question 1

An electronics firm which has developed a new type of fire-alarm system has been asked to quote for a prospective contract. The customer requires separate price quotations for each of the following possible orders:

Order	*Number of fire-alarm systems*
First	*100*
Second	*60*
Third	*40*

The firm estimates the following cost per unit for the first order:

Direct materials	*Rs. 500*
Direct labour	
Deptt. A (Highly automatic) 20 hours at Rs. 10 per hour	
Deptt. B (Skilled labour) 40 hours at Rs. 15 per hour	
Variable overheads	*20% of direct labour*
Fixed overheads absorbed:	
Deptt. A	*Rs. 8 per hour*
Deptt. B	*Rs. 5 per hour*

Determine a price per unit for each of the three orders, assuming the firm uses a mark up of 25% on total costs and allows for an 80% learning curve. Extract from 80% Learning curve table:

X	1.0	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Y%	100.0	91.7	89.5	87.6	86.1	84.4	83.0	81.5	80.0

X represents the cumulative total volume produced to date expressed as a multiple of the initial order.

Y is the learning curve factor, for a given X value, expressed as a percentage of the cost of the initial order.

Answer

(i) Price per unit for first order of 100 units

	Rs	Rs
Direct material		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200 Dept B 40 Hrs @ 15 = 600	800.00
Variable Overhead	20% of Rs 800	160.00
Fixed Overhead	Dept A 20 Hrs @ 8 = 160 Dept B 40 Hrs @ 5 = 200	360.00
Total cost		1,820.00

Profit 25%	455.00
Selling price per unit	2,275.00

(ii) Price per unit for second order of 60 units

Learning will be applicable only in department B.

Cumulative output becomes 100 units + 60 units = 160 units i.e 1.6 times for which learning is 86.1 % from the tables.

Therefore Total Hrs for 160 units = 160 units $\times$40 $\times$ .861 = 5,510.4 Hrs

Therefore Hrs for 60 units = Hrs for 160 units less Hrs for 100 units

Or 5510.4 less 40 $\times$ 100 = 1510.4 Hrs

Therefore Hrs per unit = $\frac{1510.4}{60}$ = 25.17

Calculation of selling price per unit

		Rs
Direct materials		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200 Dept B 25.17 Hrs @ 15 = 377.55	577.55
Variable Overhead	20% of 577.55	115.51
Fixed Overhead	Dept A 20 Hrs @8= 160 Dept B 25.17 Hrs @5=125.85	285.85
Total cost		1,478.91
Profit 25%		369.73
Selling price per unit		1,848.64

(iii) Price per unit for third order of 40 units

Cumulative output becomes 100 + 60 + 40 = 200 units i.e. 2 times for which learning is 80% from the table

Total Hrs for 200 units = 200 $\times$40 $\times$.80 = 6,400 Hrs

Hrs for 40 units = Hrs for 200 units less Hrs for 160 units

Or 6,400 less 5510.4 = 889.6 Hrs

Therefore Hrs per unit = $\frac{889.6}{40}$ = 22.24

Calculation of selling price per unit

		Rs
Direct materials		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200.00 Dept B 22.24 @ 15 = 333.60	533.60
Variable Overhead	20% of 533.60	106.72
Fixed Overhead	Dept A 20 Hrs @ 8 = 160 Dept B 22.24 Hrs @ 5 = 111.20	271.20
Total cost		1,411.52
Profit 25%		352.88
Selling price per unit		1,764.40

Question 2

Explain the concept 'Learning curve'. How can it be applied for Cost management?

Answer

The first time when a new operation is performed, both the workers and the operating procedures are untried. As the operation is repeated and the workers become more familiar with work, labour efficiency increases and the labour cost per unit declines. This process continues for some time and a regular rate of decline in cost per unit can be established. This rate can be used to predict future labour costs. The learning process starts from the point when the first unit comes out of the production line. In other words 'Learning curve' is a function that measures how labour hours per unit decline as units of production increase because workers are learning and becoming better at their jobs.

Cost Management Application:

1. Learning curve is useful in analysing cost volume profit relationship. The company can set low price of its product to generate high demand. As the production increases, cost per unit drops.
2. It helps in budgeting and profit planning.
3. It enables the company in price fixation. In particular, the company can fix a lower price for repeat orders.
4. It helps the design engineers to take suitable decisions based on expected rates of improvement.
5. It helps in price negotiations.
6. It is useful in setting standards and in performance evaluation.