

SUGGESTED ANSWERS

TO

QUESTIONS

SET AT THE

INSTITUTE'S EXAMINATIONS

MAY, 1999 – NOVEMBER, 2008

A COMPILATION

FINAL EXAMINATION

PAPER – 5 : COST MANAGEMENT



BOARD OF STUDIES
THE INSTITUTE OF CHARTERED ACCOUNTANTS OF INDIA
(Set up by an Act of Parliament)

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Website : www.icai.org

Department/Committee : Board of Studies

E-mail : bosnoida@icai.org

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FOREWORD

I am extremely happy to know that Board of Studies has planned and taken many constructive measures to help students prepare a better strategy to excel in the examinations. These are in the forms of *compilation of question papers, suggested answers, comments on the questions* etc. All these exercises aim at simplifying the fundamentals and covering the relevant areas of the main subjects. Questions and Answers are formulated in a manner so that the students get maximum benefit from the study materials. This will leave no scope for any ambiguity and confusion.

The compilation of the subjects for the final examination includes **Advanced Accounting, Advanced Audit, Corporate Law and Secretarial Practices, Management Accounting and Financial Analysis, Cost Management, Management Information and Control System**. They cover the questions and answers upto November, 2008 examinations.

These effective measures by the Board of Studies are worth commending and deserve a special mention. I sincerely congratulate the entire team.

June, 2009
New Delhi

CA. Uttam Prakash Agarwal
President, ICAI

FOREWORD

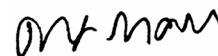
The theory of Cost Accounting has seen rapid changes in the recent past. Although traditional concepts are very much relevant to the present era, new tools and techniques have emerged alongside.

As a result of these developments, the Council of the Institute of Chartered Accountants of India brought in certain changes in the syllabus of 'Advanced Cost Accounting and Cost Systems' paper in the year 2002. The paper was renamed as ' Cost Management' and the proposed syllabus was a mix of traditional as well as modern concepts of Cost Accounting, Cost Management and Operations Research. The result of these changes can be seen from November 2002 examination onwards where there is a higher emphasis on the knowledge of concepts of TQM, LCC, Target Costing etc as compared to the previous examinations.

However, it is important for every student to have sound knowledge of traditional concepts like Marginal Costing, Standard Costing etc, as they still remain extremely popular in the industry all over the world. In fact, almost all of the new tools and techniques are refined traditional concepts, which call for an extremely sound understanding of the latter.

Keeping this in mind, the Board of Studies has decided to bring out a compilation of this important subject, which contains 21 chapters in all. These chapters have been numbered in consonance with chapter numbering of Cost Management study material for easy co-relation and understanding by the students. This will facilitate better preparation for the examination. I am sure that this volume shall be of immense help for examinees.

June, 2009
New Delhi



CA. Jaydeep Narendra Shah
Chairman, Board of Studies

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BASIC COST CONCEPTS IN DECISION MAKING

Question 1

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 2

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:

<i>Material:</i>		<i>Rs.</i>
	<i>X (in stock – at original cost)</i>	<i>1,50,000</i>
	<i>Y (on order – on contract)</i>	<i>1,80,000</i>
	<i>Z (to be ordered)</i>	<i>3,00,000</i>
<i>Labour</i>		
	<i>Skilled</i>	<i>5,40,000</i>
	<i>Non-skilled</i>	<i>3,00,000</i>
	<i>Supervisory</i>	<i>1,00,000</i>
<i>General overheads</i>		<u><i>10,80,000</i></u>
<i>Total cost</i>		<i>26,50,000</i>
<i>Price offered by department store</i>		<u><i>18,00,000</i></u>

Cost Management

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 (Refer to working note 1)	-	2,10,000
Total cash inflows: (A)	<u>18,00,000</u>	<u>2,10,000</u>
Cash outflows		
Material X substitute (Refer to working note 2)	1,35,000	-
Adaptation required for the use of obsolete material X	-	27,000
Material Z	3,00,000	-
Replacement of semi-skilled labour by skilled labour (Refer to working note 3)	5,70,000	-
Non-skilled labour cost	3,00,000	-

Basic Cost Concepts in Decision Making

(Refer to working note 4)

Supervisory staff cost	35,000	-
------------------------	--------	---

(Refer to working note 5)

Avoidable overheads	1,25,000	-
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(Refer to working note 6)

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

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 on 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:	

Cost Management

	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	<u>006</u>
	Total Cost	<u>150</u>

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 worth Rs.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 Rs.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 lacs of the same can be avoided.

Basic Cost Concepts in Decision Making

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 (Refer to working note 1)		20	
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 (Refer to working note 2)		9	
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	

Cost Management

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 :

- | | Rs. (Lacs) |
|---|------------|
| 1. | |
| 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 this 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 4

- (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 managers 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 divided 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.

Basic Cost Concepts in Decision Making

Question 5

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 from 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 6

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 maximum capacity. However, the capacity utilization of all the four departments are not equal and the present individual capacity utilizations are as under :

	Department	
Capacity Utilisation %	A	75
	B	100
	C	70

Cost Management

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:

- 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

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

Basic Cost Concepts in Decision Making

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

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)						<u>180.00</u>
Total return						<u>189.96</u>
Return on investment						

Cost Management

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

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

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

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 7

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	

Basic Cost Concepts in Decision Making

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 though 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

Cost Management

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)	<u>55,000</u>	70,000	
Variable overheads 15,000 hours @ Re.1 (Refer to working note 6)		15,000	

Basic Cost Concepts in Decision Making

Extra selling and delivery expenses	27,000		
Extra advertising	<u>18,000</u>	<u>45,000</u>	<u>2,50,000</u>
Fixed advertising		Nil	
(To remain same, not relevant)			<u> </u>
Excess of relevant revenues			<u>20,000</u>

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.

Cost Management

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 8

- (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:

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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 be 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 stated 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 manager responsible for

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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 consist 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	<u>1,500</u>
Total minimum price which may be quoted	<u>61,975</u>

Working notes:

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

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	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)	<u>30</u>
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)	<u>60</u>
Net loss on material cost saving of equipment	<u>11,700</u>

Question 9

Explain with one example each that sunk 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 10

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 in fixed costs, but the variable costs per unit during overtime will be Rs.12 inc excess of 8,000 units upto the capacity of 15,000 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?*

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- (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 extend 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.

$$x \text{ units} \times \text{Rs.}12 + \text{Rs.}30,000 = x \text{ units} \times \text{Rs.}10.50 + \text{Rs.}36,000$$

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

Range

Above 8,000 units but less than 12,000 units

At 12,000 units

12,001 to 16,000 units

Method to be adopted

Overtime working

Any one method may be adopted

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 $\times$ Rs.10 + Rs.30,000)	1,10,000	1,10,000

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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 of 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 11

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

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

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	1,10,000	80,000
	(Rs.45,000 –	(Rs.1,25,000 –	(Rs.1,25,000 –

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	Rs.15,000)	Rs.15,000)	Rs.45,000)
Differential variable costs per case : (II)	100	200	100
	(Rs.240 – Rs.140)	(Rs.240 – Rs.40)	(Rs.140 – Rs.40)
Cost indifference point (I/II)	300	550	800
(Differential fixed costs / Differential variable costs per case)	Cases	Cases	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, if 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 up to 850 cases, alternative C is most appropriate.

Question 12

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:

<i>Material</i>	<i>Rs. 4,80,000</i>	<i>Labour</i>	<i>Rs. 1,60,000</i>
<i>Variable overhead</i>	<i>Rs. 3,20,000</i>	<i>Fixed overhead</i>	<i>Rs. 5,00,000</i>

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 $12\% \div (1 - 0.4) = 20\%$ (gross) on capital employed.

Let selling price per unit to be 'x'

Since Total sales = Total cost + profit

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

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

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

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

Hence selling price per unit will be Rs. 23.61

Question 13

A businessman employs 20 sewing 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 machinists 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.

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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	

Basic Cost Concepts in Decision Making

(984000 – 720000)

Cost of training 100000

Benefit from training 164000

Question 14

“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 15

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.

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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.

Question 16

Explain the concept of relevancy of cost by citing three examples each of relevant costs and non-relevant costs. **(Nov 2008, 4 Marks)**

Answer

Relevant costs are those costs which are pertinent to a decision. In other words, these are the costs which are influenced by a decision. Those costs which are not affected by the decision are not relevant costs.

Examples of relevant costs are:

- (1) All variable costs are relevant costs.
- (2) Fixed Costs which vary with the decision are relevant costs.
- (3) Incremental costs are relevant costs.

Examples of non-relevant costs:

- (1) All fixed costs are generally non-relevant.
- (2) Variable costs which do not vary with the decision are not relevant costs.
- (3) Book value of the asset is not relevant.

MARGINAL COSTING

Question 1

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:

$$\begin{aligned}\text{Margin of safety} &= \frac{\text{Profit}}{\text{P/V ratio}} \text{ or} \\ &= \frac{\text{Profit}}{(\text{Contribution/Sales})}\end{aligned}$$

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 using the following formula:

$$\begin{aligned}\text{Margin of safety ratio} &= \frac{\text{Margin of Safety}}{\text{Sales}} \times 100 \\ &= \frac{\text{Actual sales} - \text{Break even sales}}{\text{Sales}} \times 100\end{aligned}$$

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.

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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 2

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

$$\begin{aligned}\text{Combined P/V ratio} &= \frac{\text{Total Contribution}}{\text{Total Sales}} \times 100 \\ &= \frac{\text{Rs.21,000}}{\text{Rs.60,000}} \times 100 = 35\%\end{aligned}$$

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

Marginal Costing

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 3

What are the limitations of a break-even chart?

(May 1999)

Answer

The limitations of break even chart are as follows:

1. While preparing a break-even chart, it is assumed that revenue and costs can be represented with the help of straight lines. It is not always true.
2. The preparation of a break-even chart requires the segregation of semi-variable costs into fixed and variable components. It may not 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 apportionment 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 4

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:

Cost Management

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.

$$\begin{aligned}\text{Present output per employee} &= \frac{\text{Total present output}}{\text{Total number of present employees}} \\ &= \frac{\text{Rs.48,000 units}}{160 \text{ employees}} = 300 \text{ units}\end{aligned}$$

$$\begin{aligned}\text{Total future expected output} &= \\ \text{Total number of future employee} &\left(\frac{\text{Present output}}{\text{per employee}} + \frac{60\% \text{ of present output}}{\text{per employee}} \right) \\ &= 120 \times (300 \text{ units} + 60\% \times 300 \text{ units}) \\ &= 57,600 \text{ units}\end{aligned}$$

2. Present and proposed piece work rate:

$$\begin{aligned}\text{Present piece work rate} &= \text{Re 1/- per unit} \\ \text{Proposed piece work rate} &= \text{Present piece work rate} + 30\% \times \text{Re.1} \\ &= \text{Re 1/-} + 0.30 \text{ P} \\ &= \text{Rs.1.30 per unit}\end{aligned}$$

3. Present and proposed sale price per unit:

$$\begin{aligned}\text{Present sale price per unit} &= \text{Rs.12.50/- per unit} \\ &(\text{Rs.6,00,000}/48,000 \text{ units}) \\ \text{Proposed sale price per unit} &= \text{Rs.12} \\ &(\text{Rs.12.50} - 4\% \times \text{Rs.12.50})\end{aligned}$$

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

$$\begin{aligned}&= \frac{\text{Present Sales Value} - \text{Contribution towards fixed expenses \& profit} - \text{Present wages}}{\text{Present output (units)}} \\ &= \frac{\text{Rs.6,00,000} - \text{Rs.2,40,000} - \text{Rs.48,000}}{48,000 \text{ units}} = \text{Rs.6.50 p.u.}\end{aligned}$$

Marginal Costing

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)	<u>4,49,280</u>
Marginal contribution : [(A) – (B)]	2,41,920
Less: Present contribution	<u>2,40,000</u>
Increase in contribution (per week)	<u>1,920</u>
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 5

- (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 :

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	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.

Marginal Costing

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 in 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.

	<i>First year</i>		<i>Second Year</i>	
	<i>Monthly Rs.</i>	<i>Yearly Rs.</i>	<i>Monthly Rs.</i>	<i>Yearly Rs.</i>
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
	$\left(\frac{\text{Rs.3,000 units}}{12 \text{ months}} \right) \times 400$			
Total fixed overhead	108	1,296	110	1,320
(Refer to working note 1)	$\left(\frac{\text{Rs.1,296}}{12 \text{ months}} \right)$		$\left(\frac{\text{Rs.1,320}}{12 \text{ month}} \right)$	
Total cost : (B)	492	5,904	494	5,928
Profit : C = [(A)-(B)]	108	1,296	106	1,272

Cost Management

Working Note :

1. (i)

<i>Fixed overhead</i>	<i>First year : (Rs.)</i>	<i>Second year (Rs.)</i>
Depreciation	8,96,000	8,96,000
<u>Rs. 24,00,000 + Rs.2,88,000 duty</u>		
3 years		
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 Rs.	1401 – 1450 Rs.	1451 – 1500 Rs.	1501 – 1550 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)	(31 boxes × 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
$\left(\frac{\text{Total fixed and semi - variable costs}}{\text{Contribution per unit}} \right)$	(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	1,43,200	1,43,600	1,44,000	1,44,000

Marginal Costing

boxes costs):
(B)

	(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.80)	(Rs.14,32,600 / Rs.80)	(Rs.14,40,000 / Rs.80)	(Rs.14,40,400 / 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 6

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:

Cost Management

- (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 7

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.

Marginal Costing

- (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 8

“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 9

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.,

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

Cost Management

$$\begin{aligned} &= \frac{\text{Rs.}58,000 - \text{Rs.}30,000}{\text{Rs.}(60 + 80) - \text{Rs.}(40 + 30)} \\ &= \frac{\text{Rs.}28,000}{\text{Rs.}70 \text{ (per unit of 100 copies)}} = 400 \text{ Nos. (Multiple of 100 copies)} \end{aligned}$$

Cost indifference point for two machines viz.

$$\begin{aligned} \text{B \& C} &= \frac{\text{Rs.}1,00,000 - \text{Rs.}58,000}{\text{Rs.}(40 + 30) - \text{Rs.}(20 + 20)} \\ &= \frac{\text{Rs.}42,000}{\text{Rs.}30 \text{ (per unit of 100 copies)}} \\ &= 1,400 \text{ Nos. (Multiple of 100 copies)} \end{aligned}$$

Cost indifference point for two machines viz.

$$\begin{aligned} \text{C \& A} &= \frac{\text{Rs.}1,00,000 - \text{Rs.}30,000}{\text{Rs.}(60 + 80) - \text{Rs.}(20 + 20)} \\ &= 700 \text{ Nos. (Multiple of 100 copies)} \end{aligned}$$

- (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 9

Explain, how Cost Volume Profit (CVP) - based sensitivity analysis can help managers 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.

Marginal Costing

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

Question 10

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 11

Briefly discuss on curvilinear CVP analysis.

(Nov 2001)

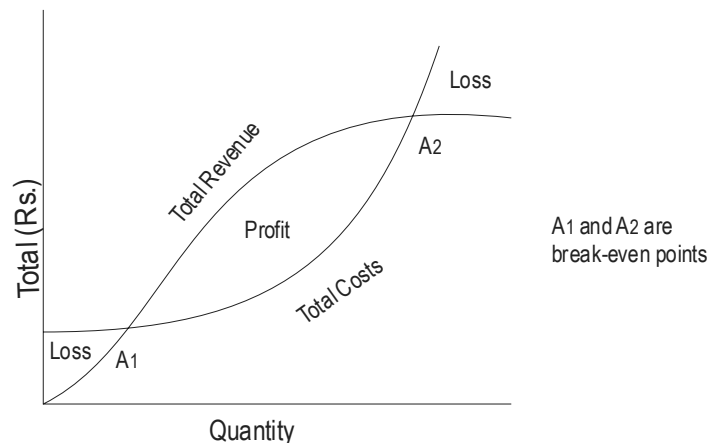
Answer

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:

Cost Management

- 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 12

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.

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

Marginal Costing

- (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:

$$(80x + 60x) - \text{Rs.15,00,000} = \text{Rs.1,50,000} + \text{Rs.30,000}$$

$$\text{or } x = 12,000 \text{ units}$$

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

Cost Management

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

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

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

	Rs.
Revised contribution from Product A [10,000 units (Rs.240 – Rs.129)]	11,10,000
Revised contribution from Product B [12,000 units (Rs.120 – Rs.64.50)]	6,66,000
Total revised contribution	17,76,000
Less: Revised fixed cost	12,75,000
Revised profit	5,01,000
Less: Existing profit	1,80,000
Increase in profit	3,21,000

Advise: A comparison of increase in profit figures under above three options clearly indicates that the option (iii) is the best as it increases the profit of the concern by 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 13

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

Marginal Costing

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 summarised 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 than 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 14

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 $30,000(100 - 40) = \text{Rs}18,00,000$.

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

Variable Cost for the year 2005 ($\text{Rs}40 + 25\% \text{ of Rs}40$) = Rs50 per Unit

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

Cost Management

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 15

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

	May Rs.	June Rs.
(i) <i>Budgeted Costs and Selling prices:</i>		
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) <i>Actual production and sales:</i>		
	Units	Units
Production	24,000	24,000
Sales	21,000	26,500
(iii) <i>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.</i>		
(iv) <i>Actual costs incurred corresponded to those budgeted for each month.</i>		
<i>You are required to calculate the relative effects on the monthly operating profits of applying: (i) Absorption costing and (ii) Marginal costing.</i>		

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

Marginal Costing

Budgeted output	units	25,000	25,000
Fixed overheads absorption rate per unit	Rs.	1.60	1.76

(i) Profitability based on absorption costing:

	<i>May 2003</i>	<i>June 2003</i>
	<i>Rs.</i>	<i>Rs.</i>
<i>Sales:</i>		
May: 21,000 units @ Rs. 5.00	1,05,000	
June: 26,500 units @ Rs. 5.50		1,45,750
<i>Production Costs:</i>		
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
<i>Add: Opening stock</i>		
May Nil		
June 3,000 units @ Rs. 3.60*		10,800
Total	86,400	1,05,840
<i>Less: Closing stock</i>		
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	<u>89,600</u>	<u>1,19,260</u>
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	<u>13,800</u>	<u>24,730</u>
*Total cost =		VC + FC

Cost Management

May	$2.00 + 1.60 = 3.60$
June	$2.20 + 1.76 = 3.96$

(ii) Profitability based on marginal costing:

	May 2003	June 2003
	Rs.	Rs.
Sales	1,05,000	1,45,750
Production cost – variable	48,000	52,800
Add: Opening stock		
May Nil		
June		<u>6,000</u>
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:		
Production	40,000	44,000
Marketing	14,000	15,400
Net profit	9,000	28,650

Question 16

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.

- Prepare the profitability statement for production levels of 2,000 units and 3,000 units, when fixed cost = Rs. 1 lakhs.
- What is the break-even point (BEP) for the above data?

Marginal Costing

(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:

Particulars	Volume Level	
	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	$(6 \times 2,000) = 12,000$	$(12 \times 2,000) = 24,000$
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

Cost Management

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
	$10 \times 2,000$	$11 \times 2,000$
Total fixed cost	2,00,000	2,02,000
Gross contribution/unit	200	200
BEP	1,000 units	1,010 units

Question 17

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

Marginal Costing

<i>Particulars</i>	<i>Rs. 000's</i>	<i>Particulars</i>	<i>Rs. 000's</i>
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:

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

(iii) Reconciliation

	<i>Rs. 000's</i>
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))

Cost Management

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.

Question 18

The following information of a company is available for the year 2006:

	Rs.
Sales	40,000
Raw materials	20,000
Direct wages	6,000
Variable and fixed OH	10,000
Profit	4,000
Units sold	200 Nos.

In the year 2007, wages rate will increase by 50% and fixed cost will decrease by Rs. 600. If 300 units are sold in 2007, the total fixed and variable OH will be 11,400. How many units should be sold in 2007, so that the same amount of profit per unit as in year 2006 may be earned?
(May 2007, 4 Marks)

Answer

Particulars (Data per unit)	2006	2007
	Rs.	Rs.
Selling price (40,000 / 200)		200
Raw materials (20,000 / 200)		100
Direct wages (6,000 / 200)	30	(30 × 150%) 45
Variable overhead		20
Total variable cost		165
Contribution		35
Profit per unit (4,000 / 200)		20
Net contribution per unit to cover fixed overheads		15
Fixed overheads	6,000	5,400
No. of units		5,400 / 15 = 360 units

Working Notes:

No. of units sold	200	300
Total variable and fixed overheads	10,000	11,400 + 600 = 12,000
Differential cost in 2007		100 units Rs. 2,000
Variable overhead per unit		2,000 / 100 = 20

Marginal Costing

Total variable cost	4,000	6,000
Total fixed cost	6,000	(6,000 – 600) 5,400

Question 19

A company makes 1,500 units of a product for which the profitability statement is given below:

		Rs.
Sales		1,20,000
Direct materials	30,000	
Direct labour	36,000	
Variable OH	<u>15,000</u>	
Subtotal variable cost	81,000	
Fixed cost	<u>16,800</u>	
Total cost		<u>97,800</u>
Profit		<u>22,200</u>

After the first 500 units of production, the company has to pay a premium of Rs. 6 per unit towards overtime labour. The premium so paid has been included in the direct labour cost of Rs. 36,000 given above.

You are required to compute the Break-even point.

(May 2007, 6 Marks)

Answer

Data / Unit	1 – 500	501 – 1,500
	Rs.	Rs.
Sales (1,20,000 / 1,500)	80	80
Direct material (20,000 / 1,000)	20	20
Direct labour	20	26
Variable overheads 15,000 / 1,500	10	10
Contribution	30	24
No. of units	500	
Total contribution	15,000	
Fixed costs	16,800	
Shortfall	1,800	
No. of units required above 500 to recover shortfall		1,800 / 24 = 75
Break even point		(500 + 75) = 575 units

Let X be the Direct Labour per unit upto 500 units.

Cost Management

Total Direct Labour $500X + 1,000(X + 6) = 36,000$

$$1,500X + 6,000 = 36,000$$

$$X = 20.$$

Therefore, up to 500 units the Direct Labour is Rs. 20. After 500 units it is Rs. 26.

Question 20

A Ltd. Makes and sells a single product. The company's trading results for the year are:

	Figs. – Rs. '000 (Year 2007)	
Sales		3,000
Direct materials	900	
Direct labour	600	
Overheads	<u>900</u>	<u>2,400</u>
Profits		<u>600</u>

For the year 2008, the following are expected:

- (i) Reduction in the selling price by 10%.
- (ii) Increase in the quantity sold by 50%.
- (iii) Inflation of direct material cost by 8%.
- (iv) Price inflation in variable overhead by 6%.
- (v) Reduction of fixed overhead expenses by 25%.

It is also known that :

- (a) In 2006, overhead expenditure totalled to Rs. 8,00,000.
- (b) Total overhead cost inflation for 2007 has been 5% more than 2006.
- (c) Production and sales volumes have been 25% higher in 2007 than in 2006.

The high-low method is being used by the company to estimate overhead expenditure.

You are required to:

- (i) Prepare a statement showing the estimated trading results for 2008.
- (ii) Calculate the Break-even point for 2007 and 2008.
- (iii) Comment on the BEP and profits of the years 2007 and 2008. (May 2008, 12 Marks)

Answer

(a) (i)

	Trading Results			
	Figures Rs. '000			
	2006	2007	2008	Workings
Sales:		3,000	4,050	$(3,000 \times 1.5 \times .9)$
		(Refer to Note 1)		

Marginal Costing

Direct Material	900	1,458	$(900 \times 1.5 \times 1.08)$
Direct Labour	600	900	$(600 \times 1.5 \times 1)$
Variable Overhead	<u>300*</u>	<u>477</u>	$(300 \times 1.06 \times 1.5)$
	(Refer Note 2)		
Total Variable Cost	<u>1,800</u>	<u>2,835</u>	Total variable cost
Contribution	1,200	1,215	
Fixed Overhead	600	450	$(600 \times .75)$
	(Refer to Note 3)		
Total Overhead	800	<u>900</u>	<u>927</u>
Total Cost	2,400	3,285	
Profits	600	765	

(ii) P/V Ratio Contribution/ Sales 40%30%

$$\text{BEP} \quad \text{Fixed Cost/PV Ratio} \quad \frac{600}{40\%} = 1,500 \quad \frac{450}{30\%} = 1,500$$

(Note 1) $3,000 \times 1.5 \times 0.9$

(Note 2) Overhead Cost in 2006 = 800

Increase in price = 5%

$\therefore$ Overhead cost for same production $800 \times 5\% + 800 = 840$.

Overhead increase due to quantity = $900 - 840 = \text{Rs. } 60$

Rs. 60 represents increase in variable Overhead in 2007 due to increase in quantity by 25%.

$\therefore$ Variable Overhead amount in 2007 = $1\frac{1}{4}$ times

$$\text{i.e. } \frac{5}{4} = 5 \text{ times} \left(\frac{1}{4} \text{th quantity} \right) = 5 \times 60 = 300$$

(Note 3)

In 2007 Total Overhead	900
Variable Overhead (Refer to Note 2)	<u>300</u>
Fixed Overhead	<u>600</u>

Cost Management

(iii)

	2007	2008	Difference	%
BEP	1,500	1,500	0	
Fixed Overhead	600	450	150	25%
PV Ratio	40%	30%	10%	25% $\frac{10}{40}$
Profit	600	765	165	27.5%
$\text{BEP} = \frac{\text{Fixed Cost}}{\text{P/V ratio}}$				

Both Fixed Cost and P/V ratio have declined by 25% equally. So BEP sales remains the same.

The contribution is only Rs. 1,215 in 2008 though quantity is increased by 50%. This is due to increase in production cost and decrease in selling price. This is more than made up by decrease in fixed cost so that overall profit has increased by 27.5%.

Alternative Solution (for identifying variability and fixedness of overheads):

$$V_1 q_1 = \text{Variable Overhead / unit in 2007} \times \text{quantity in 2007}$$

$$V_2 q_2 = \text{Variable Overhead / unit in 2008} \times \text{quantity in 2008}$$

$$V_2 q_2 = V_1 (1.06) (1.5) q_1 = 1.59 V_1 q_1$$

$$V_0 q_0 + F_0 = 800$$

$$V_1 q_0 + F_0 = \underline{840} \text{ where } q_0 \times 1.25 = q_1$$

$$V_1 q_0 - V_0 q_0 = 40$$

$$V_0 q_0 = V_1 q_0 - 40$$

$$V_1 q_0 + F_1 - (V_0 q_0 + F_0) = \frac{5}{100} \times 800 = 40$$

$$\text{i.e. } V_1 q_0 + F_1 = 840$$

$$V_1 q_1 + F_1 = \underline{900}$$

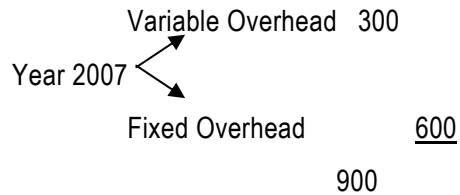
$$V_1 (q_0 - q_1) = -60$$

$$V_1 (q_1 - 1.25q_0) = -60 \times 1.25$$

$$V_1 (-.25)q_1 = -75$$

$$V_1 q_1 = \frac{-75}{-.25} = 300$$

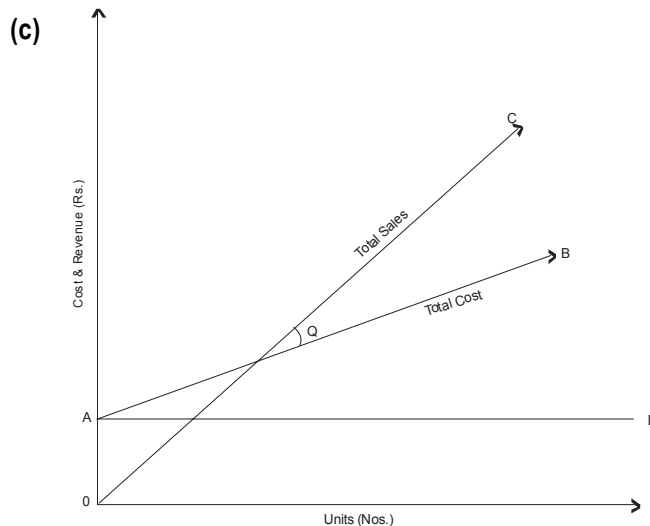
Marginal Costing



Question 21

Draw and explain the angle of incidence in a break-even chart. What is its significance to the management? (May 2008, 3 Marks)

Answer



Angle of incidence (θ) is the angle between the total cost line and the total sales line.

If the angle is large, the firm is said to make profits at a high rate and vice-versa.

A high angle of incidence and a high margin of safety indicate sound business conditions.

Question 22

A single product manufacturing company has an installed capacity of 3,00,000 units per annum. The normal capacity utilization of the company is 90%. The company has prepared the following budget for a year:

Variable costs:

Factory costs	Rs. 33 per unit
Selling and Administration costs	Rs. 9 per unit

Fixed costs:

Factory costs	Rs. 21,60,000
---------------	---------------

Cost Management

Selling and Administration costs	Rs. 7,56,000
Selling Price	
Selling price per unit	Rs. 60

The actual production, sales, price and cost data relating to the year under review are as given below:

Production	2,40,000 units
Sales	2,25,000 units
Finished goods stock in the beginning of the year:	15,000 units
Actual factory variable costs exceeded the budget by	Rs. 1,20,000

Required:

- Calculate the budgeted profit and break-even point in units.
- What increase in selling price was necessary during the year under review to maintain the budgeted profit?
- Prepare statements showing the actual profit during the year under review by using (1) absorption costing method and (2) marginal costing method. (Nov 2008, 11 Marks)

Answer

- (i) **Contribution per unit:**

	Rs.	Rs.
Selling price per unit		60
Variable costs per unit:		
Factory	33	
Selling & Administration	<u>9</u>	<u>42</u>
Contribution per unit		<u>18</u>
(Selling price – Variable cost)		

Budgeted Profit:

	Units	Rs.	Rs.
Installed capacity	3,00,000		
Normal capacity utilization (3,00,000 × 90%)	2,70,000		
Total contribution (A)			
(Contribution per unit × Normal capacity utilization) (2,70,000 × 18)			48,60,000
Fixed Costs (B)			

Marginal Costing

Factory Costs	21,60,000	
Selling and Administration costs	<u>7,56,000</u>	<u>29,16,000</u>
Profit (A – B)		<u>19,44,000</u>

$$\text{Break - even point (in units)} = \frac{\text{Fixed costs}}{\text{Contribution per unit}}$$

$$= \frac{29,16,000}{18} = 1,62,000.$$

(ii)	1. Actual variable costs per unit	Rs.	Rs.
	Budgeted factory costs	33	
	Increase in Factory costs per unit		
	$\left(\frac{1,20,000}{2,40,000} \right)$	<u>0.50</u>	33.50
	Selling and Administration costs		<u>9.00</u>
			<u>42.50</u>
	2. Selling price required to maintain the budgeted profit:		
	A. Total contribution required (Rs.)		48,60,000
	B. Actual production (units)		2,40,000
	C. Contribution desired per unit (A ÷ B) (Rs.)		20.25
	D. Variable cost per unit (Rs.)		42.50
	E. Selling price required to maintain budgeted profit (C + D) (Rs.)		62.75
	F. Increase in selling price necessary Rs. (62.75 – 60)		2.75

(iii) **Fixed overhead recovery rate:**

Fixed factory overheads	Rs. 21,60,000
Normal Production	2,70,000 units

Absorption Rate per unit : 21,60,000 / 2,70,000 = Rs. 8

Stock analysis:

	Units
Opening stocks	15,000
Add: Production	2,40,000
Total	2,55,000
Less: Sales	2,25,000
Closing stocks	30,000

Cost Management

1. Profitability based on Absorption Costing Method:

	Rs.	Rs.
A. Sales (2,25,000 units @ Rs. 60)		<u>1,35,00,000</u>
B. Production costs:		
Variable factory cost:(2,40,000 units × Rs. 33)	79,20,000	
Increase in cost	1,20,000	
Fixed factory costs (2,40,000 units × Rs. 8)	<u>19,20,000</u>	
Total production costs	99,60,000	
Less: Closing stock		
(30,000 units × 99,60,000) / 2,40,000	<u>12,45,000</u>	
	87,15,000	
Add: Opening stock 15,000 units × Rs. 41*	<u>6,15,000</u>	
Production cost of goods sold		93,30,000
C. Selling and Administration Costs:		
Variable costs: 2,25,000 units × Rs. 9	20,25,000	
Fixed Costs	<u>7,56,000</u>	
		<u>27,81,000</u>
D. Less: Total cost of goods sold (B + C)		<u>1,21,11,000</u>
		13,89,000
Less: Under absorption of factory fixed overheads		
(2,40,000 – 2,70,000 units) × Rs. 8		<u>2,40,000</u>
Profit		<u>11,49,000</u>
Cost of opening stock (per unit)	= Variable Factory cost + Fixed overhead recovery rate	
	= Rs. 33 per unit + Rs. 8 per unit	
	= Rs. 41 per unit.	

Profitability based on Marginal Costing Method:

	Rs.	Rs.
A Sales (2,25,000 units @ Rs. 60)		<u>1,35,00,000</u>
Production variable costs:		
Variable cost (2,40,000 units × Rs. 33)	79,20,000	
Increase in cost	<u>1,20,000</u>	
Total	80,40,000	

Marginal Costing

Less: Closing stock:		
(30,000 × 80,40,000) / 2,40,000	<u>10,05,000</u>	
	70,35,000	
Add: Opening Stock (15,000 units × Rs. 33)	<u>4,95,000</u>	
B Production variable cost of goods sold	75,30,000	
C Variable Selling & Administrative Expenses (2,25,000 × Rs. 9)	20,25,000	
D Total variable costs (B + C)		<u>95,55,000</u>
E Contribution (A – D)		39,45,000
F Less: Fixed overheads: Factory	21,60,000	
Selling & Administration	<u>7,56,000</u>	<u>29,16,000</u>
G Profit (E – F)		<u>10,29,000</u>

Cost Management

NOTE

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3 & 4

DECISION MAKING

Question 1

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)	Cash outflow (Buying cost)
		Rs.	Rs.
(a)	(b)	(c)	(e)
		(d)=(b)×(c)	(f)=(b)×(e)
0	1.000	4	4.000
1	0.909	6+2	7.272
2	0.826	7+2	7.434
3	0.751	8+2	7.510
			11
			8.261

Cost Management

4	0.683	10+2	<u>8.196</u>	14	<u>9.562</u>
Total			<u>34.412</u>		<u>24.264</u>

$$\begin{aligned} \text{Saving in cash outflow} &= \left[\begin{array}{l} \text{total present value of} \\ \text{cash outflow, when the} \\ \text{component is manufactured} \\ \text{internally} \end{array} \right] - \left[\begin{array}{l} \text{Total present value of} \\ \text{cash outflow, when the} \\ \text{component is bought} \\ \text{from outside.} \end{array} \right] \\ &= \text{Rs.24.412} - \text{Rs.34.264} \\ &= \text{Rs.0.148 (lakhs)} \end{aligned}$$

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 2

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

$$= (2 \text{ units} \times \text{Rs.900} + 3 \text{ units} \times \text{Rs.360})$$

$$= \text{Rs.1,800} + \text{Rs.1,080} = \text{Rs.2,880}$$

$$\text{Break-even point} = \frac{\text{Annual fixed Production \& Selling costs}}{\text{Total Contribution under 1st option}}$$

Decision Making

$$= \frac{\text{Rs. } 88,000}{\text{Rs. } 2,880} = 30.56 \text{ (sets of 5 units each)}$$

		<i>Products</i>		
		<i>Vee</i>	<i>Jay</i>	<i>Total</i>
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

$$= (1 \text{ unit} \times \text{Rs. } 900 + 2 \text{ units} \times \text{Rs. } 360)$$

$$= \text{Rs. } 900 + \text{Rs. } 720 = \text{Rs. } 1,620$$

Break-even point

$$= \frac{\text{Rs. } 88,000}{\text{Rs. } 1,620} = 54.32 \text{ (set of 3 units each)}$$

		<i>Products</i>		
		<i>Vee</i>	<i>Jay</i>	<i>Total</i>
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.

Cost Management

Question 3

- (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

Decision Making

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	7.91
the sale of 3,30,000 kgs. of S	
(Rs.26,10,000 / 3,30,000 kgs.)	

Question 4

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.

Cost Management

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. Its 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:

- 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.
 - 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.
 - 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:

- 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

Decision Making

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	<u>10,000</u>
Total future fixed cost for 225 batches	<u>40,000</u>

3. Expected purchase cost of components

View point	Probability	Component		
		A Expected price	B Expected Price	C Expected Price
		Rs.	Rs.	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		<u>105</u>	<u>150</u>	<u>140</u>

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.**

Cost Management

(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/44 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 48 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)			

Decision Making

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	<u>177.78</u>	<u>40,000</u>	
(Rs.40,000 / 225 batches)			
(Refer to working note 2)			
Profit	<u>228.22</u>	<u>51.350</u>	

Question 5

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

Cost Management

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)

Decision Making

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 costs (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 6

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)

Cost Management

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	25,000	95	2,85,000	85,00,000
		(Rs.1,05,000 – Rs.80,000)				(Rs.2,85,000 – Rs.2,00,000)
4000	34	1,36,000	31,000	94	3,76,000	91,000
		(Rs.1,36,000 – 1,05,000)				(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 total 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 $\left(\frac{\text{Rs.50,000}}{2,000 \text{ units}} \right)$

Since the price quoted per unit is Rs.28, which is more than Rs.25, therefore, the order should be accepted.

Question 7

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.

Decision Making

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	<u>10</u>
Total Costs	<u>65</u>

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.

Cost Management

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 of 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)

Decision Making

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.		
	<i>JCP Co. Ltd.</i>	<i>K. Co. Ltd.</i>
	<i>Rs.</i>	<i>Rs.</i>
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 8

State the non-cost factors to be considered in make/buy decisions.

(May 2001)

Answer

Non-cost 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.

Cost Management

- (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 9

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.

Decision Making

(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.

	<i>Department</i>	
	<i>A</i>	<i>B</i>
Normal capacity hours	600	520
Overtime hours	<u>300</u>	<u>260</u>
(50% of normal hours in each department)		
Total available hours	<u>900</u>	<u>780</u>

(b) Total hours required to meet fully the market demand of 2,500 units of P and 2,000 units of Q.

	<i>Department</i>	
	<i>A</i>	<i>B</i>
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;

<i>Product</i>	<i>P</i>		<i>Q</i>	
	<i>Normal hours</i>	<i>Overtime hours</i>	<i>Normal hours</i>	<i>Overtime hours</i>

Cost Management

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.) (C) = [(B) – (A)]	4.60	2.90	1.60	1.10
(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 hours to meet fully monthly market demand of 2,500 units of P and 2,000 of Q.
- 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)).
 - 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

Decision Making

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.**

	<i>Departments</i>			
	<i>A</i>		<i>B</i>	
	<i>Normal time hours</i>	<i>Overtime hours</i>	<i>Normal time hours</i>	<i>Overtime hours</i>
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 (ii))	(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.)	

Cost Management

1067 units of Q (Refer to working note 4(iii))	320 (1,067 units × 0.3 hrs.)	-- (1,067 units × 0.2 hrs.)	-- (1,067 units × 0.2 hrs.)	213
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(ii) **Statement Showing Total Cost**
(Based on the solution in (i) above)

Particulars	Products		Sub contract price	Total
	P	Q		
	Rs.	Rs.	Rs.	Rs.
Direct Material Cost	25,000 (2,500 units × Rs.10)	5,835 (1,167 units × Rs.5)	-	30,855
Direct Wages:				
Dept. A	2,500 (250 hours × Rs.10)	3,500 (350 hours × Rs.10)	--	6,000
Dept. B	6,000 (500 hours × Rs.12)	4,074 (20 hours × Rs.12 + 213 hours × Rs.18)	--	10,075
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 10

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:

- Additional fixed overheads involved should be considered.
- Possible decrease in selling price due to increased production capacity.
- Whether the demand is sufficient to absorb the increased production.

Question 11

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 no change in variable costs. The company

Decision Making

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%)	

Cost Management

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 12

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 on a sub-contracting basis and to continue its administrative and marketing functions. Currently, four products are being manufactured and sold by catering to 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)

Decision Making

	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 charges 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)

Cost Management

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	<u>0.6</u>	<u>0.3</u>	<u>0.9</u>	<u>0.6</u>	<u>2.4</u>
Total allocated overheads during notice period of 3 months	<u>2.1</u>	<u>1.5</u>	<u>2.7</u>	<u>1.8</u>	<u>8.1</u>
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.

Decision Making

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)			<u>8.1</u>
Profit / (Loss)			<u>(3.6)</u>

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 × <u>Rs.80</u>)	(15 lacs × <u>Rs.70</u>)	(30 lacs × <u>Rs.90</u>)	(20 lacs × <u>Rs.130</u>)
Total variable costs : (Y)	<u>64.0</u>	<u>40.5</u>	<u>81.0</u>	<u>62.0</u>
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		
	A	B	C
Contribution: (X)	8.0	13.5	3.0
			24.5

Cost Management

(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 13

(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

Decision Making

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 maximisation. Variable costs are relevant costs in product mix decisions and consequently contribution plays a major role in maximisation of profit. In addition to the relevancy of costs, the other factors and costs that should be taken into account at the time of deciding the products mix are:

- (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)	

Cost Management

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	<u>20.00</u>
Profit	<u>12.40</u>

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	<u>20.00</u>
Profit	<u>5.20</u>
B. Profit from 60,000 moulded toys	3.75
(Refer to (i) above)	
Total profit: (A + B)	<u>8.95</u>

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.

$$\begin{aligned}\text{If toys are manufactured, the profit is} &= (\text{Rs.}60 - \text{Rs.}50) x - \text{Rs.}2,25,000 \\ \text{and, if toys are sub-contracted, the profit is} &= (\text{Rs.}60 - \text{Rs.}57.50) x \\ \text{Indifference point would be } 10x - \text{Rs.}2,25,000 &= 2.5x \\ \text{or } x &= 30,000 \text{ moulded toys}\end{aligned}$$

Decision Making

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 (4,50,000 × Rs.6)	27.00
Contribution from 45,000 toys (45,000 × Rs.10)	4.50
Total contribution	31.50
Less: Fixed cost (20 lacs + 2.25 lacs)	22.25
Profit	9.25
Profit from 15,000 sub-contracted toys (15,000 × Rs.2.50)	<u>0.375</u>
Total profit	<u>9.625</u>

If demand was accurately forecasted & 4,80,000 cans were manufactured, excess machine hour capacity available was 2,000 hrs, such excess being the point 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 (4,80,000 × Rs.6)	28.80
Less: Fixed cost	20.00
Profit	8.80
Profit from Toys	<u>1.50</u>
60,000 Nos. sub-contracted (60,000 × Rs.2.5)	
Total profit	<u>10.30</u>

Cost Management

Therefore, the loss for improper prediction and negotiation is Rs.10,30,000 – Rs.9,62,500 or Rs.67,500.

Question 14

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:

- The cost break-up of each unit per M.T. of output;
- 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;
- 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 (156 lacs/ 12,000 M. T.)	192	1,280 (192 lacs/ 15,000 M. T.)
Fixed Cost	108	900 (108 lacs/ 12,000 M. T.)	120	800 (120 lacs/ 15,000 M. T.)
Total Cost	462	3,850	552	3,680

Decision Making

Working Note:

	<i>Sambalpur</i>	<i>Bilaspur</i>
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:

	<i>Sambalpur</i>	<i>Bilaspur</i>
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.)	<u>1,300</u>	<u>1,280</u>
[Refer to part (i)]		
Total variable cost / M. T. of output	<u>2,740</u>	<u>2,880</u>
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 :

	<i>Sambalpur</i> (Rs. lacs)	<i>Bilaspur</i> (Rs. lacs)	<i>Total</i> (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	<u>108.0</u>	<u>120.0</u>	<u>228.0</u>
Total cost: (A)	313.5	681.6	995.1

Cost Management

Previous total cost: (B)	<u>462.0</u>	<u>552.0</u>	<u>1014.0</u>
[as per (i) above]			
Cost savings: {(B) – (A)}	<u>148.5</u>	<u>(129.6)</u>	<u>18.9</u>

Question 15

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 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 16

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:

	<i>Rs.</i>	<i>Rs.</i>
<i>Selling price per unit</i>		<i>900</i>
<i>Costs per unit:</i>		
<i>Direct materials</i>	<i>200</i>	

Decision Making

Variable machine operating costs	150	
(Rs.100 per machine hour)		
Manufacturing overhead costs	180	
Marketing and administrative costs	<u>200</u>	<u>730</u>
Operating income per unit of 'XY 100'		<u>170</u>

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, has 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	<u>110</u>	<u>420</u>
Operating income per unit of 'XY 100'		<u>180</u>

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.

Calculate the quantity of each product that XYZ Limited should manufacture and/or purchase to maximize operating income.

Cost Management

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	<u>120</u>	<u>35</u>
Total variable costs per unit	<u>470</u>	<u>285</u>

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

$$5,000 \text{ units} \times 1.5 \text{ hours} = 7,500 \text{ hours}$$

Ranking between manufactured "XY 100" and manufactured "XY 200"

	Manufactured "XY 100"	Manufactured "XY 200"
	Rs.	Rs.
Variable cost of production	470	285
(Refer to working note 2)		
Variable marketing and administrative cost	80	60
Total variable cost per unit: (A)	350	345

Decision Making

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”

	<i>Manufactured</i> “XY 100” Rs.	<i>Manufactured</i> “XY 200” 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 17

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:

Cost Management

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 overhead of Rs.5,80,000 to be avoided. Information on Y is as follows:

Decision Making

	<i>Per unit</i>
<i>Selling price</i>	<i>Rs.700</i>
<i>Labour Grade 2</i>	<i>4 hours</i>
<i>Materials relevant variable costs</i>	<i>Rs.120</i>

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:

- 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
- 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.
- Statement of loss of contribution from the reduction in the sale of product Y.

	<i>Rs.</i>	<i>Rs.</i>
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)	<u>120</u>	<u>320</u>
(4 hours × Rs.30)		
Contribution per unit: [(A) – (B)]		<u>380</u>
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		<u>5,90,000</u>
Net Loss		<u>13,20,000</u>

Cost Management

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)	<u>4,800</u>
Total variable cost	16,200
Incremental fixed costs	<u>2,280</u>
	18,480
Add: Loss of contribution on product Y	
(Refer to working note 3)	
Total relevant cost: (ii)	<u>19,800</u>
Excess of relevant revenue over relevant cost:	<u>200</u>
Advice to A Limited: to accept the contract, as it will enhance the pre-tax operating income by Rs.2,00,000.	

Question 18

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

Decision Making

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*

Cost Management

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 your 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)

Decision Making

Therefore additional contribution (6000 units × Rs 5) = Rs.30,000

Total hours on product '43 grade' (1,80,000 units × 4) = 7,20,000 Hrs

Total hours on component 'EH' (1,80,000 units × 0.5*) = 90,000 Hrs

$$* \frac{\text{Direct Labour cost}}{\text{No of units produced} \times \text{Labour rate per hour}} = \frac{\text{Rs 52,500}}{15,000 \text{ units} \times \text{Rs 7 per hour}} = 0.5 \text{ Hrs}$$

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 × 0.5 = 90,000 Hrs

Cost of buying component 'EH' = (1,80,000 units × Rs 7.90) = Rs 14,22,000

Cost of making component 'EH' = (1,80,000 units × Rs 7.20) = Rs 12,96,000

Hence , excess cost of buying = Rs.1,26,000

Rent income (90,000 hours × Re1) = Rs.90,000

$$\text{Contribution per unit from making component 'GYP'} = \text{Rs } 8 - \frac{\text{Rs } 1,12,500}{15,000 \text{ Units}} = \text{Rs } 0.5$$

per unit.

$$\text{Direct labour cost per unit of 'GYP'} = \frac{\text{Rs } 31,500}{15,000 \text{ Units}} = \text{Rs. } 2.10 \text{ per unit.}$$

Cost Management

$$\text{No. of labour hours required for one unit of 'GYP'} = \frac{\text{Rs } 2.10}{\text{Rs } 7} = 0.3 \text{ Hrs}$$

$$\text{No. of units of 'GYP' in 90,000 hours} = \frac{90,000 \text{ hours}}{0.3 \text{ hours}} = 3,00,000$$

$$\text{Contribution from component 'GYP'} = 3,00,000 \times \text{Rs } 0.50 = \text{Rs } 1,50,000$$

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 19

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.

Decision Making

(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 quantify 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

Cost Management

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 $(800 \text{ Hrs} \times \frac{4}{3}) = 1,067 \text{ units}$

* Dept. 5 $(800 \text{ Hrs} \times 3) = 2400 \text{ units}$

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

Selling price	Rs. 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 $\times$ Rs. 10 per hr	160
Additional gain for introducing the new product	470

Decision Making

Question 20

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 on 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

Cost Management

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 21

"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

Decision Making

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 22

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:

- 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?
- 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?

Cost Management

Answer

Contribution analysis:

	<i>Product X</i>	<i>Product Y</i>
	<i>Rs.</i>	<i>Rs.</i>
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	
	<i>Wage cost</i>	<i>Hours/unit</i>	<i>Wage cost</i>	<i>Hours/unit</i>
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: $\frac{64,800}{9 \text{ hrs per unit}} = 7,200 \text{ units}$

Department 4 : Maximum available hours:

Workers	×	Hours/day	×	Days/year	
36	×	8	×	300	= 86,400 hours

Decision Making

Maximum possible production of product Y: $\frac{86,400}{12 \text{ hrs per unit}} = 7,200 \text{ units}$

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 1 and 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	3	6
Hours		
Contribution per hour of Department 2	Rs. 24	Rs. 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

Cost Management

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:

- Produce 7,200 units of product X and use the balance capacity to produce product Y.
- 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 $7,200 \times 3 =$	21,600 hours
Balance hours on Y	36,000
Production of Y $36,000 \div 6 =$	6,000 units

<i>Contribution:</i>	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 $7,200 \times 6 =$	43,200 hours
Balance hours on X	14,400
Production of X $14,400 \div 3 =$	4,800 units

<i>Contribution:</i>	X $4,800 \times 72$	Rs. 3,45,600
	Y $7,200 \times 108$	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.

Decision Making

Question 23

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

Cost Management

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

$$\text{Or } \frac{\text{Rs}85 + (\text{Rs}6,900 \times 11.5 + 600 \times 6.66)}{2,500} = \frac{\text{Rs}85 + (79350 + 4000)}{2500}$$
$$= \text{Rs } (85 + 33.34) = \text{Rs } 118.3$$

Question 24

A research project, to date, has cost a company Rs. 2,50,000 and is under review. It is anticipated that, should the project be allowed to proceed, it will be completed in about one year and can be sold for Rs. 4,00,000. The following additional information is available:

- (i) Materials have just been received for Rs. 60,000. These are extremely toxic, and if not used in the project, have to be disposed of by special means at Rs. 15,000.
- (ii) Labour: Rs. 75,000. The men are highly skilled. If they are released from the Research Project, they may be transferred to the Works Department of the company and consequently the sales could increase by Rs. 1,50,000. The accountant estimates that the prime cost of those sales would be Rs. 1,00,000 and the overhead absorbed (all fixed) would amount to Rs. 25,000.
- (iii) Research staff: Rs. 1,60,000. A decision has already been taken that this will be the last major piece of research undertaken and consequently, when work on the project ceases, the staff involved will be made redundant. Redundancy and severance pay have been estimated at Rs. 25,000.
- (iv) Share of General Building Expenses : Rs. 35,000.

The Managing Director is not sure what is included in this amount, but the accounts staff charge similar amounts each year to each department.

You are required to advise whether the project should be allowed to proceed and explain the reasons for the treatment of each of the amounts above in your analysis.

(May 2007, 10 marks)

Answer

Research Project

Particulars	Relevancy	Reason	Amount (Rs. '000s)
Project cost till date	Not relevant	Sunk cost	—
Sale price of the project	Relevant	Incremental revenue/opportunity gain	400
Cost of materials received	Not relevant	Sunk cost	—

Decision Making

Cost of disposal of materials	Relevant	Avoidable/opportunity cost	15
Cost of labour	Not relevant	Common costs	—
Contribution lost on the alternative use	Relevant	Opportunity cost [Sales – (Prime cost – labour)]	(125)
Absorbed Fixed overheads	Not relevant	Sunk cost	—
Cost of Research Staff	Relevant	Incremental / out of pocket	(160)
Redundancy and severance pay	Not relevant	Common costs	—
Share of General Building expenses	Not relevant	Sunk costs	—
Total incremental inflow if the project is proceeded with			<u>130</u>

Decision: Better to continue the project.

Question 25

Hardware Ltd. Manufactures computer hardware products in different divisions which operate as profit centres. Printer Division makes and sells printers. The Printer Division's budgeted income statement, based on a sales volume of 15,000 units is given below. The Printer Division's Manager believes that sales can be increased by 2,400 units, if the selling price is reduced by Rs. 20 per unit from the present price of Rs. 400 per unit, and that, for this additional volume, no additional fixed costs will be incurred.

Printer Division presently uses a component purchased from an outside supplier at Rs. 70 per unit. A similar component is being produced by the Components Division of Hardware Ltd. And sold outside at a price of Rs. 100 per unit. Components Division can make this component for the Printer Division with a small modification in the specification, which would mean a reduction in the Direct Material cost for the Components Division by Rs. 1.5 per unit. Further, the Component Division will not incur variable selling cost on units transferred to the Printer Division. The Printer Division's Manager has offered the Component Division's Manager a price of Rs. 50 per unit of the component.

Component Division has the capacity to produce 75,000 units, of which only 64,000 can be absorbed by the outside market.

The current budgeted income statement for Components Division is based on a volume of 64,000 units considering all of it as sold outside.

	Printer Division	Component Division
	Rs. '000	Rs. '000
Sales revenue	<u>6,000</u>	<u>6,400</u>
Manufacturing cost:		

Cost Management

Component	1,050	—
Other direct materials, direct labour And variable OH	1,680	1,920
Fixed OH	<u>480</u>	<u>704</u>
Total manufacturing cost	<u>3,210</u>	<u>2,624</u>
Gross margin	2,790	3,776
Variable marketing costs	270	384
Fixed marketing and Admn. OH	<u>855</u>	<u>704</u>
Non-manufacturing cost	<u>1,125</u>	<u>1,088</u>
Operating profit	<u>1,665</u>	<u>2,688</u>

- (i) Should the Printer Division reduce the price by Rs. 20 per unit even if it is not able to procure the components from the Component Division at Rs. 50 per unit?
- (ii) Without prejudice to your answer to part (i) above, assume that Printer Division needs 17,400 units and that, either it takes all its requirements from Component Division or all of it from outside source. Should the Component Division be willing to supply the Printer Division at Rs. 50 per unit?
- (iii) Without prejudice to your answer to part (i) above, assume that Printer Division needs 17,400 units. Would it be in the best interest of Hardware Ltd. for the Components Division to supply the components to the Printer Division at Rs. 50?

Support each of your conclusions with appropriate calculations. (May 2007, 12 Marks)

Answer

Particulars	Printer Division			Components Division	
	Existing price	Reduction in selling price	If component is purchased internally	Existing	If transfer is effected
Selling price	400	380	380	100	50
Component cost	70	70	50		
Other direct materials, labour and Variable overhead	112	112	112	30	28.50
Variable marketing cost	18	18	18	6	
Contribution	200	180	200	64	21.50
Volume units	15,000	17,400	17,400	64,000	17,400
Total contribution ('000)	3,000	3,132	3,480	4,096	374.10

Decision Making

Volume lost in the market	6,400 units
Contribution lost	$6,400 \times 64 = 409.60$

- (i) Yes, Printer Division should institute the Rs. 20 price reduction on its printer units because net income would increase by Rs. 1,32,000 (Rs. 31,32,000 – Rs. 30,00,000).

Alternatively by incremental approach the net increase can be computed as follows:

	Rs.
Contribution margin of sales increase (Rs. $180 \times 2,400$)	4,32,000
Loss in contribution margin on original volume arising from decrease in selling price ($15,000 \times \text{Rs. } 20$)	3,00,000
Increase in operating profit	1,32,000

- (ii) No, the Component Division should not sell all 17,400 units to Printer Division for Rs. 50. If the Component Division does sell all 17,400 units to Printer, Component Division will only be able to sell 57,600 units to outside customers instead of 64,000 units due to the capacity restrictions. This would decrease Component Division's profit before taxes by Rs. 35,500. Supporting calculations are as follows:

	Rs.
Contribution from sales to printer (Rs. $21.50 \times 17,400$)	3,74,100
Loss in contribution from loss of sales to outsiders (Rs. $64 \times 6,400$)	<u>4,09,600</u>
Decrease in operating profit	<u>35,500</u>

- (iii) Yes, it would be in the best interest of Hardware Ltd. for the Component Division to sell the units to the Printer division at Rs. 50 each. The net advantage to the Hardware Ltd. is Rs. 3,12,500 as shown below. The net Advantage is the result of the cost savings from purchasing the Component unit internally and the contribution margin lost from 6,400 units that the Component Division otherwise would sell to outsiders.

Total Company

Rs. '000s

Incremental contribution – if the component is transferred within (Rs. '000) ($3,480 - 3,132$)	348.00
Contribution to the Component Division	374.10
Total incremental contribution	722.10
Less: Contribution lost by the Component Division	409.60
Net contribution gain	312.50

Cost Management

Question 26

A manufacturer produces three products whose cost data are as follows:

	X	Y	Z
Direct materials (Rs. / Unit)	32.00	76.00	58.50
Direct Labour:			
Deptt.	Rate / hour (Rs.)	Hours	Hours
1	2.50	18	10
2	3.00	5	4
3	2.00	10	5
Variable overheads (Rs.)	8	4.50	10.50

Fixed overheads (Rs.) 4,00,000 per annum.

The budget was prepared at a time, when market was sluggish. The budgeted quantities and selling prices are as under:

Product	Budgeted quantity (Units)	Selling Price / unit (Rs.)
X	19,500	135
Y	15,600	140
Z	15,600	200

Later, the market improved and the sales quantities could be increased by 20 per cent for product X and 25 per cent each for product Y and Z. The sales manager confirmed that the increased sales could be achieved at the prices originally budgeted. The production manager stated that the output could not be increased beyond the budgeted level due to the limitation of Direct labour hours in department 2.

Required:

- Prepare a statement of budgeted profitability.
- Set optimal product mix and calculate the optimal profit. (Nov 2007, 14 Marks)

Answer

Working Notes:

	X	Y	Z
Selling price per unit (A)	135.00	140.00	200.00
Variable costs per unit			

(Amount in Rupees)

Decision Making

Direct material	32.00	76.00	58.50
Direct labour			
Department 1	45.00	25.00	50.00
Department 2	15.00	12.00	21.00
Department 3	20.00	10.00	40.00
Variable overheads	<u>8.00</u>	<u>4.50</u>	<u>10.50</u>
Total variable costs (B)	<u>120.00</u>	<u>127.50</u>	<u>180.00</u>
Contribution per unit (A–B)	<u>15.00</u>	<u>12.50</u>	<u>20.00</u>

(i) Statement of budgeted profitability

	X	Y	Z
Budgeted quantity (units)	19,500	15,600	15,600
Contribution per unit (Rs.)	15.00	12.50	20.00
Total contribution (Rs.)	2,92,500	1,95,000	3,12,000
Contribution fund (Rs.)			7,99,500
Fixed overheads (Rs.)			<u>4,00,000</u>
Profit (Rs.)			<u>3,99,500</u>

(ii) Contribution per direct labour hour for Department 2

	X	Y	Z
Contribution per unit (Rs.)	15.00	12.50	20
Direct labour hours per unit	5	4	7
Contribution per labour hour	3.00	3.125	2.857
Rank	II	I	III

(iii) Total hours available in department 2

X	19,500 units × 5 =	97,500 hours
Y	15,600 units × 4 =	62,400 hours
Z	15,600 units × 7 =	<u>1,09,200 hours</u>
Total	=	<u>2,69,100 hours</u>

Cost Management

Optimal Product Mix

Product	Maximum Sales (units)	Direct labour hours available	Hours per unit	Output (units)	Hours used	Balance hours
Y	19,500	2,69,100	4	19,500	78,000	1,91,100
X	23,400	1,91,100	5	23,400	1,17,000	74,100
Z	19,500	74,100	7	10,585	74,095	5

Optimal profit (Rs.)

Contribution (Rs.)

Y	$19,500 \times \text{Rs. } 12.50 =$	Rs. 2,43,750
X	$23,400 \times \text{Rs. } 15 =$	Rs. 3,51,000
Z	$10,585 \times \text{Rs. } 20 =$	<u>Rs. 2,11,700</u>
Total Contribution		= Rs. 8,06,450
Less fixed cost		= <u>Rs. 4,00,000</u>
Profit		= <u>Rs. 4,06,450</u>

Question 27

A company manufactures a single product, which requires two components. The company purchases one of the components from two suppliers: X Limited and Y Limited. The price quoted by X Limited is Rs. 180 per hundred units of the component and it is found that on an average 3 per cent of the total receipt from this supplier is defective. The corresponding quotation from Y Limited is Rs. 174 per hundred units, but the defective would go up to 5 per cent. If the defectives are not detected, they are utilised in production causing a damage of Rs. 180 per 100 units of the component.

The company intends to introduce a system of inspection for the components on receipt. The inspection cost is estimated at Rs. 24 per 100 units of the component. Such an inspection will be able to detect only 90 per cent of the defective components received. No payment will be made for components found to be defective in inspection.

Required:

- Advise whether inspection at the point of receipt is justified?
- Which of the two suppliers should be asked to supply?

(Assume total requirement is 10,000 units of the component).

(Nov 2007, 10 Marks)

Decision Making

Answer

Calculation of cost of per 100 units of good components:

(A)	X Ltd.	Y Ltd.
If not inspected		
Units required	10,000	10,000
Estimated defectives	300 (3%)	500 (5%)
Cost	Rs.	Rs.
Purchase price (Rs.)	18,000	17,400
Production damage (Rs.)	<u>540</u>	<u>900</u>
Total Cost (Rs.)	<u>18,540</u>	<u>18,300</u>
Good component (units)	9,700	9,500
Cost per 100 good component (Rs.)	<u>191.13</u>	<u>192.63</u>
(B) If inspected		
Defectives not detected	30	50
Defectives detected	270	450
Components paid for	9,730	9,550
Cost	Rs.	Rs.
Purchase cost	17,514	16,617
Inspection cost	2,400	2,400
Production damage	<u>54</u>	<u>90</u>
Total cost	<u>19,968</u>	<u>19,107</u>
Good components	<u>9,700</u>	<u>9,500</u>
Cost per 100 good components (Rs.)	<u>205.86</u>	<u>201.3</u>

Decision:

- (i) On the basis of the cost per 100 good component calculated at (A) and (B) above, it is concluded that inspection at the point of receipt is not justified.
- (ii) It will be advantageous to purchase the component from X Ltd.

Cost Management

Question 28

X Limited having an installed capacity of one lakh units of a product is currently operating at 70 per cent utilization. At current level of input prices, the F.O.B. costs per unit, taking credit for applicable export incentive workout as follows:

Capacity Utilisation	70%	80%	90%	100%
FOB cost per unit (Rs.)	97	92	87	82

The company has received three Foreign offers as under:

Source A : 5,000 units @ Rs. 55 per unit FOB

Source B : 10,000 units @ Rs. 52 per unit FOB

Source C : 10,000 units @ Rs. 51 per unit FOB

Required:

Advice the company whether it should accept any or all of the export orders.

Answer

Statement of differential cost

Capacity	Output(Units)	FOB cost per unit (Rs.)	Total cost (Rs.)	Differential Cost (Rs.)	Differential Cost per unit (Rs.)
70%	70,000	97	67,90,000	—	—
80%	80,000	92	73,60,000	5,70,000	57
90%	90,000	87	78,30,000	4,70,000	47
100%	1,00,000	82	82,00,000	3,70,000	37

Statement showing gain or loss for various export orders

Source	Quantity (Units)	Differential Cost per unit (Rs.)	Differential Cost Total (Rs.)	Sales Revenue (Rs.)	Profit / Loss (Rs.)
A	5,000	57	2,85,000	2,75,000	—10,000
B	10,000	57 for 5,000 47 for 5,000	5,20,000	5,20,000	—
C	10,000	47 for 5,000 37 for 5,000	4,20,000	5,10,000	+90,000
Total	<u>25,000</u>		<u>12,50,000</u>	<u>13,05,000</u>	<u>+80,000</u>

Decision Making

If proposal A is accepted the company will suffer a loss of Rs. 10,000 with an idle capacity of 5,000 units.

If proposals A and B are accepted, the company will suffer a loss of Rs. 10,000 with an idle capacity of Rs. 5,000 units.

If the company accepts all the three proposals, it will earn profit of Rs. 80,000 with an idle capacity of 5,000 units.

Therefore, the company should accept all three proposals.

Question 29

Is it justifiable to sell at a price below marginal cost at any time? Mention the circumstances in which it is justifiable.
(May 2008, 6 Marks)

Answer

(a) It is justifiable to sell at a price below marginal cost for a limited period.

The circumstances may be:

- (i) Where materials are of perishable nature.
- (ii) Where stocks have been accumulated in large quantities and the market prices have fallen. This will save the carrying cost of stocks, e.g., electronic goods – market prices fall due to quick obsolescence or advanced technological replenishment.
- (iii) It is essential to reduce the prices to such an extent in order to popularize a new product.
- (iv) Where such reduction enables the firm to boost the sales of other products having larger profit margin.

Question 30

What are the major areas of decision-making in which differential costing is used?

(May 2008, 4 Marks)

Answer

Differential costing can be used for all short, medium and long term decisions. When two levels of activities are being considered, or while choosing between competing alternatives differential cost analysis is essential. The differential cost is useful for decision making in the following areas:

- ◆ Capital expenditure decisions
- ◆ Make or buy decision
- ◆ Production planning
- ◆ Sales mix decision

Cost Management

- ◆ Production or product decision
- ◆ Change in level or nature of an activity.

Question 31

Kangan Resorts operates a lodging house with attached facilities of a shopping arcade and restaurant on a National Highway. The following details are available:

(i) The lodging house has 40 twin-bedded rooms, which are to be rented for Rs. 200 per night on double occupancy basis. The occupancy ratio is expected at 85% and always both the beds in the room will be occupied. The lodging facilities are operated, for 200 days in the year during foreign tourists season time only.

(ii) As per past record the spending pattern of each tourist staying in the lodge will be as under:

Rs. 50 per day in the shopping arcade and Rs. 80 per day in the restaurant.

(iii) Ratios of variable cost to respective sales volume are:

Shops	Restaurant
50%	60%

(iv) For the lodging house the variable cost on house-keeping and electricity will amount Rs. 30 per day per occupied room.

(v) Annual fixed overhead for the entire complex is estimated at Rs. 10,00,000.

Required:

- (i) Prepare an income statement for the next year.
- (ii) The Lodging House Manager suggests a proposal of reducing room rent to Rs. 150 per day on double occupancy basis, which will increase occupancy level to 95%. Should the proposal be accepted or not? (May 2008, 7 Marks)

Answer

(i) **Income Statement of Kangan Resort for the next year**

	Rs.
Sales Revenue	
Lodging house room receipts (40 Rooms × 200 days × Rs. 200 × 85%)	13,60,000
Shopping Arcade (40 Rooms × 2 persons × 200 days × Rs. 50 × 85%)	6,80,000
Restaurant (40 Rooms × 2 persons × 200 days) × Rs. 80 × 85%)	<u>10,88,000</u>
Total Sales Revenue	<u>31,28,000</u>

Decision Making

Variable Cost	
Lodging house rooms (40 Rooms × 200 days × Rs. 30 × 85%)	2,04,000
Shopping Arcade (50% of Rs. 6,80,000)	3,40,000
Restaurant (60% of Rs. 10,88,000)	<u>6,52,800</u>
Total Variable Cost	<u>11,96,800</u>
Contribution (Total Sales Revenue – Total Variable Cost)	19,31,200
Less: Fixed Cost	<u>10,00,000</u>
Profit (Estimated)	<u>9,31,200</u>

(ii) **Income Statement on the basis of reduced room rent**

Rs.

Sales Revenue

Lodging house room receipts (40 Rooms × 200 days × Rs. 150 × 95%)	11,40,000
Shopping Arcade (40 Rooms × 2 persons × 200 days × Rs. 50 × 95%)	7,60,000
Restaurant (40 Rooms × 2 persons × 200 days × Rs. 80 × 95%)	<u>12,16,000</u>
Total Revenue	<u>31,16,000</u>

Less: Variable Cost

Lodging house rooms (40 Rooms × 200 days × Rs. 300 × 95%)	2,28,000
Shopping Arcade (50% of Rs. 7,60,000)	3,80,000
Restaurant (60% of Rs. 12,16,000)	<u>7,29,600</u>
Total Variable Cost	<u>13,37,600</u>
Contribution	17,78,400
Less: Fixed Cost	<u>10,00,000</u>
Profit	<u>7,78,400</u>

The profitability decreases by $9,31,200 - 7,78,400 = \text{Rs. } 1,52,800$.

Hence reducing room rent proposal may not be accepted.

Alternative Solution :

Occupancy ratio 85%

Lodging facilities for 200 days

40 twin bedded rooms – Rs. 200 per night

Shopping Arcade = Rs. 50 per day.

Restaurant = Rs. 80 per day.

Cost Management

Annual Fixed Overhead Rs. 10,00,000.

	Lodging House 30/days/ occupied/room	Shopping Arcade Variable Cost 50%	Restaurant 60%	
Revenue 40 rooms × 200 days × 85% × 200 Rs. / person × 2 persons / room				
Days:	170	170	170	
No. of persons: 2 × 170 × 40:	13,600			
Revenue / person	100	50	80	
Revenue	1,360	680	1,088	in '000
Variable Cost 30 × 170 × 40	<u>204</u>	<u>340</u>	<u>652.80</u>	
Contribution	1,156	340	435.20	
Contribution	19,31,200			
Fixed Cost	10,00,000			
Profit	9,31,200			
Room Days: 95% × 40 × 200 =7,600				
Person days	15,200			
Rev. 150/2 × 15,200	1,140	760	1,216	
Cost: 30/days :	<u>228</u>	<u>380</u>	<u>729.6</u>	
	<u>912</u>	<u>380</u>	<u>486.4</u>	
				1,778.40

No, do not accept the proposal as there is decrease in profit by Rs 1,52,800.

Question 32

State the characteristic features of a database created for operational control and decision making.
(Nov 2008, 4 Marks)

Answer

The characteristic features of a data-base created for operational control and decision making are as under:

- There should be a file structure that facilitates the association of one internal record with other internal records.
- There should be cross functional integration of files.

Decision Making

- (iii) Independence of program / data file for ease of updating and maintenance of data base.
- (iv) There must be common standards throughout with respect to data definitions, record formats and other data descriptions.
- (v) A data dictionary should be available.

Cost Management

NOTE

[illegible]

STANDARD COSTING AND VARIANCE ANALYSIS

Question 1

"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 favourable 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

Cost Management

end. In other words, the calculation of variances in standard costing is not an end in itself, but a means to an end.

Question 2

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)			

Standard Costing And Variance Analysis

* Decrease in sales = Rs.120 – Rs.108 = Rs.12 lakhs or 10% of 1997-98

Sales figure at 1997-98 rate

$$\begin{aligned} \text{Contribution to sales ratio during 1997-98} &= \frac{\text{Sales} - \text{Variable costs}}{\text{Sales}} \\ &= \frac{\text{Rs.120} - \text{Rs.100}}{\text{Rs.120}} \text{ or } (1/6) \text{ of per rupee sale} \end{aligned}$$

Loss of combination during 1998-99 on the sale of 12 lakhs – Rs.12 lakhs × 1/6 = Rs.2 lakhs.

$$\begin{aligned} \text{Sales price variance} &= \text{Actual sales} - \text{Standard sales} \\ &= \text{Rs.129.60} - 108 = \text{Rs.21.60 (Lakhs) (Fav.)} \end{aligned}$$

$$\begin{aligned} \text{Material price variance} &= \text{Standard cost of actual quantity} - \text{Actual cost} \\ &= \text{Rs.79.22} - \text{Rs.91.10} = 11.88 \text{ (Lakhs) (Adv.)} \end{aligned}$$

$$\begin{aligned} \text{Variable overhead expenditure variance} &= \left(\begin{array}{cc} \text{Budgeted variable} & \text{Actual} \\ \text{overhead for} & - \text{Variable} \\ \text{actual hours} & \text{overhead} \end{array} \right) \\ &= (\text{Rs.21.82} - \text{Rs.24}) = \text{Rs.2.18 (Lakhs) (Adv.)} \end{aligned}$$

$$\begin{aligned} \text{Variable overhead efficiency variance} &= \left(\begin{array}{cc} \text{Standard variable} & \text{Standard variable} \\ \text{overhead for} & - \text{overhead for} \\ \text{Standard hours} & \text{actual hour} \end{array} \right) \\ &= (\text{Rs.18} - \text{Rs.21.62}) = \text{Rs.3.62 (Lakhs) (Adv.)} \end{aligned}$$

* 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 on 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.

$$= \text{Rs.16.82} - \text{Rs.18.50} = \text{Rs.1.68 (Lakhs) (Adv.)}$$

$$\begin{aligned} \text{Fixed overhead volume variance} &= \left(\begin{array}{cc} \text{Standard variable} & \text{Standard fixed} \\ \text{overhead for} & - \text{overhead for} \\ \text{Actual hours} & \text{budgeted output} \end{array} \right) \\ &= (16.82 - 15) \text{ Rs.1.82 (Lakhs) (Adv.)} \end{aligned}$$

Cost Management

Reconciliation statement

	Rs.	Rs.
Profit during 1997-98		5,00,000
Add: Net increase in profit due to the sales of 1998-99 [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)		19,60,000
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:

- Sales during 1998-99 at 1997-98 price level = $\frac{\text{Rs.129.60}}{\text{Rs.120}} \times 100 = \text{Rs.108 (Lakhs)}$
- Material cost of 1998-99 at 1997-98 price level = $\frac{91.10}{115} \times 100 = \text{Rs.79.22 (Lakhs)}$
- Variable overhead of 1998-99 at 1997-98 price level = $\frac{24}{110} \times 100 = \text{Rs.21.82 (Lakhs)}$
- Fixed overhead of 1998-99 at 1997-98 price level = $\frac{18.50}{110} \times 100 = \text{Rs.16.82 (Lakhs)}$
- 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)

Standard Costing And Variance Analysis

Question 3

- (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) Variable 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.

Cost Management

- (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

$$\begin{aligned}\text{Or Actual material cost incurred} &= \left(\text{Standard variable of material of actual output} - \text{Material cost variance} \right) \\ &= (10,000 \text{ units} \times 2 \text{ units} \times \text{Rs.15} + \text{Rs.50,000}) \\ &= \text{Rs.3,00,000} + \text{Rs.50,000}\end{aligned}$$

(2) Standard cost of materials actually consumed

Material price variance = (Standard cost – Actual cost) Actual quantity consumed

Or Standard cost of materials actually consumed =

$$\begin{aligned}&\left(\text{Actual material cost incurred} + \text{Material price variance} \right) \\ &= \text{Rs.3,50,000} - \text{Rs.70,000} = \text{Rs.2,80,000}\end{aligned}$$

(3) Labour efficiency variance (Refer to working note 1)

$$\begin{aligned}&= \left(\text{Standard hours for actual output} - \text{Actual hours worked} \right) \text{Standard rate per hour} \\ &= (10,000 \text{ units} \times 3 \text{ hours} - 35,000 \text{ hours}) \text{Rs.20} \\ &= (\text{Rs.6,00,000} - \text{Rs.7,00,000}) = \text{Rs.1,00,000 (Adv.)}\end{aligned}$$

(4) Variable OH efficiency variance (Refer to working note 2)

$$\begin{aligned}&= \frac{\text{Standard variable overhead rate per hour}}{\left(\text{Standard hours} - \text{Actual hours} \right)} \\ &= \text{Rs.5} (30,000 \text{ hours} - 35,000 \text{ hours}) - \text{Rs.25,000 (Adv.)}\end{aligned}$$

Standard Costing And Variance Analysis

- (5) Variable OH expenditure variance (Refer to working note 1)

$$= \left(\frac{\text{Budgeted variable overhead}}{\text{for actual hours}} - \frac{\text{Actual variable overhead}}{\text{overhead}} \right)$$

$$= (\text{Rs.}5 \times 35,000 \text{ hours} - \text{Rs.}2,00,000) - \text{Rs.}25,000 \text{ (Adv.)}$$

- (6) Fixed OH efficiency variance (Refer to working notes 1 & 2)

$$= \left[\frac{\text{Standard fixed overhead}}{\text{rate per hour}} \right] - \left[\frac{\text{Standard hour for actual output}}{\text{hours}} - \frac{\text{Actual hours}}{\text{hours}} \right]$$

$$= \text{Rs.}5 (30,000 \text{ hours} - 35,000 \text{ hours}) = \text{Rs.}25,000 \text{ (Adv.)}$$

Fixed OH capacity variance (Refer to working notes 1 & 2)

$$= \left[\frac{\text{Standard variable overhead}}{\text{rate per hour}} \right] - \left[\frac{\text{Actual capacity hours}}{\text{hours}} - \frac{\text{Budgeted capacity hours}}{\text{capacity hours}} \right]$$

$$= \text{Rs.}5 (35,000 \text{ hours} - 50,000 \text{ hours}) = \text{Rs.}75,000 \text{ (Adv.)}$$

- (7) Fixed OH volume variance (Refer to working note 3)

$$= \frac{\text{Standard variable overhead}}{\text{rate per hour}} \left(\frac{\text{Actual output}}{\text{output}} - \frac{\text{Budgeted output}}{\text{output}} \right)$$

$$= \text{Rs.}15 \left(10,000 \text{ units} - \frac{50,000 \text{ hours}}{3 \text{ hours}} \right)$$

$$= \text{Rs.}1,50,000 - \text{Rs.}2,50,000 = \text{Rs.}1,00,000 \text{ (Adv.)}$$

Working notes:

1. Labour rate variance:

$$= (\text{Standard rate per hour} - \text{Actual rate per hour}) \text{ Actual hours (x)}$$

$$\text{Or Rs.}50,000 = 20x - \text{Rs.}6,50,000$$

$$\text{Or } x = 35,000 \text{ hours}$$

2. Standard hours = 10,000 units × 2 hours = 30,000 hours

$$\text{Budgeted hours} = \left(\frac{30,000 \text{ hours} \times 100}{60} \right) = 50,000 \text{ hours}$$

$$\text{Budgeted fixed overhead} = \text{Actual fixed overhead} + \text{Expenditure variance}$$

$$= \text{Rs.}3,00,000 - \text{Rs.}50,000 = \text{Rs.}2,50,000$$

$$\left[\frac{\text{Standard fixed overhead}}{\text{recovery rate per hour}} \right] = \frac{\text{Rs.}2,50,000}{50,000 \text{ hours}} = \text{Rs.}5 \text{ per hour}$$

Cost Management

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 4

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:

<i>Element of cost</i>	<i>Variance of Efficiency</i>	<i>Variance of price</i>	<i>Variance of volume</i>
Material	Usage, Mixture, Yield	Price	Revision
Labour	Efficiency, idle time	Rate of pay	--
- Variable	Efficiency	Expenditure	Revision
- Fixed	Efficiency	Expenditure	Revision
			Capacity
			Calendar

Question 5

The working results of a company for two corresponding years are shown below:

	<i>Year 1</i>	<i>Year 2</i>
	<i>Rs. in lacs</i>	<i>Rs. in lacs</i>
Sales	1,200	1,540
Direct Material	600	648
Direct Wages and Variable Overheads	360	412

Standard Costing And Variance Analysis

<i>Fixed overheads</i>	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
<i>Direct material consumption in m/t</i>	5,00,000	5,40,000
<i>Direct Labour Hours</i>	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

	<i>Favourable in Rs. (lakhs)</i>	<i>Adverse in Rs. (lakhs)</i>
Increase in contribution due to increase in volume (Rs. 280 lakhs – Rs.240 lakhs) (Refer to working note 3)	40	
Sales price variance (Refer to working note 3)	140	
Material usage variance (Refer to working note)	52	
Material price variance (Refer to working note 4)		0
Direct Labour rate variance (Refer to working note 4)	--	28
Direct labour efficiency variance (Refer to working note 4)	36	--
Fixed overhead expenditure variance	--	140

Cost Management

(Refer to Working note 3)

	268	168
Total change in profit	100	168

(ii)

$$\begin{aligned} \text{Break-even sales (year 1) (Refer to working note 3)} &= \frac{\text{Fixed costs}}{\text{P/V ratio}} \\ &= \frac{\text{Rs.160 lakhs}}{\left(\frac{\text{Rs.240 lakhs}}{\text{Rs.1,200 lakhs}} \right)} = \text{Rs.800 lakhs} \\ \text{Break even sales (year 2) (Refer to working note 3)} &= \frac{\text{Rs.1300 lakhs}}{\left(\frac{\text{Rs.480 lakhs}}{\text{Rs.1,540 lakhs}} \right)} = \text{Rs.962.50} \end{aligned}$$

(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.

$$\text{P/V ratio} = (\text{Rs.480 lakh} / \text{Rs.1,540 lakhs} \times 100 = 31.169\%$$

$$\text{Break even sales} = \frac{\text{Rs.962.50 lakhs}}{\text{Rs.1,540}} \times 100 = 62.5\%$$

$$= (5,83,333 - 5,40,000) \text{ Rs.120} - \text{Rs.52 lakhs (Fav.)}$$

If Margin of safety to be earned is 45% then Break-even point should be 55%.

$$\text{Contribution increase required} = \frac{62.5 \times 31.169}{55} \times 100 = 35.4193\%$$

$$\begin{aligned} \text{Revised contribution} &= 1,540 \text{ lakhs} \times 35.4193\% \\ &= \text{Rs.545.45 lakhs} \end{aligned}$$

$$\text{Present contribution} = \text{Rs.480 lakhs}$$

$$\text{Increase in selling price required} = \text{Rs.65.45 lakhs (Rs.545.45 lakhs} - \text{Rs.480 lakhs)}$$

Percentage increase in selling price

$$\text{Over the sales value of year 2} = \frac{\text{Rs.65.45 lakhs}}{\text{Rs.1,540 Lakhs}} \times 100 = 4.25\%$$

Working notes:

1. Budgeted sales in year 2

If actual sales in year 2 is Rs.110 then budgeted sales is Rs.100

Standard Costing And Variance Analysis

If actual sales in year 2 is Re1 then budgeted sales = $\frac{\text{Rs.100}}{\text{Rs.110}}$

If actual sales in year 2 is Rs.15,40,00,000 then budgeted sales are

$$= \frac{\text{Rs.100}}{\text{Rs.110}} \times \text{Rs.15,40,00,000}$$

$$= \text{Rs.1,400 lakhs}$$

2. Budgeted figures of direct material; direct wages; and variable overhead worked out on the basis of % of sales in year 2:

$$\begin{aligned} \text{Direct material \% to sale (in year 1)} &= \frac{\text{Direct material cost}}{\text{Sales}} \times 100 \\ &= \frac{600}{1,200} \times 100 = 50\% \end{aligned}$$

Budgeted figure of direct Material (in year 2)

$$= 50\% \times \text{Rs.1,400 lakhs} = \text{Rs.700 lakhs}$$

Direct wages and variable overhead

$$\begin{aligned} \% \text{ to sales (in year 1)} &= \frac{\text{Direct wages and variable overhead}}{\text{Sales}} \times 100 \\ &= \frac{300}{1,200} \times 100 = 30\% \end{aligned}$$

Budgeted figure of direct wages and variable overhead (in year 2)

$$= 30\% \times 1,400 \text{ lakhs}$$

$$= 420 \text{ lakhs}$$

3. Statement of figures extracted from working results of a company.

(Figures in lakhs of Rs.)

	<i>Year 1 Actual</i>	<i>Years 2 (Budgeted)</i>	<i>Years 2 Actual</i>	<i>Total variance</i>
	<i>(a)</i>	<i>(b)</i>	<i>(c)</i>	<i>(d)=(c)-(b)</i>
Sales (A)	1,200	1,400	1,540	140 (Fav)
		(Refer to w.n. 1)		
Variable costs:				
Direct material	600	700	648	52 (Fav)

Cost Management

(Refer to w. n. 2)

Direct wages and variable overhead (Refer to w. n. 2)	<u>360</u>	<u>420</u>	<u>412</u>	<u>8 (Fav.)</u>
Total variable costs (B)	960	1120	1060	60 (Fav.)
Contribution (C) = [(A) – (B)]	240	280	480	200 (Fav)
Less: Fixed cost	<u>160</u>	<u>160</u>	<u>300</u>	<u>140 (Adv.)</u>
Profit	<u>80</u>	<u>120</u>	<u>180</u>	<u>60 (Fav.)</u>

4. (i) Data for Material variances:

<i>Standard data for actual output</i>			<i>Actual data</i>		
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

$$= (\text{Standard rate} - \text{Actual rate}) \text{ Actual quantity}$$

$$= \text{Nil}$$

Material usage variance

$$= (\text{Standard quantity} - \text{Actual quantity}) \text{ Standard rate per m/t}$$

$$= (5,83,333 - 5,40,000) \text{ Rs.120} = \text{Rs.52 lakhs (Fav.)}$$

- (ii) Data for Labour and variable overhead variances

<i>Standard data for actual output</i>			<i>Actual data</i>		
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:

$$= (\text{Standard rate} - \text{Actual rate}) \text{ Actual labour hours}$$

$$= (\text{Rs.4.80} - \text{Rs.5.15}) 80,00,000 = \text{Rs.28 lakhs (Adv.)}$$

Labour and variable overhead efficiency variance:

$$= (\text{Standard labour hours} - \text{Actual labour hours}) \times \text{Standard rate per hour}$$

$$= (87,50,000 - 80,00,000) \text{ Rs.4.80} = \text{Rs.36 lakhs (Adv.)}$$

Standard Costing And Variance Analysis

Question 6

- (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.

Cost Management

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:

$$\begin{aligned} &= (\text{Standard price p.u.} - \text{General market price p.u.}) \text{ Actual quantity purchased} \\ &= (\text{Rs.5} - \text{Rs.5.20}) 10,000 \text{ units} = \text{Rs.2,000 (Adverse)} \end{aligned}$$

Controllable material purchase price efficiency variance:

$$\begin{aligned} &= (\text{General market price p.u.} - \text{Actual price paid p.u.}) \text{ Actual quantity purchased} \\ &= (\text{Rs.5.20} - \text{5.18}) 10,000 \text{ units} \\ &= \text{Rs.200 (Fav.)} \end{aligned}$$

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:

$$\begin{aligned} &= (\text{Original std. quantity in kgs.} - \text{Revised std. quantity in kgs.}) \text{ Standard price per kg.} \\ &= (1,250 \text{ kgs.} - 1,500 \text{ kgs}) \text{ Re.1} \\ &= \text{Rs.250 (Adverse)} \end{aligned}$$

Controllable material usage efficiency variance:

$$\begin{aligned} &= (\text{Revised standard quantity in kgs.} - \text{Actual quantity used in kgs.}) \text{ Standard price per kg.} \\ &= (1,500 \text{ kgs.} - 1,450 \text{ kgs.}) \text{ Re.1} \\ &= \text{Rs.50 (Favourable)} \end{aligned}$$

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.

Standard Costing And Variance Analysis

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):

$$= \{ \text{Expert's budgeted sales volume} \times (\text{Expert's selling price} - \text{Standard cost}) - \text{Original budgeted sales volume} \times (\text{Budgeted selling price} - \text{Standard cost}) \}$$

Total sales margin variance (appraisal element):

$$= \{ \text{Actual sales volume} \times (\text{Actual selling price} - \text{Standard cost}) \}$$

$$= \text{Expert's budgeted sales volume} \times (\text{Expert's selling price} - \text{Standard cost}) \}$$

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

$$= \frac{\text{Std. fixed overhead}}{\text{rate per hour}} \left(\frac{\text{Std. machine hours}}{\text{for actual output}} - \frac{\text{Budgeted machined hours}}{\text{for actual output}} \right)$$

$$\text{or Rs.80,000 (Fav.)} = \text{Rs.100} (11,300 - Y)$$

$$\text{or } 800 = 11,300 - Y$$

$$\text{or } Y = (11,300 - 800) \text{ hours}$$

$$\text{or } Y = 10,500 \text{ hours}$$

Hence budgeted machine hours for actual output are 10,500 hours.

(ii) Actual machine Hours: We know that:

$$\text{Efficiency variance} = \frac{\text{Std. variable overhead}}{\text{rate per hour}} \left(\frac{\text{Std. hours for}}{\text{actual output}} - \frac{\text{Actual hours}}{\text{for actual output}} \right)$$

$$\text{or Rs.36,000 (Fav.)} = \text{Rs.60} (11,300 \text{ hours} - X)$$

$$\text{or } 600 = 11,300 \text{ hours} - X$$

Cost Management

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)

Standard Costing And Variance Analysis

= 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 7

- (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	Adverse	
	Rs.	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 Statement for April, 2001 in the following format:

Cost Management

<i>Account</i>	<i>Qty./ Hours</i>	<i>Rate / Price</i>	<i>Actual Value Rs.</i>
<i>Sales</i>			
<i>Direct Materials</i>			
<i>Direct Labour</i>			
<i>Fixed Overheads</i>			
<i>Total Costs</i>			
<i>Profit</i>			

(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:

$$= (\text{Budgeted fixed overheads p.a} / \text{Budgeted output for the year})$$

$$= \text{Rs.4,80,000 p.a.} / 1,20,000 \text{ units} = \text{Rs.4 per unit.}$$
- (b) Budgeted fixed overhead hour:

$$= \text{Budgeted fixed overhead per unit} / \text{Standard labour hours per unit}$$

$$= \text{Rs.4} / 2 \text{ hours} = \text{Rs.2 per hour}$$
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)	

Standard Costing And Variance Analysis

- | | | |
|----|---|----|
| | Fixed overhead | 4 |
| | (2 hours × Rs.2) | |
| | Total standard cost (per unit) | 30 |
| 3 | (b) Budgeted selling price per unit | |
| | Standard cost per unit | 30 |
| | Standard profit per unit | 10 |
| | (25% on sales 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 | |
| | = Budgeted margin per unit $\left(\frac{\text{Actual sales quantity units} - \text{Budgeted quantity units}}{\text{quantity units}} \right)$ | |
| | = 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 = $\left(\frac{\text{Actual Selling price per unit} - \text{Budgeted selling price per unit}}{\text{price per unit}} \right) \text{Actual Sales units}$ | |

Cost Management

or Rs.9,600 (Fav.) = $(x - \text{Rs.}40) \times 9,600 \text{ units}$

or Actual selling price per unit = Rs.41/-

5. (a) Actual quantity of material consumed:

$$\text{Material usage variance} = \left(\frac{\text{Standard quantity} - \text{Actual quantity}}{\text{per unit}} \right) \text{Standard price}$$

or 6,400 (Adv.) = $(9,600 \text{ units} \times 5 \text{ kgs.}) \text{ Rs.}4$

or x kgs. = 49,600 kgs.

(actual quantity of material consumed)

- (b) Actual price per kg:

Actual price per kg.:

Material price variance = $(\text{Standard price per kg} - \text{Actual price per kg}) \text{ Actual quantity of material consumed}$

-Rs.4,960 = $(\text{Rs.}4 - \text{Rs. } y \text{ per kg.}) 49,600 \text{ kg.}$

-0.1 = $(\text{Rs.}4 - \text{Rs. } y \text{ per kg})$

or y = $\text{Rs.}4.10 \text{ per kg.}$

6. (a) Actual direct labour hour used:

Labour efficiency variance = $(\text{Standard hours} - \text{Actual hours}) \text{ Standard rate per hour}$

Rs.3,600 (Favourable) = $(9,600 \text{ units} \times 2 \text{ hours} - p \text{ hours}) \text{ Rs.}3$

Rs.3,600 (Favourable) = $(19,200 \text{ hours} - p \text{ hours}) \text{ Rs.}3$

P hours = $(19,200 \text{ hours} - 1,200 \text{ hours}) - 18,000 \text{ hours}$
(Actual direct labour hours)

- (b) Actual direct labour hour rate:

$$\text{Labour rate variance} = \left(\frac{\text{Standard rate per hour} - \text{Actual rate per hour}}{\text{labour hours}} \right) \text{Actual Direct}$$

Rs.3,600 (Adverse) = $(\text{Rs.}3 \text{ per hour} - t \text{ per hour}) 18,000 \text{ hours}$

or t = $\text{Rs.}3 + \text{Rs.}0.20 - \text{Rs.}3.20 \text{ per hour}$

(actual direct labour hour rate)

7. Actual fixed overheads:

Fixed overhead expense variance = $\text{Budgeted fixed overhead} - \text{Actual fixed overhead}$

or Rs.1,400 (Favourable) = $10,000 \text{ units} \times \text{Rs.}4 \text{ p.u.} - \text{Actual fixed overhead}$

Standard Costing And Variance Analysis

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 8

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

<i>Fruits extract</i>	<i>400 kgs @ Rs. 16 per kg.</i>
<i>Glucose syrup</i>	<i>700 kgs @ Rs. 10 per kg.</i>
<i>Pectin</i>	<i>99 kgs. @ 33.2 per kg.</i>
<i>Citric acid</i>	<i>1 kg at Rs. 200 per kg.</i>
<i>Labour</i>	<i>18 hours @ Rs. 32.50 per hour.</i>

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%.

Cost Management

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:

- Calculate the ingredients planning variances that are deemed uncontrollable.
- Calculate the ingredients operating variances that are deemed controllable.
- Calculate the mixture and yield variances.
- 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)

Standard Costing And Variance Analysis

Ingredients Price variance

(Revised Material Price – Actual Material Price) × (Actual Qty Consumed)

		<i>Variance in Rs</i>
Fruit extract	$(19 - 18) \times 428$	428(F)
Glucose syrup		Nil
Pectin	$(33.2 - 32.8) \times 125$	50(F)
Citric acid	$(200 - 95) \times 1$	105(F)
		583(F)

Usage variance

(Std Qty on Actual Production less Actual Qty on Actual Production) × Revised Std Price/Unit

	<i>Rs</i>	<i>Variance in Rs</i>
Fruit extract	$(400 - 428) \times 19$	532(A)
Glucose syrup	$(700 - 742) \times 12$	504(A)
Pectin	$(99 - 125) \times 33.2$	863.2(A)
Citric acid		Nil
		1,899.2(A)

(iii) Mix Variance

(Actual usage in std mix less Actual usage in actual mix) × std price

		<i>Variance in Rs</i>
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) × 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.

$$\text{Or Total Variance} = (2,600) + (1,899.2) + 583 + (15) = 3931.2 (A).$$

Cost Management

Question 9

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 -1 and 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.

Standard Costing And Variance Analysis

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

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

Cost Management

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 10

“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 11

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)	<u>18,000</u>
	5,17,200
Costs:	
Direct material	1,68,000
Direct labour	1,05,000
Variable overhead	<u>42,000</u>
	3,15,000
Fixed overhead	1,20,000
Fixed Admn. Overhead	40,000
Variable distribution Overhead	19,200

Standard Costing And Variance Analysis

Fixed selling Overhead	<u>40,000</u>	
	<u>2,19,200</u>	
Total costs		<u>5,34,000</u>
Loss		<u>17,000</u>

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	<u>4,99,200</u>	416
	1,200	
(2) Raw materials	<u>1,48,000</u>	120
	1,400	
Labour	<u>1,05,000</u>	60
	1,750	
[Equivalent units (1,400/80%)]		
Factory overhead	<u>42,000</u>	
	1,400	30
Total manufacturing cost		210
Distribution overheads	<u>19,200</u>	
	1,200	16
Total cost		226
Contribution		190
Total fixed cost: factory	1,20,000	
Administration	40,000	
Selling	40,000	2,00,000

Cost Management

(ii) Standard Profit for 1,200 units sold:

	Rs.	
Contribution	$1,200 \times 190$	2,28,000
Less: Fixed costs		<u>2,00,000</u>
Profit		<u>28,000</u>

(iii) Reconciliation

	Rs.	
Budgeted profit	$(2,000 \times 190 - 2,00,000)$	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	$100 \times (210 - 180)$	3,000
Actual profit		<u>-17,000</u>

Question 12

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	<u>600</u>	<u>(12,200)</u>
		2,800
Add: Favourable variances		
Contribution quantity variance	1,800	
Direct wages variance	600	
Variable overhead variance	<u>1,800</u>	<u>4,200</u>
Actual profit		<u>7,000</u>

There is no inventory

Production units = Sales units for both actual and budget.

Standard selling price Rs. 18/unit

Standard Costing And Variance Analysis

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.

Cost Management

	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)	$60,600 \times 4$	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 13

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

Standard Costing And Variance Analysis

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)

Question 14

A company produces a product X, using raw materials A and B. The standard mix of A and B is 1 : 1 and the standard loss is 10% of input.

You are required to compute the missing information indicated by “?” based on the data given below:

	A	B	Total
Standard price of raw material (Rs./kg.)	24	30	
Actual input (kg.)	<u>?</u>	70	
Actual output (kg.)			<u>?</u>
Actual price Rs./kg.	30	<u>?</u>	
Standard input quantity (kg.)	<u>?</u>	<u>?</u>	
Yield variance (sub usage)	<u>?</u>	<u>?</u>	270(A)
Mix variance	<u>?</u>	<u>?</u>	<u>?</u>
Usage variance	<u>?</u>	<u>?</u>	<u>?</u>
Price variance	<u>?</u>	<u>?</u>	<u>?</u>
Cost variance	0	<u>?</u>	1300(A)

(May 2007, 14 marks)

Answer

Computation of Yield Variance for 'A' and 'B'

DM yield variance for 'A' =

$$\text{DM yield variance for 'A'} = \left[\begin{array}{c} \text{Std qty of} \\ \text{all DM} \\ \text{allowed} \\ \text{for actual} \\ \text{output} \end{array} - \begin{array}{c} \text{Actual} \\ \text{total qty} \\ \text{of all DM} \\ \text{used} \end{array} \right] \times \begin{array}{c} \text{Std} \\ \text{Mix} \\ \text{\%age} \\ \text{of 'A'} \end{array} \times \text{Std price of 'A'}$$

$$= [SQ_A - RSQ_A] \times \text{Std price of 'A'}$$

Where RSQ_A = Revised Standard Quantity of 'A' = (Actual total qty of all DM used) $\times$ Std

Cost Management

Mix %age of 'A' and

SQ_A = Standard Quantity of DM 'A' for Actual Production = Standard quantity of all DM allowed for actual output $\times$ Std Mix %age of 'A'

$$\begin{array}{l} \text{DM yield} \\ \text{variance} \\ \text{for 'B'} \end{array} = \left[\begin{array}{l} \text{Std qty of} \\ \text{all DM} \\ \text{allowed} \\ \text{for actual} \\ \text{output} \end{array} - \begin{array}{l} \text{Actual} \\ \text{total qty} \\ \text{of all DM} \\ \text{used} \end{array} \right] \times \begin{array}{l} \text{Std} \\ \text{Mix} \\ \text{\%age} \\ \text{of 'B'} \end{array} \times \text{Std price of 'B'}$$

$$= [SQ_B - RSQ_B] \times \text{Std price of 'B'}$$

Where RSQ_B = Revised Standard Quantity of 'B' = (Actual total qty of all DM used) $\times$ Standard Mix %age of 'B' and

SQ_B = Standard quantity of DM 'B' for Actual Production = Standard quantity of all DM allowed for actual output $\times$ Standard Mix %age of 'B'

Since Standard Mix %age is the same for both 'A' and 'B' (1:1) we have,

Total Yield variance for 'A' and 'B' = $T \times (\text{Std price of 'A'} + \text{Std price of 'B'})$

Where $T = (\text{Std qty of all DM allowed for actual output} - \text{Actual total qty of all DM used}) \times 0.5$

As Total Yield variance for 'A' and 'B' is given as – Rs 270, we have

$$- \text{Rs } 270 = T \times \text{Rs } 24 + T \times \text{Rs } 30$$

$$\text{Or } T = -5$$

Hence Yield Variance for 'A' = $-5 \times 24 = -\text{Rs } 120$ and

Yield variance for 'B' = $-5 \times 30 = -\text{Rs } 150$.

Also

$$(SQ_A - RSQ_A) \times 24 = -120 \text{ or } SQ_A - RSQ_A = -5$$

Similarly

$$(SQ_B - RSQ_B) \times 30 = -150 \text{ or } SQ_B - RSQ_B = -5$$

Alternative 1

Let total actual quantity consumed; X kg.

Then, Quantity of A = $X - 70$

$$RSQ = \frac{X}{2} \text{ of A \& } \frac{X}{2} \text{ of B. (Since the Mix ratio is 1:1)}$$

The Standard input for both 'A' and 'B' will be $0.5X - 5$

Since Cost Variance for 'A' is given to be nil, we have,

Standard Costing And Variance Analysis

$$(SP_A \times SQ_A) - (AQ_A \times AP_A) = 0$$

$$\text{i.e. } 24 \times (0.5X - 5) - (X - 70) \times 30 = 0$$

$$\text{or } X = 110 \text{ Kgs}$$

$$\text{Therefore Actual Input for 'A' } = 110 - 70 = 40 \text{ Kgs}$$

$$\text{Also, Standard Input for 'A' and 'B' will be } \left(\frac{110}{2} - 5 \right) = 50 \text{ Kgs. Using this quantity in the Cost}$$

Variance of 'B', the actual price per kg of 'B' (AP_B) will be ,

$$50 \times 30 - 70 \times AP_B = -1,300$$

$$\text{Or } AP_B = \text{Rs } 40.$$

Alternative 2

Let the standard input of 'A' = X kg. Therefore, the total standard input for 'A' + 'B' = 2X

$$\text{Actual input} = (2X + 10) \text{ Kgs. } \therefore \text{Actual input for 'A'} = (2X + 10 - 70) = (2X - 60) \text{ Kgs}$$

Forming the equation for nil cost variance of 'A'.

$$\text{Rs. } 24 \times X - \text{Rs. } 30 \times (2X - 60) = 0$$

Or $X = 50$ Kgs. Using this quantity in the Cost Variance of 'B', the actual price per kg. of 'B' (AP_B) will be ,

$$50 \times 30 - 70 \times AP_B = -1,300$$

$$\text{Or } AP_B = \text{Rs. } 40.$$

Alternative 3

Let the actual input of 'A' = X

Then the total actual input = (X + 70). Therefore, RSQ of 'A' and 'B' each = $0.5X + 35$ and Standard Input of 'A' and 'B' each = $0.5X + 30$.

Forming the equation for nil cost variance of 'A', we have,

$$24 \times (0.5X + 30) - 30 \times X = 0$$

$$\text{Or } X = 40 \text{ Kgs.}$$

$\therefore$ Standard Input will be 50 Kgs. Using this, quantity in the Cost Variance of 'B', the actual price per kg. of 'B' (AP_B) will be,

$$50 \times 30 - 70 \times AP_B = -1,300$$

$$\text{Or } AP_B = \text{Rs. } 40.$$

Cost Management

Substituting various values for quantity and price, we get the following table.

	(1)	(2)	(3)	(4)
	Std. Price $\times$ SQ	Std. Price $\times$ RSQ	Std. Price $\times$ Actual Qty.	Actual Price $\times$ Actual Qty.
A	$24 \times 50 = 1200$	$24 \times 55 = 1320$	$24 \times 40 = 960$	$30 \times 40 = 1200$
B	$30 \times 50 = 1500$	$30 \times 55 = 1650$	$30 \times 70 = 2100$	$40 \times 70 = 2800$
	<u>2700</u>	<u>2970</u>	<u>3060</u>	<u>4000</u>
	(1) – (2)	(2) – (3)	(1) – (3)	(3) – (4)
	Yld variance	Mix variance	Usage variance	Price variance
A	$1200 - 1320 =$ 120(A)	$1320 - 960 =$ 360(F)	$1200 - 960 =$ 240(F)	$960 - 1200 =$ 240(A)
B	$1500 - 1650 =$ 150(A)	$1650 - 2100 =$ 450(A)	$1500 - 2100 =$ 600(A)	$2100 - 2800 =$ 700(A)
	<u>270A)</u>	<u>90A)</u>	<u>360A)</u>	<u>940A)</u>
	(1) – (4)			
	Cost variance			
	$1200 - 1200 =$ 0			
	$1500 - 2800 =$ 1300(A)			
	<u>1300A)</u>			

Actual Output = 90 Kgs.

(Actual output and standard output are always equal numerically in any material variance analysis)

Standard output = Standard input – Standard loss or $100 - 10 = 90$ Kgs.

Question 15

The working results of a Software Company for two corresponding years are shown below:

	Amount (Rs. in lakhs)	
	Year 2005	Year 2006
Sales (A)	600	770
Cost of Sales:		
Direct materials	300	324
Direct wages and variable overheads	180	206
Fixed overheads	<u>80</u>	<u>150</u>
Total (B)	<u>560</u>	<u>680</u>
Profit (A – B)	<u>40</u>	<u>90</u>

In year 2006, there has been an increase in the selling price by 10 per cent. Following are the details of material consumption and utilization off direct labour hours during the two years:

	Year 2005	Year 2006
Direct material consumption (M. tons)	5,00,000	5,40,000
Direct labour hours	75,00,000	80,00,000

Standard Costing And Variance Analysis

Required:

- (i) Taking year 2005 as base year, analyse the variances of year 2006 and also workout the amount which each variance has contributed to change in profit.
- (ii) Find out the breakeven sales for both years.
- (iii) Calculate the percentage increase in selling price in the year 2006 that would be needed over the sale value of year 2006 to earn margin of safety of 45 per cent.

(Nov 2007, 19 Marks)

Answer

Working Notes:

- (i) Budgeted sales in year 2006 = $(100/110) \times 770 = \text{Rs. } 700 \text{ lakhs}$
- (ii) Budgeted direct material cost = $(300/600) \times 700 = \text{Rs. } 350 \text{ lakhs}$
- (iii) Budgeted direct wages and variable overheads = $(180/600) \times 700 = \text{Rs. } 210 \text{ lakhs}$
- (iv) Rate per M. ton of direct material: Year 2005 = $(300/5) = \text{Rs. } 60$
: Year 2006 = $(324/5.40) = \text{Rs. } 60$
- (v) Material usage budget for the year 2006 = $(5/600) \times 700 = 5.83333 \text{ lakhs}$
- (vi) Direct labour hours budget for the year 2006 = $(75/600) \times 700 = 87.50 \text{ lakhs}$
- (vii) Direct labour and variable overheads rate per hour: Year 2005 = $(180/75) = \text{Rs. } 2.40$
Year 2006 = $(206/80) = \text{Rs. } 2.575$
- (viii) Material price variance = $(\text{Rs. } 60 - \text{Rs. } 60) \times 5,40,000 = \text{zero}$
- (ix) Material usage variance = $(5.83333 - 5.40) \times \text{Rs. } 60 = \text{Rs. } 26 \text{ lakhs (F)}$
- (x) Labour and variable overheads rate variance = $(2.40 - 2.575) \times 80 = \text{Rs. } 14 \text{ lakhs (A)}$
- (xi) Labour and variable overheads efficiency variance = $(87.50 - 80.00) \times \text{Rs. } 2.40 = \text{Rs. } 18 \text{ lakhs (F)}$
- (xii) Fixed overheads expenditure variance = $(150 - 80) = \text{Rs. } 70 \text{ lakhs (A)}$
- (xiii) **Statement of working results of the company**

	Actuals	Budget	Variance
	2006	2006	
Sales	<u>770</u>	<u>700</u>	<u>70(F)</u>
Less: Direct material	324	350	26(F)
Direct wages and variable overheads	<u>206</u>	<u>210</u>	<u>4(F)</u>
Contribution	240	140	100(F)
Less: Fixed overheads	<u>150</u>	<u>80</u>	<u>70(A)</u>
Profit	<u>90</u>	<u>60</u>	<u>30(F)</u>

Cost Management

I Reconciliation statement showing variances contribution to change in profit (Rs. in lakhs)

	<i>Favourable</i>	<i>Adverse</i>
Increase in contribution due to volume	20	—
Sales price variance	70	—
Material usage variance	26	—
Material price variance	—	—
Direct labour and variable overheads rate variance	—	14
Direct labour and variable overheads efficiency variance	18	—
Fixed overheads expenditure variance	<u>—</u>	<u>70</u>
	<u>134</u>	<u>84</u>
Total change in profit (increase)	<u>50</u>	

II Break-even point

Year 2005 : $(80/120) \times 600 = \text{Rs. } 400 \text{ lakhs}$

Year 2006 : $(150/240) \times 770 = \text{Rs. } 481.25 \text{ lakhs}$

III Required percentage increase in selling price in the year 2006 to earn a margin of safety of 45%.

Break-even sales = $(1 - 0.45)$ or 55 per cent of total sales.

Contribution at 55% sales = Fixed overheads = Rs. 150 lakhs.

Required contribution at total sales = $\text{Rs. } 150 / 0.55 = \text{Rs. } 272.73 \text{ lakhs}$

Additional contribution required = $(272.73 - 240) = \text{Rs. } 32.73 \text{ lakhs}$

Percentage increase in selling price required = $(32.73/770) \times 100 = 4.25\%$.

Question 16

The following information has been extracted from the books of Goru Enterprises which is using standard costing system:

Actual output	= 9,000 units
Direct wages paid	= 1,10,000 hours at Rs.22 per hour, of which 5,000 hours, being idle time, were not recorded in production
Standard hours	= 10 hours per unit
Labour efficiency variance	= Rs. 3,75,000 (A)
Standard variable Overhead	= Rs. 150 per unit
Actual variable Overhead	= Rs. 16,00,000

Standard Costing And Variance Analysis

You are required to calculate:

- (i) Idle time variance
- (ii) Total variable overhead variance
- (iii) Variable overhead expenditure variance
- (iv) Variable overhead efficiency variance.

(May 2008, 6 Marks)

Answer

Actual output = 9,000 units

Idle time = 5,000 hours

Production time (Actual) = 1,05,000 hours

Standard hours for actual production = 10 hours / unit $\times$ 9,000 units = 90,000 hours.

Labour efficiency variance = 3,75,000 (A)

i.e. Standard rate $\times$ (Standard Production time – Actual production time) = 3,75,000(A).

SR (90,000 – 1,05,000) = – 3,75,000

$$SR = \frac{-3,75,000}{-15,000} = \text{Rs. 25}$$

(i) Idle time variance = 5,000 hours $\times$ 25 Rs. / hour = 1,25,000. (A)

(ii) Standard Variable Overhead = Rs. 150 / unit

Standard hours = 10 hours / unit

Standard Variable Overhead rate / hour = 150 / 10 = Rs. 15 / hour

Total Variable Overhead variance = Standard Variable Overhead – Actual Variable Overhead

= Standard Rate $\times$ Standard hours – Actual rate $\times$ Actual hours

= (15) $\times$ (10 $\times$ 9,000) – 16,00,000

= 13,50,000 – 16,00,000

Total Variable Overhead Variance = 2,50,000 (A)

(iii) Variable Overhead Expenditure Variance = (Standard Rate $\times$ Actual Hours) – (Actual Rate $\times$ Actual Hours)

= (15 $\times$ 1,05,000) – 16,00,000

= 15,75,000 – 16,00,000

= 25,000 (A)

Cost Management

$$\begin{aligned} \text{(iv) Variable Overhead Efficiency Variance} &= \text{Standard Rate} \times (\text{Standard Hours for} \\ &\quad \text{actual output} - \text{Actual hours for Actual output}) \\ &= 15 (90,000 - 1,05,000) \\ &= 15 (-15,000) \\ &= 2,25,000 \text{ (A)} \end{aligned}$$

Alternative Solution

Actual Output = 9,000 Units

Idle time = 5,000 hrs

Direct Wages Paid = 1,10,000 hours @ Rs. 22 out of which 5,000 hours being idle, were not recorded in production.

Standard hours = 10 per unit.

Labour efficiency variance = Rs. 3,75,000 (A)

or

Standard Rate (Standard Time – Actual Time) = – 3,75,000

$$\text{Or } (90,000 - 1,05,000) = \frac{-3,75,000}{\text{Standard Rate}}$$

Or Standard Rate = Rs 25/-

(i) Idle time variance = Standard Rate $\times$ Idle time

$$25 \times 5,000 = \text{Rs } 1,25,000 \text{ (A)}$$

(ii) Standard Variable Overhead / unit = 150

$$\text{Standard Rate} = \frac{150}{10} = \text{Rs. } 15/\text{hour}$$

Standard Quantity = 10 hours

Actual Variable Overhead = 16,00,000

$$\text{Standard Variable Overhead} = 150 \times 9,000 = 13,50,000$$

$$\text{Actual Variable Overhead} = \underline{16,00,000}$$

$$\text{Total Variable Overhead Variance} = 2,50,000 \text{ (A)}$$

$$\begin{aligned} \text{(iii) Variable Overhead expenditure Variance} &= \text{Standard Variable Overhead for} \\ &\quad \text{actual hours} - \text{Actual Variable Overhead} \\ &= (150 \times 1,05,000) - 16,00,000 \\ &= 15,75,000 - 16,00,000 \\ &= 25,000 \text{ (A)} \end{aligned}$$

Standard Costing And Variance Analysis

$$\begin{aligned}
 \text{(iv) Variable overhead efficiency variance} &= \text{Standard Variable Overhead for actual output} - \text{Standard Variable Overhead for Actual hours} \\
 &= 15 (10 \text{ hours} \times 90,000 \text{ units} - 1,05,000) \\
 &= 15 (90,000 - 1,05,000) \\
 &= 15 (-15,000) \\
 &= 2,25,000 \text{ (A)}
 \end{aligned}$$

Question 17

A manufacturing company has furnished the following financial data relating to the actual output of 9,600 units produced in the last quarter:

		Rs.
Sales		4,45,500
Costs:		
Direct Materials	59,400	
Direct Wages	89,400	
Variable Overheads	1,45,500	
Fixed Overheads	<u>78,000</u>	<u>3,72,300</u>
Profit		<u>73,200</u>

The standard wage rate is Rs. 4.50 per hour and the standard variable overhead rate is Rs. 7.50 per hour. The company uses a JIT system and the budgeted production and sales quantity is 10,000 units.

The following are the variances from standard costs recorded during the last quarter:

		Rs.
Direct materials	Price V	600 A
	Usage V	1,200 A
Direct Wages	Rate V	1,500 F
	Efficiency V	4,500 A
Variable Overheads	Expense V	6,000 F
	Efficiency V	7,500 A
Fixed Overheads	Expense V	3,000 A
Sales	Price V	13,500 F

You are required to:

- (i) Prepare the Original budget and Standard cost sheet per unit of output;

Cost Management

(ii) Produce a statement reconciling the budgeted profit with actual profit.

(Nov 2008, 11 Marks)

Answer

Direct Materials:

SQ	AQ	SP	SQ × SP	AQ × SP	AP	AQ × AP
				59,400		
				Usage variance		Price variance
				1200 A		600 A

$$AQ \times SP = 58,800^1$$

$$SQ \times SP = 57,600^2$$

Standard cost of materials for actual output of 9,600 units = Rs. 57,600.

Hence, standard cost per unit is $57,600 / 9,600 = \text{Rs. } 6$.

Direct Labour:

SH	AH	SR	SH × SR	AH × SR	AR	AH × AR
				89,400		
				Efficiency variance		Rate variance
				4500 A		1500 F

$$AH \times SR = 90,900^3$$

$$SH \times SR = 86,400^4$$

Standard wage cost per unit is $86,400 / 9,600 = \text{Rs. } 9$.

Standard wage rate is Rs. 4.50.

Standard time per unit is $9/4.5 = 2$ hours.

Variable Overheads:

Standard rate is Rs. 7.50 per hour

Standard cost per unit is $2 \text{ hours} \times \text{Rs. } 7.50 = \text{Rs. } 15$.

Fixed Overheads:

Actual units	9,600
Standard time / unit 2 hours	
Standard hours produced	$9,600 \times 2 = 19,200$ hours
Actual overheads	78,000

Standard Costing And Variance Analysis

Expense variance	3,000 A
Budgeted overheads	75,000
Budgeted units	10,000
Fixed overheads per unit	Rs. 7.50.
Charged to Production: $9,600 \times 7.50 =$	Rs. 72,000
Budgeted overheads	Rs. 75,000
Volume variance	Rs. 3,000 (A)

Sales:

SQ	AQ	SP	SQ $\times$ SP	AQ $\times$ SP	AP	AQ $\times$ AP
						4,45,500
						Price variance 13,500 F

$$AQ \times SP = 4,32,000^5$$

$$\text{Actual units} = 9,600$$

$$\text{Standard price is } 4,32,000 / 9,600 = \text{Rs. 45 per unit.}$$

Original Budget and Standard Cost Sheet:

	<i>Budget</i>	<i>Standard Cost</i>
Units budgeted	10,000	
Sales	<u>4,50,000</u>	<u>45.00</u>
Direct materials @ Rs. 6 per unit	60,000	6.00
Direct Wages	90,000	9.00
Variable Overheads @ Rs. 15 per unit	1,50,000	15.00
Fixed overheads @ Rs. 7.50 per unit	<u>75,000</u>	<u>7.50</u>
Total costs	<u>3,75,000</u>	<u>37.50</u>
Profit	<u>75,000</u>	<u>7.50</u>

$$\text{Sales volume variance is } (9,600 - 10,000) \times 7.50 = \text{Rs. 3,000 A}$$

Reconciliation Statement:

Budgeted Profit	75,000
Sales volume variance	3,000 A
Standard profit	72,000
Sales price variance	13,500 F
Total	85,500

Cost Management

Cost variances:

		F	A	
Materials:	Price		600	
	Usage		1,200	
Direct Labour:	Rate	1,500		
	Efficiency		4,500	
Variable Overhead:	Efficiency		7,500	
	Expense	6,000		
Fixed Overhead:	Volume		3,000	
	Expense		<u>3,000</u>	
Total variances		<u>7,500</u>	<u>19,800</u>	12,300 A
Actual profit				73,200

Working Notes:

- (1) Price Variance = $[\text{SP} - \text{AP}] \text{AQ}$
 $600 \text{ (A)} = [\text{SP} \times \text{AQ} - 59,400]$
 $\text{SP} \times \text{AQ} = 58,800.$
- (2) Usage Variance = $[\text{SQ} \times \text{SP}] - [\text{AQ} \times \text{SP}]$
 $1200 \text{ (A)} = \text{SQ} \times \text{SP} - 58,800$
 $\text{SQ} \times \text{SP} = 57,600.$
- (3) Rate Variance = $[\text{SR} - \text{AR}] \text{AH}$
 $1500 \text{ (F)} = \text{SR} \times \text{AH} - 89,400$
 $\text{SR} \times \text{AH} = 90,900.$
- (4) Efficiency Variance = $[\text{SH} - \text{AH}] \times \text{SR}$
 $4500 \text{ (A)} = \text{SH} \times \text{SR} - 90,900$
 $\text{SH} \times \text{SR} = 86,400.$
- (5) Price Variance = $(\text{AP} - \text{SP}) \times \text{AQ}$
 $13500 \text{ (F)} = \text{SP} \times \text{AQ} - 4,45,500$
 $\text{SP} \times \text{AQ} = 4,59,000.$

PRICING DECISIONS, PARETO ANALYSIS

Question 1

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 2

Chum-Chum Ltd. is about to introduce a new product with the following estimates:

<i>Price per unit (in rupees)</i>	<i>Demand (in thousand units)</i>
30-00	400
31-50	380
33-00	360
34.50	340

Cost Management

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)

Pricing Decisions, Pareto Analysis

$$\begin{aligned} &= \text{Rs.}45,36,000 - (\text{Rs.}14,40,000 + \text{Rs.}10,80,000) \\ &= \text{Rs.}45,36,000 - \text{Rs.}25,20,000 \\ &= \text{Rs.}20,16,000 \end{aligned}$$

Question 3

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 4

In what circumstances it may be justifiable to sell at a price below marginal cost? (May 2000)

Cost Management

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 5

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)?*

Pricing Decisions, Pareto Analysis

- (iv) What is the minimum price for which Morning Flower can sell 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.**

	<i>Evergreen</i>	<i>Morning Flower</i>	<i>Evening Flower</i>	<i>Total</i>
	<i>Rs.</i>	<i>Rs.</i>	<i>Rs.</i>	<i>Rs.</i>
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	2,40,000	2,00,000	6,40,000
	(10,000 units × Rs.20)	(6,000 units × Rs.40)	(4,000 units × Rs.50)	--
Net realization value at the point of split off	2,00,000	3,60,000	4,00,000	9,60,000
Less: Joint cost apportioned (Refer to working note)	1,16,667	2,10,000	2,33,333	5,60,000
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 over 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.

	<i>Evergreen</i>	<i>Morning Flower</i>	<i>Evening Flower</i>	<i>Total</i>
	<i>Rs.</i>	<i>Rs.</i>	<i>Rs.</i>	<i>Rs.</i>
Total Joint cost	2,80,000	1,68,000	1,12,000	5,60,000

Cost Management

	(10,000 units × Rs.28)	(6,000 units × Rs.28)	(4,000 units × Rs.28)	--
Joint cost	1,16,667	2,10,000	2,33,333	5,60,000
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)				--
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 of Rs.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)	<u>6,40,000</u>
Total cost	12,00,000
Add: Profit margin (20% on sales or 25% on total cost)	3,00,000
Expected desired sales revenue	<u>15,00,000</u>
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	3,60,000

Pricing Decisions, Pareto Analysis

received will be

Loss of revenue resulting from the sale of Morning Flower	1,40,000
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(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
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(Refer to (ii) part

Quantity (in units)	6,000
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Hence minimum price per unit (Rs.)	83.33
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(Rs.5,00,000 / 6,000 units)

Question 6

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 7

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.

Cost Management

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 8

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)

Pricing Decisions, Pareto Analysis

- (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

$$\text{Rs.100} = \frac{\text{Rs.100}}{\text{Rs.120}}$$

$$\begin{aligned}\text{If Rs.24,000 is the S. P. then C. P. is} &= \frac{\text{Rs.100}}{\text{Rs.120}} \times \text{Rs.24,000} \\ &= \text{Rs.20,000}\end{aligned}$$

3. Cost of local procurements:

$$140\% \text{ of the supplies made by Z Inc. or } 140\% \times \text{Rs.10,000}^* = \text{Rs.14,000}$$

*Being 50% of cost of a dismantled kit to Z Inc.

Cost Management

4. Landed cost of a dismantled kit:

	Rs.
FOB price	12,000
(50% × Rs.24,000) (Refer to working note 1)	
Add: Insurance & freight	<u>500</u>
CIF price	12,500
Add: Customs duty	3,750
(30% × Rs.12,500)	
Landed cost of a dismantled kit	<u>16,250</u>

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

$$X = 1.25 (\text{Rs. } 32,250 + \text{Rs. } 150 + y)$$

$$Y = 10\% \{x - (\text{Rs. } 6,720 + \text{Rs. } 16,250)\}$$

On solving the above equations we get:

$$X = \text{Rs. } 43,000$$

$$Y = \text{Rs. } 2003.43 \text{ or Rs. } 2,000 \text{ (Approx)}$$

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	<u>2,000</u>
D. Total cost of manufacture: (A+ B + C)	33,250

Pricing Decisions, Pareto Analysis

E. Technology fee per computer (Rs. 3,00,00,000 / 2,00,000 computer)	150
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)	<u>8,600</u>
I. Selling price (per computer)	<u>43,000</u>

Question 9

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 10

How Pareto analysis is helpful in pricing of product in the case of firm dealing with multi-products?

Answer

In the case of firm dealing with multi products, it would not be possible for it to analyse price-volume relationship for all of them. Pareto Analysis is used for analysing the firm's estimated sales revenue from various products and it might indicate that approximately 80% of its total sales revenue is earned from about 20% of its products. Such analysis helps the top management to delegate the pricing decision for approximately 80% of its 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

Cost Management

80% of total sales revenue. For the remaining 80% products, which account for 20% of the total sales value the firm may use cost based pricing method.

Question 11

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	<u>40,000</u>
Apportioned Investment (Rs.)	<u>1,50,000</u>

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) $(30,000 \div 60) \times 100$	50,000
Sales = cost + return or $1,50,000 + 50,000$	2,00,000
Number of units produced	20,000
Selling price $\text{Rs. } 2,00,000 \div 20,000 = \text{Rs. } 10 \text{ per unit}$	

Alternative solution

$(\text{Sales} - \text{cost}) (1 - \text{Tax}) = \text{ROI}$
 $(\text{Sales} - 1,50,000) (1 - 0.40) = 1,50,000 \times 20\%$
 $(0.60 \text{ Sales} - 90,000) = 30,000$
 $0.60 \text{ Sales} = 1,20,000$
 $\text{Sales} = 1,20,000 \div 0.60 = \text{Rs. } 2,00,000$
Number of units 20,000
Selling price $\text{Rs. } 2,00,000 \div 20,000 = \text{Rs. } 10.$

Pricing Decisions, Pareto Analysis

(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 $(1 - 0.40) = 0.60 = (6 \div 0.60) =$	10	
List price		100
Discount		40
Net price		60
Profit desired		10
Cost		50
Cost of 50% = Rs. 1,50,000		
Sales = $(\text{Rs. } 1,50,000 \div 50) \times 100 = \text{Rs. } 3,00,000$		
Number of units	20,000	
List selling price $(3,00,000 \div 20,000) = \text{Rs. } 15$		
Discount 40%		
Net price $(15 \times 60\%) = \text{Rs. } 9$ per unit		

Alternative solution

Let s be the list sales

$$[\text{List Sales } (1 - \text{tax discount}) - \text{cost}] (1 - \text{Tax rate}) = 0.60s$$

$$[s (1 - .40) - 1,50,000] (1 - 0.40) = .06s$$

$$s = \text{Rs. } 3,00,000$$

$$\text{List sales price per unit is Rs. } 15 \left(\frac{3,00,000}{20,000} \right)$$

Net selling price per unit is Rs. 9 (Rs. 15 – 40% of 15%).

Question 12

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.

Cost Management

(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".

Question 13

S Limited is engaged in manufacturing activities. It has received a request from one of its important customers to supply a product which will require conversion of material 'M', which is a non-moving item.

The following details are available:

Book value of material M	Rs. 60
Realisable value of material M	Rs. 80
Replacement cost of material M	Rs. 100

It is estimated that conversion of one unit of 'M' into one unit of the finished product will require one labour hour. At present, labour is paid at the rate of Rs. 20 per hour. Other costs are as follows:

Out-of-pocket expenses	Rs. 30 per unit
Allocated overheads	Rs. 10 per unit

The labour will be re-deployed from other activities. It is estimated that the temporary redeployment will not result in loss of contribution. The employees to be re-deployed are permanent employees of the company.

Required:

Estimate the minimum price to be charged from the customer so that the company is not worse off by executing the order. (Nov 2007, 4 Marks)

Answer

Relevant costs of producing one unit of the finished product

	Rs.
Cost of material 'M' (realisable value)	80

Pricing Decisions, Pareto Analysis

Cost of labour (Being sunk cost)	0
Out-of-pocket expenses	<u>30</u>
	<u>110</u>

Allocated overhead is not relevant for the decision. The customer should be charged Rs. 110 per unit.

Question 14

What is Pareto Analysis? Name some applications.

(May 2008, 5 Marks)

Answer

Vilfredo Pareto, an Italian economist, observed that about 70 – 80% of value was represented by 30 – 20% of volume. This observation was found to exist in many business solutions.

Analysing and focusing on the 80% value relating to 20% volume helps business in the following areas.

- (i) Pricing of a product (in a multi-product company)
- (ii) Customer profitability.
- (iii) Stock control.
- (iv) Activity Based Costing (20% cost drivers are responsible for 80% of total cost)
- (v) Quality Control.

Question 15

State the general guidelines to be used in adopting a pricing policy in a manufacturing organization.

(Nov 2008, 3 Marks)

Answer

The general guidelines to be used in adopting a pricing policy are as under:

- (i) The pricing policy should encourage optimum utilization of resources.
- (ii) The pricing policy should work towards a better balance between demand and supply.
- (iii) The pricing policy should promote exports.
- (iv) The pricing policy should serve as an incentive to the manufacturers to maximize production by adopting improved technology.
- (v) The pricing policy should avoid adverse effects on the rest of the economy.

Question 16

Enumerate the uses of Pareto Analysis.

(Nov 2008, 3 Marks)

Answer

Pareto analysis is useful to:

Cost Management

- (i) Prioritize problems, goals and objectives.
- (ii) Identify the root causes.
- (iii) Select and define the key quality improvement programs, key employee relations improvement programs etc.
- (iv) Verify the operating procedures and manufacturing processes.
- (v) Allocate physical, financial and human resources effectively.
- (vi) Maximise research and product development time.

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

Cost Management

- (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		
$1,05,000 \times X = 23,49,000 + 25\% (1,05,000 \times X) = 78750 X = 23,49,000$ 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	12,000	600 × 1	600
	20		

Costing of Service Sector

Cottage ward	$50 \times 360 \times 80\%$	$14,400 \times 2.5$	36,000
Deluxe ward	$50 \times 360 \times 60\%$	$6,480 \times 5$	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.

$$\text{Rent} = 23,49,000 + 25\% \times (1,05,000 \times 1.08) + 0.08 \times (1,05,000 \times 1.08) = 1,05,000 \times 1.08$$

$$= 23,49,000 + 28350X + 8400X = 1,13,400X$$

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

Question 2

Discuss with examples, the basic costing methods to assign costs to services.

(May 2007, 5 Marks)

Answer

- (i) **Job costing method:** The cost of a particular service is obtained by assigning costs to a distinct identifiable service.
e.g. Job Costing method is used in service sectors – like Accounting Firm, Advertisement campaign.
- (ii) **Process Costing method:** Cost of a service is obtained by assigning costs to masses of similar unit and then computing cost / unit on an average basis.
e.g. Retail banking, postal delivery, credit card etc.
- (iii) **Hybrid method:** Combination of both (i) & (ii) above.

Question 3

A city health centre provides health and other related services to the citizens who are covered under insurance plan. The health centre receives a payment from the insurance company each time any patient attends the centre for consultation as under:

Cost Management

<i>Consultations involving</i>	<i>Payment from Insurance company</i>
	<i>Rs.</i>
<i>No treatment</i>	<i>60</i>
<i>Minor treatment</i>	<i>250</i>
<i>Major treatment</i>	<i>500</i>

In addition, the adult patients will have to make a co-payment which is equivalent to the amount of payment for the respective category of treatment made by the insurance company. However, children and senior citizens are not required to make any such co-payment.

The health centre will remain open for 6 days in a week for 52 weeks in a year. Each physician treated 20 patients per day although the maximum number of patients that could have been treated by a physician on any working day is 24 patients.

The health centre received a fixed income of Rs. 2,25,280 per annum for promotion of health products from the manufacturers.

The annual expenditure of the health centre is estimated as under:

<i>Materials and consumable (100% variable)</i>	<i>Rs. 22,32,000</i>
---	----------------------

Staff salaries per annum per employee (fixed):

<i>Physician</i>	<i>Rs. 4,50,000</i>
<i>Assistants</i>	<i>Rs. 1,50,000</i>
<i>Administrative staff</i>	<i>Rs. 90,000</i>
<i>Establishment and other operating costs (fixed)</i>	<i>Rs. 16,00,000</i>

The non-financial information is as under:

(i) Staff:

<i>Number of physicians employed</i>	<i>6</i>
<i>Assistants</i>	<i>7</i>
<i>Administrative staff</i>	<i>2</i>

(ii) Patient Mix:

<i>Adults</i>	<i>50%</i>
<i>Children</i>	<i>40%</i>
<i>Senior Citizens</i>	<i>10%</i>

(iii) Mix of patient appointments (%)

<i>Consultation requiring no treatment</i>	<i>70%</i>
<i>Minor treatment</i>	<i>20%</i>
<i>Major treatment</i>	<i>10%</i>

Costing of Service Sector

Required:

- (i) Calculate the Net income of the city health centre for the next year;
- (ii) Determine the percentage of maximum capacity required to be utilized next year in order to break even. (Nov 2008, 8 Marks)

Answer

1. (1) Total number of patients attended

Number of patients attended per day by a physician: 20

Number of physicians employed 6

Number of days in week 6

Number of weeks in a year 52

Total number of patients attended = $20 \times 6 \times 6 \times 52 = 37,440$.

- (2) Patient Mix:

Adults (50%) $37,440 \times 50/100 = 18,720$

Children (40%) $37,440 \times 40/100 = 14,976$

Senior Citizens (10%) $37,440 \times 10/100 = \underline{3,744}$

37,440

- (3) Patient Appointments:

No treatment required (70%) $37,440 \times 70/100 = 26,208$

Minor treatment (20%) $37,440 \times 20/100 = 7,488$

Major treatment (10%) $37,440 \times 10/100 = \underline{3,744}$

37,440

- (4) Income from Insurance Companies:

	<i>Number of patients</i>	<i>Rs.</i>	<i>Rs.</i>
	(A)	(B)	(A × B)
No treatment patients	26,208	60	15,72,480
Minor treatment patients	7,488	250	18,72,000
Major treatment patients	3,744	500	<u>18,72,000</u>
Total			<u>53,16,480</u>

Cost Management

(5) Co-payment from adult patients:

	<i>Number of patients</i>	<i>Payment (Rs.)</i>	<i>Total payment (Rs.)</i>
Total number of adult patients	18,720		
No treatment patients (70%)	13,104	60	7,86,240
Minor treatment (20%)	3,744	250	9,36,000
Major treatment (10%)	1,872	500	<u>9,36,000</u>
Total			<u>26,58,240</u>

(6) Net income:

	<i>Rs.</i>	<i>Rs.</i>
Payment from Insurance companies	53,16,480	
Co-payment from adult patients	<u>26,58,240</u>	
Total	79,74,720	
Other Income (fixed)	<u>2,25,280</u>	
Total Income (A)		82,00,000
Less: Expenditure		
Variable expenses:		
Material and consumables	22,32,000	
Fixed expenses:		
Physician's salary ($6 \times 4,50,000$)	27,00,000	
Assistants salary ($7 \times 1,50,000$)	10,50,000	
Administrative staff's salary ($2 \times 90,000$)	1,80,000	
Establishment and other operating costs	16,00,000	<u>55,30,000</u>
Total Expenditure (B)		<u>77,62,000</u>
Net Income (A – B)		<u>4,38,000</u>

(ii) 1. Contribution Analysis:

	<i>(Rs.)</i>
Total Fees from Insurance Companies and adult patients	79,74,720
Less: Variable costs	22,32,000

Costing of Service Sector

Contribution	57,42,720
Average contribution per patient	$\frac{57,42,720}{37,440} = 153.38$

2. Break-even patients:

	(Rs.)
Fixed costs	55,30,000
Less: Fixed income	2,25,280
Net Fixed costs	53,04,720
Break-even patients = $\frac{\text{Net fixed costs}}{\text{Contribution per patient}}$	$\frac{53,04,720}{153.38} = 34,585$

3. Percentage of maximum capacity required to be utilized in order to break-even

$$\text{Present utilization} = \frac{20 \text{ patients}}{24 \text{ patients}} = 83.33\% = 0.8333$$

$$100\% \text{ patient capacity is } \frac{37,440}{0.8333} = 44,930 \text{ patients}$$

$$\begin{aligned} \text{Percentage of maximum capacity required to be utilized in order to break-even} \\ &= \frac{\text{Break - even patients}}{100\% \text{ patient capacity}} \times 100 \\ &= \frac{34,585}{44,930} \times 100 = 76.98\% \text{ say } 77\%. \end{aligned}$$

Assumption: Patient mix and mix of patient appointments will be same in the next year.

Cost Management

NOTE

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Question 1

“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 heading different units. In other words, management of decentralized units is given autonomy with regard to decision-making. In this system top management is expected to preserve ‘autonomy in decision making’. The management of such companies also expects that each division should not only achieve its own objective – necessary for evaluating the performance but should also achieve the objective of goal congruence.

A divisional head in a company under aforesaid set up is free to use a price as a transfer price for goods and services, which may provide incentive. Such a transfer price may fail to achieve the objective of ‘Goal congruence’ (which means a perfect congruence between division’s goal and the goal of the company). In case of failure of a division to achieve the objective of ‘Goal congruence’ the management of the company may dictate their transfer price. Such a interference of management of the company is usually the main basis of conflict between a division and the company as a whole.

Further this conflict is aggravated if the management advocates the transfer of goods and services at cost. As such, the transfer price will not reflect a good picture about the performance of the transferring division. The profitability of the transferring division will not be known by the use of such a transfer price.

Each division appreciates the transfer of its goods/services at usual selling price/market price so as to arrive at the correct return / profitability figure, used for measuring the performance. There is no incentive to the transferring division if goods and services are transferred at variable cost.

Cost Management

Question 2

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 3

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?

Transfer Pricing

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	<u>Rs.130</u>	<u>Rs.100</u>	<u>Rs.90</u>	<u>Rs.85</u>
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

Cost Management

(ii) Statement of product mix (when total available hours in division Z are 30,000)

<i>Product (Refer to W.N.)</i>	<i>Maximum demand (units)</i>	<i>Hours per unit</i>	<i>Units produced</i>	<i>Hours used</i>	<i>Balance hours</i>
(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

<i>Transfer price</i>	<i>2,500 units of product D</i>	<i>Per unit of Product D</i>
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 × Rs.20)	35,333.20	14.13
Transfer price	2,47,833.20	99.13

Question 3

- What will be the marketable transfer pricing procedure regarding the goods transferred under the following conditions (each condition is independent of the other)?
 - 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.
 - If the external market for the transferred good is not reasonably competitive.
- Discuss the potential for maximization of income by a multinational through the use of transfer pricing mechanism.
- 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,

Transfer Pricing

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	
	Parts	Rs.20	Parts	Rs.10
Material				
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-chip 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:

- 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?
- 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)
- 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)

Cost Management

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:

	<i>Super-chips</i>	<i>Okay-chips</i>
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)

Transfer Pricing

2. Details of hours utilized in meeting 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 (15,000 units × 2 hours)	30,000
Hours utilized for manufacturing 40,000 units of Okay-chips (40,000 units × 0.5 hours)	<u>20,000</u>
	<u>50,000</u>

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 (Material + Labour costs)	300
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

Cost Management

- (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

$$= \text{Rs.}300 + 2 \text{ hours} \times \text{Rs.}80$$

$$= \text{Rs.}460$$

- (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 4

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 for the period are as under:

Harvesting division

Variable cost per kg of oil seed *Rs.2.50*

Transfer Pricing

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 cans of edible oil packed by the aforesaid divisions respectively during the period under review.

The other oil mills buy the oil seeds of same quality at 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)	

Cost Management

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) (500 cans × Rs.150)				75,000
Profit (Rs.) [(D) – (C)]				36,250

(ii) Working note:

$$\begin{aligned} \text{(a) Total Contribution} &= (\text{Sales revenue} - \text{total variable cost}) \\ &= \text{Rs.75,000} - \text{Rs.16,875} = \text{Rs.58,125} \end{aligned}$$

(b) Amount of shared contribution in relation to variable costs:

$$\text{Harvesting Division} = \text{Rs.58,125} \times \frac{\text{Rs.5,000}}{\text{Rs.16,875}} = \text{Rs.17,222}$$

$$\text{Oil Mill Division} = \text{Rs.58,125} \times \frac{\text{Rs.10,000}}{\text{Rs.16,875}} = \text{Rs.34,445}$$

$$\text{Marketing Division} = \text{Rs.58,125} \times \frac{\text{Rs.1,875}}{\text{Rs.16,875}} = \text{Rs.6,458}$$

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

$$= \text{Variable cost of Harvesting Division} + \text{Shared contribution of Harvesting Division in relation to variable costs}$$

$$= \text{Rs.5,000} + \text{Rs.17,222 (Refer to working note 2)} = \text{Rs.22,222}$$

Transfer price from Oil Mill Division to Marketing Division

$$= \text{Transfer price from Harvesting Division to Oil Mill Division} + \text{Variable cost of Oil Mill}$$

Division + Shared contribution of Oil Mill Division in relation to variable costs
(Refer to working note 2)

$$= \text{Rs.22,222} + \text{Rs.10,000} + \text{34,445}$$

$$= \text{Rs.66,667}$$

(2) Market price:

Transfer price from Harvesting Division to Oil Mill Division

Transfer Pricing

- = 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)

	<i>From Harvesting Division to Oil Mill Division</i>	<i>From Oil Mil to Marketing Division</i>	<i>From Marketing Division to market (500 cans of 2 Kgs.)</i>
	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

Cost Management

(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 5

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 in 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 loses control by delegating decision making to divisional managers. There are risks of mistakes committed by the divisional managers, which the top management, may avoid.
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 identify and define precisely suitable profit centres.
10. It confuses division's results with manager's performance.

Question 6

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:

<i>Sales per day (Unit)</i>	<i>Average price per unit of P (Rs.)</i>
5,000	393.75
10,000	298.50
15,000	247.50
20,000	208.50
25,000	180.00
30,000	150.75

Transfer Pricing

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	9,00,000	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

Cost Management

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	<u>(9,00,000)</u>
Operating profitability / (Loss) of the company	<u>(5,40,000)</u>
(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	<u>3,97,500</u>
Operating profitability of the company	<u>3,97,500</u>

(iii) Profitability of the company, if it is not organised on profit centre basis

No. of components	Sales revenue on average basis	Cost of component to division X	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	5,62,500	14,06,250	19,68,750	-
10,000	29,85,000	9,00,000	16,87,500	25,87,500	3,97,500
15,000	37,12,500	12,37,500	19,68,750	32,06,250	5,06,250
20,000	41,70,000	15,75,000	22,50,000	38,25,000	3,45,000
25,000	45,00,000	19,12,500	25,31,250	44,43,750	56,250
30,000	45,22,500	22,50,000	28,12,500	50,62,500	(5,40,000)

The level of output, the company will earn maximum profit, if the company is not organized on profit centre basis is 15,000 components.

Question 7

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.

Transfer Pricing

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 Rs.	Process house Rs.
Raw material (per metre) on 1 st 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

Cost Management

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)	14,00,000		
(1,50,000 × 6.0)	9,00,000		
	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 = Rs 4,00,500

(ii) Comments on the profitability of processing units:-

Transfer price (Rs) Profit (Rs)

Transfer Pricing

(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 8

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:

<i>Estimated selling price of final product</i>	<i>Rs. 3,000 p.u.</i>
<i>Long run average market price of sub-assembly</i>	<i>Rs. 2,000 p.u.</i>
<i>Incremental cost of completing sub-assembly in division B</i>	<i>Rs. 1,500 p.u.</i>
<i>Incremental cost in Division A</i>	<i>Rs. 1,200 p.u.</i>

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.

Cost Management

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 9

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 outside 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 outside 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

Transfer Pricing

Division Y contribution	1,68,750
Division X contribution	<u>Nil</u>
Total contribution	<u>1,68,750</u>

(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	<u>1,01,250</u>
Total contribution		<u>2,02,500</u>

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	<u>1,68,750</u>
Company's total contribution	<u>2,19,375</u>

(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

Cost Management

- (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 10

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 11

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?

Transfer Pricing

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

$$\text{Or } \frac{\text{Rs}85 + (\text{Rs}6,900 \times 11.5 + 600 \times 6.66)}{2,500} = \frac{\text{Rs}.85 + (79350 + 4000)}{2500}$$

$$= \text{Rs } (85 + 33.34) = \text{Rs } 118.34$$

Question 12

X Ltd. has two divisions, A and B, which manufacture products A and B respectively. A and B are profit centres with the respective Divisional Managers being given full responsibility and credit for their performance.

The following figures are presented:

	Division A Rs. Per Unit	Division B Rs. Per Unit	
Direct material cost	50	24*	*(other than A)
Material A, if transferred from Division A	—	144	
Material A, if purchased from outside	—	160	
Direct labour	25	14	
Variable production overhead	20	2	

Cost Management

Variable selling overhead	13	26
Selling price in outside market	160	300
Selling price to B	144	—
Selling price to S Ltd.	—	250

Other Information:

To make one unit of B, one unit of component A is needed. If transferred from A, B presently takes product A at Rs.144 per unit, with A not incurring variable selling overheads on units transferred to B.

Product A is available in the outside market at Rs. 160 per unit from competitors.

B can sell its product B in the external market at Rs. 300 per unit, whereas, if it supplied to X Ltd.'s subsidiary, S Ltd., it supplies at Rs. 250 per unit, and need not incur variable selling overhead on units transferred to S Ltd. S Ltd. requires 6,000 units and stipulates a condition that either all 6,000 units be taken from B or none at all.

	A(units)	B(units)	
Manufacturing capacity	20,000	28,000	
Demand in external market	18,000	26,000	
S Ltd.'s demand	—	6,000	or zero

Assume that Divisions A and B will have to operate during the year.

What is the best strategy for:

- Department A?
- Department B, given that A will use its best strategy?
- For X Ltd. As a whole?

(May 2008, 14 Marks)

Answer

	Div A	B	B
	Rs. / unit	Rs. / unit	Rs. / unit
Direct Material (Other than A)	50	24	
Direct Labour	25	14	
Variable Overhead (Production)	<u>20</u>	<u>2</u>	
Variable Production Cost (excl. A)	95	40	40
From A		144	
From Outside		—	<u>160</u>
Variable production Cost / unit		184	200
Selling Price			

Transfer Pricing

From outside	160	300	
Less: Selling Overhead	<u>13</u>	<u>26</u>	
Net Selling Price (outside)	<u>147</u>	<u>274</u>	
Net Selling Price to B	<u>144</u>		
Net Selling Price to S		<u>250</u>	
Net Selling Price (outside)	147	274	274
Variable Production Cost	<u>- 95</u>	<u>- 184</u>	<u>-200</u>
Contribution / unit (outside)	52	90	74
(Sale to B & S respectively)	144	250	250
Variable Production Cost	<u>-95</u>	<u>-184</u>	<u>-200</u>
Contribution / unit	<u>49</u>	<u>66</u>	<u>50</u>

Best strategy

A = Maximise Production; Sell maximum no. of units @ 52 / unit (outside)	$18,000 \times 52 = 9,36,000$
(To B) remaining units	$2,000 \times 49 = \underline{98,000}$
Total Contribution for A	<u>10,34,000</u>

Best strategy for B:

Maximise contribution / unit by selling outside and procuring from A 90 / unit

Contribution $\times$ 2,000 units

Balance units can yield contribution of either 74/ unit for outside or Rs. 50 / unit to S Ltd.

Production Capacity = 28,000.

<i>Option I</i>			<i>Option II</i>
Outside Sales	Sales to S		Outside Sales $\times$ contribution / unit
$20,000 \times 74 = 14,80,000$	$6,000 \times 50$	$= 3,00,000$	$24,000 \times 74 = 17,76,000$
$2,000 \times 90 = 1,80,000$			$2,000 \times 90 = 1,80,000$
16,60,000		3,00,000	
Total Contribution	(16,60,000 + 3,00,000) 19,60,000		19,56,000

(B) Choose Option I i.e. get 2,000 units from A, sell 6,000 units to S and 20,000 to outside. Make 28,000 units @ full capacity. Total Contribution Rs19,60,000.

If A and B are allowed to act independent of the group synergy,

Cost Management

			Rs.
Total contribution	A –	10,34,000	
	B –	<u>19,60,000</u>	
Total contribution for X Ltd.		<u>29,94,000</u>	
Cost from X Ltd.'s Perspective			
Variable Cost of production	Div A		Rs. 95
	Div B		
Variable cost of production other than A	40		40
A supplied by Division	95		
A – Variable Cost			
A purchased			<u>160</u>
	<u>135</u>		<u>200</u>
Option I	Outside 26,000 units	Option II	
Outside 20,000 × (274 – 135)	27,80,000	20,000 (274 – 135)	27,80,000
<u>2,000</u> × (274 – 200)	1,48,000	6,000 (274 – 200)	<u>4,44,000</u>
22,000			
S Ltd. 6,000 units (250 – 200)	<u>3,00,000</u>		
	<u>32,28,000</u>		<u>32,24,000</u>

Choose Option I

Contribution = Rs. 32,28,000 for X Ltd. as a whole

Transfer (2,000 units)

Make A transfer all output to B. Sell 6,000 units of B to S and 22,000 units to outside market. This will make X Ltd. better off by 32,28,000 – 29,94,000 = Rs 2,34,000

(i.e. 18,000 units of A sold to outside increases contribution to A by 3 Rs. / unit and decreases contribution to B by 16 Rs. / unit Net negative effect = 13 × 18,000 = Rs.2,34,000).

Question 13

A large business consultancy firm is organized in to several divisions. One of the divisions is the Information Technology (IT) division which provides consultancy services to its clients as well as to the other divisions of the firm. The consultants in the IT divisions always work in a team of three professional consultants on each day of consulting assignment. The external clients are charged a fee at the rate of Rs. 4,500 for each consulting day. The fee represents

Transfer Pricing

the cost plus 150% profit mark up. The break up of cost involved in the consultancy fee is estimated at 80% as being variable and the balance is fixed.

The textiles division of the consultancy firm which has undertaken a big assignment requires the services of two teams of IT consultants to work five days in a week for a period of 48 weeks. While the director of the textiles division intends to negotiate the transfer price for the consultancy work, the director of IT division proposes to charge the textiles division at Rs. 4,500 per consulting day.

In respect of the consulting work of the textiles division, IT division will be able to reduce the variable costs by Rs. 200 per consulting day. This is possible in all cases of internal consultations because of the use of specialized equipment.

You are required to explain the implications and set transfer prices per consulting day at which the IT division can provide consultancy services to the textiles division such that the profit of the business consultancy firm as a whole is maximized in each of the following scenarios:

- (i) Every team of the IT division is fully engaged during the 48 week period in providing consultancy services to external clients and that the IT division has no spare capacity of consultancy teams to take up the textiles division assignment.*
 - (ii) IT division will be able to spare only one team of consultants to provide services to the textiles division during the 48 week period and all other teams are fully engaged in providing services to external clients.*
 - (iii) A new external client has come forward to pay IT division a total fee of Rs. 15,84,000 for engaging the services of two teams of consultants during the aforesaid period of 48 weeks.*
- (Nov 2008, 11 Marks)*

Answer

Transfer Price is Rs. 4,500 for each consulting day.

Profit mark-up = 150%

Let cost = x

$$\text{Profit} = x \times \frac{150}{100}$$

$$= 1.5x$$

Cost + profit = Transfer price

$$\Rightarrow x + 1.5x = 4,500$$

$$\Rightarrow 2.5x = 4,500$$

$$\Rightarrow x = \frac{4,500}{2.5} = 1,800$$

$\therefore$ Cost = Rs. 1,800

Cost Management

$$\begin{aligned}\text{and profit} &= 1.5x = 1.5 \times 1,800 \\ &= \text{Rs. } 2,700\end{aligned}$$

$$\begin{aligned}\text{Variable cost (80\%)} &= \text{Rs. } 1,800 \times 80\% \\ &= \text{Rs. } 1,440\end{aligned}$$

$$\begin{aligned}\text{Fixed cost (20\%)} &= \text{Rs. } 1,800 \times 20\% \\ &= \text{Rs. } 360.\end{aligned}$$

Scenario (i):

Every consultancy team is fully engaged. There is no idle time or spare capacity.

Hence, transfer price = Marginal cost plus opportunity cost

$$\text{Marginal cost} = \text{Rs. } 1,440$$

$$\text{Saving for internal work} = \text{Rs. } 200$$

$$\text{Net Marginal Cost} = \text{Rs. } 1,240$$

Opportunity cost is the lost contribution.

Lost contribution = Contribution from external client

$$= \text{Fee charged from external client} - \text{Variable cost}$$

$$= \text{Rs. } (4,500 - 1,440)$$

$$= \text{Rs. } 3,060.$$

$$\therefore \text{Transfer price} = \text{Rs. } 1,240 + 3,060$$

$$= \text{Rs. } 4,300 \text{ per consulting day per team.}$$

Scenario (ii):

One team is idle. Idle time has no opportunity cost. Variable cost for internal work is Rs. 1,240 per consulting day. Second team is busy. Hence opportunity cost is relevant in case of second team. Hence charge of second team is Rs. 4,300 per consulting day per team.

$$\text{Average of charge of two teams} = \text{Rs. } (1,240 + 4,300) / 2$$

$$= \text{Rs. } 2,770 \text{ per consulting day per team.}$$

Scenario (iii):

New client offers a fee of Rs. 15,84,000

$$\text{Duration: } 5 \text{ days of } 48 \text{ weeks} \times 2 \text{ teams} = 480 \text{ days}$$

$$\text{Fee per day } 15,84,000 / 480 = \text{Rs. } 3,300$$

Transfer Pricing

Variable cost	= Rs. 1,440
Contribution Rs. (3,300 – 1,440)	= Rs. 1,860
Fee for consulting day for internal work:	
Variable cost	= Rs. 1,240
Contribution lost	= Rs. 1,860
Fee to be charged	= Rs. 3,100 per consulting day per team.

Cost Management

NOTE

This image shows a full page of blank white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page, providing a template for writing or drawing. There are no margins, text, or other markings on the page.

TARGET COSTING, LIFE CYCLE COSTING

Question 1

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)

Cost Management

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.

Target Costing Life Cycle Costing

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.

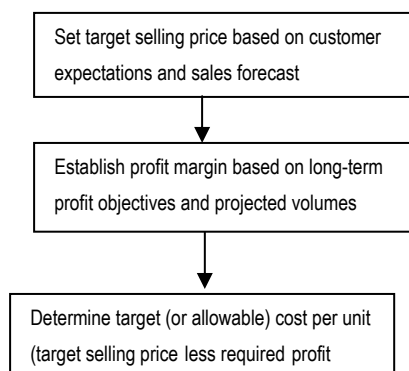
Total life-cycle costing approach accumulates product costs over the value chain. It is a process of managing all costs along the value chain starting from product's design, development, manufacturing, marketing, service and finally disposal.

Question 4

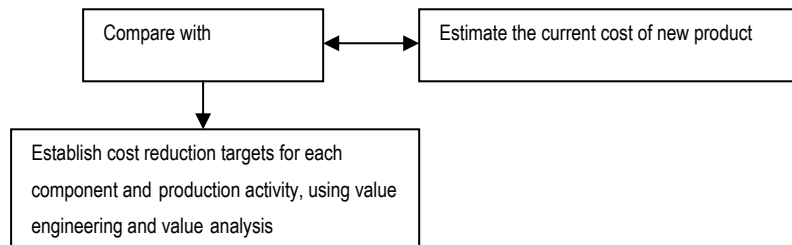
List the steps involved in target costing process with the help of a block diagram.

Answer

Target Costing Process



Cost Management



Question 5

What is product life cycle costing? What are the costs that you would include in product life cycle cost?
(May 2007, 4 Marks)

Answer

Product life cycle costing traces costs and revenues of each product over several calendar periods throughout their entire life cycle.

The costs are included in different stages of the product life cycle.

Development phase – R & D cost / Design cost.

Introduction phase – Promotional cost / Capacity costs.

Growth phase / Maturity – Manufacturing cost / Distribution costs / Product support cost.

Decline / Replacement phase – Plants reused / sold / scrapped / related costs.

Question 6

What is Target Costing? It is said that implementation of the target costing technique requires intensive marketing research. Explain why intensive marketing research is required to implement target costing technique.
(Nov 2007, 9 Marks)

Answer

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

Target Costing Life Cycle Costing

Question 7

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

(Nov 2008, 4 Marks)

Answer

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

- (i) Target costing considers the price that ought to be charged by a company to achieve a given market share.
- (ii) Target costing should take life cycle costs in to consideration.
- (iii) If there is a gap between the target cost and expected cost, ways and means of reducing or eliminating it can be explored.
- (iv) The target cost may be used for controlling costs by comparison.

Cost Management

NOTE

[illegible]

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 back 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 relieve 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.

Cost Management

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 from 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 (13,000 × 140)	18,20,260 (13,000 × 140.02)
Ordering cost	26.00(2×13 orders)	260.00(2×130 orders)
Opportunity carrying cost	10,500.00 (1/2×1000×140×15%)	1,050.15 (1/2×100×140.02×15%)
Other carrying cost (Insurance,	1,550.00(1/2×1000×3.10)	155.00

JIT, MRP & ERP

material handling etc)

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 (13,000×13.60)
Ordering Cost	260.00 (2×130 orders)
Opportunity Carrying Cost	102.00
Cost	(1/2×100×13.60× 15%)
Other Carrying Cost	150.00 (1/2×100×3.00)
Stock out Cost	2,880 (8×360)
Inspection Cost	650.00 (13,000 × .05)
Customer Return Cost	6,500.00 (13,000 × 2% × 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

Cost Management

(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.

Question 4

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

(May 2007, 4 Marks)

Answer

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

- (i) Immediate detection of defective goods being manufactured so that early correction is ensured with least scrapping.
- (ii) Eliminates/reduces WIP between machines within working cell.
- (iii) OH costs in the form of rentals for inventory, insurance, maintenance costs etc. are reduced.
- (iv) Higher product quality ensured by the JIT approach leads to higher premium in the selling price.
- (v) Detection of problem areas due to better pdn/scrap reporting/labour tracing and inventory accuracy lead to reduction in costs by improvement.

Question 5

Explain the main features on 'Enterprise Resource Planning.'

(Nov 2007, 4 Marks)

Answer

Some of the major features of "Enterprise Resource Planning" (ERP) areas follows :

- (i) ERP facilitates company-wide integrated information system covering all functional areas like manufacturing, selling and distribution, payables, receivables, inventory etc.
- (ii) It performs core activities and increases customer services thereby augmenting the corporate image.
- (iii) ERP bridges the information gap across organization.
- (iv) ERP provides complete integration of systems.
- (v) It is a solution for better project management.

JIT, MRP & ERP

- (vi) It allows automatic induction of latest technologies like electronic fund transfer (EFT), Electronic Data Interchange (EDI), Internet, Intranet, Video Conferencing, E-commerce etc.
- (vii) ERP eliminates most business problems like material shortage, productivity enhancements, customer service, cash management etc.
- (viii) It provides business intelligence tools.

Question 6

Explain, how the implementation of JIT approach to manufacturing can be a major source of competitive advantage.
(Nov 2008, 4 Marks)

Answer

JIT provides competitive advantage in the following ways:

- (i) Stocks of raw materials and finished goods are eliminated, stock holding costs are avoided.
- (ii) JIT aims at elimination of non-value added activities and elimination of cost in this direction will improve competitive advantage.
- (iii) It affords flexibility to customer requirements where the company can manufacture customized products and the competitive advantage is thereby improved.
- (iv) It focuses the direction of performance based production of high quality product.
- (v) It minimize waiting times and transportation costs.

Cost Management

NOTE

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ACTIVITY BASED COST MANAGEMENT

Question 1

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 2

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

Cost Management

- (v) Plant closed down decisions
- (vi) Evaluation of offshore production
- (vii) Capital Investment decisions
- (viii) Product line profitability.

Question 3

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	<u>19.80</u>
	<u>200.00</u>

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

Activity Based Management

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)

Cost Management

Answer

(i) Comparison of manufacturing cost per unit.

	<i>Audio Player Model</i>	
	<i>'AB 100'</i>	<i>'AB 200'</i>
	<i>Rs.</i>	<i>Rs.</i>
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	<u>198.00</u>	<u>198.00</u>
Total manufacturing cost per unit	<u>2,000.00</u>	<u>1,614.25</u>

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.

Activity Based Management

(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	<u>7.50</u>
(5% × 10,000 units × Rs.1,500)	<u>29.50</u>
Net effect on operating income	<u>(10.50)</u>

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 4

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

Cost Management

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:

- Calculate the total cost of each product, if all overhead costs are absorbed on machine hour rate basis.
- Calculate the total cost of each product using activity base costing.
- 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.

Activity Based Management

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

(b) Activity based costing system

	<i>Set up</i>	<i>Store receiving</i>	<i>Inspection</i>
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

<i>Cost</i>	<i>Rs</i>	<i>Drivers</i>	<i>No</i>	<i>Cost per unit of driver (Rs)</i>
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.

	<i>A (Rs)</i>	<i>B(Rs)</i>	<i>C(Rs)</i>	<i>D(Rs)</i>
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)

	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
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

Cost Management

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 5

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.)*

Activity Based Management

- (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 = $\frac{\text{Rs } 3,10,000}{2,000} = \text{Rs } 155$ 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.

Cost Management

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)

	<i>Receiving supplies</i>	<i>Set ups</i>	<i>Quality inspection</i>	<i>Despatch</i>	<i>Total</i>
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 inspections		34.00	25.50		59.50
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

Activity Based Management

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

	<i>R (Rs)</i>	<i>S(Rs)</i>	<i>T(Rs)</i>
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 6

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 7

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

Cost Management

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 8

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. 100.05 per 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

Activity Based Management

Indirect Costs:

Machine set up cost	462
Testing cost	2,375
Engineering cost	<u>2,250</u>
	<u>16,037</u>

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:

- 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.
- What is the Mark-up on full cost per unit of P?

Cost Management

- (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×d) (hours)	3,000	3,600
(f)	Machine set up cost (Rs.)		4,62,000
(g)	Cost driver per machine set up hour $\frac{4,62,000}{6,600} = \text{Rs. } 70$		
(h)	Testing time per unit	5 hours	9 hours
(i)	Total testing time (a×h) (hours)	5,00,000	4,50,000
(j)	Testing cost Rs. 23,75,000		
(k)	Cost driver per testing hour $\frac{23,75,000}{9,50,000} = \text{Rs. } 2.50$		

(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

Activity Based Management

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 $\times$ 28 hours $\times$ Rs. 70	1.96	1,96,000
Testing cost	1,00,000 units $\times$ Rs. 2.5 $\times$ 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.

Cost Management

- ◆ 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 9

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 10

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

Give examples of Value-added and Non-value-added activities.

Activity Based Management

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 11

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

- (i) Unit level activities*
- (ii) Batch level activities*
- (iii) Product level activities*
- (iv) Facility level activities.*

Answer

Examples:

- | | |
|-----------------------------|--|
| (i) Unit level activities | (i) Use of indirect materials |
| | (ii) Inspection or testing of every item produced or say every 100 th 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 |

Cost Management

- (ii) Plant security
- (iii) Production manager's salaries
- (iv) Advertising campaigns promoting the company

Question 12

"Cost can be managed only at the point of commitment and not at the point of incidence. Therefore, it is necessary to manage cost drivers to manage cost." Explain the statement with reference to structural and executional cost drivers. (Nov 2007, 5 Marks)

Answer

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

Question 13

What is the fundamental difference between Activity Based Costing System (ABC) and Traditional Costing System? Why more and more organisations in both the manufacturing and non-manufacturing industries are adopting ABC? (Nov 2007, 10 Marks)

Answer

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

Activity Based Management

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

- (i) Fierce competitive pressure has resulted in shrinking profit margin. ABC helps to estimate cost of individual product or service more accurately. This helps to formulate appropriate marketing / corporate strategy.
- (ii) There is product and customer proliferation. Demand on resources by products / customers differ among product / customers. Therefore, product / customer profitability can be measured reasonably accurately, only if consumption of resources can be traced to each individual product / customer.
- (iii) New production techniques have resulted in the increase of the proportion of support service costs in the total cost of delivering value to customers. ABC improves the accuracy of accounting for support service costs.
- (iv) The costs associated with bad decisions have increased substantially.
- (v) Reduction in the cost of data processing has reduced the cost of tracking resources consumption to large number of activities.

Question 14

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

<i>Inspection cost</i>	<i>Rs. p.m.</i>	<i>73,000</i>
<i>Machine – Repairs & Maintenance</i>	<i>Rs. p.m.</i>	<i>1,42,000</i>
<i>Dye cost</i>	<i>Rs. p.m.</i>	<i>10,250</i>
<i>Selling overheads</i>	<i>Rs. p.m.</i>	<i>1,62,000</i>

	<i>Product A</i>	<i>B</i>	<i>C</i>
<i>Prime cost (Rs. per unit)</i>	<i>12</i>	<i>9</i>	<i>8</i>
<i>Selling price (Rs. per unit)</i>	<i>18</i>	<i>14</i>	<i>12</i>
<i>Gross production (units/production run)</i>	<i>2,520</i>	<i>2,810</i>	<i>3,010</i>
<i>No. of defective units / production run</i>	<i>20</i>	<i>10</i>	<i>10</i>
<i>Inspection:</i>			<i>C</i>
<i>No. of hours / production run</i>	<i>3</i>	<i>4</i>	<i>4</i>
<i>Dye cost / production run (Rs.)</i>	<i>200</i>	<i>300</i>	<i>250</i>
<i>No. of machine hours / production run</i>	<i>20</i>	<i>12</i>	<i>30</i>
<i>Sales – No. of units / month</i>	<i>25,000</i>	<i>56,000</i>	<i>27,000</i>

The following additional information is given:

Cost Management

- (i) No accumulation of inventory is considered. All good units produced are sold.
- (ii) All manufacturing and selling overheads are conventionally allocated on the basis of units sold.
- (iii) Product A needs no advertisement. Due to its nutritive value, it is readily consumed by diabetic patients of a hospital. Advertisement costs included in the total selling overhead is Rs. 83,000.
- (iv) Product B needs to be specially packed before being sold, so that it meets competition. Rs. 54,000 was the amount spent for the month in specially packing B, and this has been included in the total selling overhead cost given.

You are required to present productwise profitability of statements under the conventional system and the ABC system and accordingly rank the products. (May 2008, 11 Marks)

Answer

Sales	A	B	C	Total
(i) Units Rs.	25,000	56,000	27,000	1,08,000
Selling price/unit	18	14	12	
(ii) Sales Value (Rs.)	4,50,000	7,84,000	3,24,000	15,58,000
(iii) Prime Cost Overhead	12	9	8	
(iv) No. of units/run	2,520	2,810	3,010	
(v) Prime Cost Rs.	3,02,400	5,05,800	2,16,720	
(vi) Gross Margin (ii – v)	1,47,600	2,78,200	1,07,280	5,33,080

	Total	A	B	C
Inspection Cost				
$\left(\frac{7,3000}{146} \times 30/80/36 \text{ respectively} \right)$	73,000	15,000	40,000	18,000
Machine Maintenance				
$\left(\frac{1,42,000}{710} \times 200/240/270 \text{ respectively} \right)$	1,42,000	40,000	48,000	54,000
Dye Cost	<u>10,250</u>	<u>2,000</u>	<u>6,000</u>	<u>2,250</u>
Sub Total	<u>2,25,250</u>	<u>57,000</u>	<u>94,000</u>	<u>74,250</u>

Selling Overhead Advertisement				
$\left(\frac{83,000}{56,000 + 27,000} \times 56/27 \text{ respectively} \right)$	83,000	—	56,000	27,000

Activity Based Management

Other Overheads

$\left(\frac{25,000}{108} \times 25/56/27 \text{ respectively} \right)$	25,000	5,787	12,963	6,250
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Packing

			<u>54,000</u>	
Sub Total Selling Overhead	<u>1,62,000</u>	<u>5,787</u>	<u>1,22,963</u>	<u>33,250</u>

Workings:

	A	B	C	Total
Gross Production/unit /run (1)	2,520	2,810	3,010	
Defectives/run (2)	20	10	10	
Good units / run (3)	2,500	2,800	3,000	
Sales (Goods units)(4)	25,000	56,000	27,000	
No. of runs (5)	10	20	9	
Gross Production (6) = (1) × (5)	25,200	56,200	27,090	
Prime Cost / unit (7)	12	9	8	
Prime Cost (8) Rs.	3,02,400	5,05,800	2,16,720	10,24,920
Inspection hours/run (9)	3	4	4	
Inspection hours (10) = (9) × (5)	30	80	36	146
M/c hours / run (11)	20	12	30	
M/c hours (12) = (1) × (5)	200	240	270	710
Dye Cost/run (13)	200	300	250	
Dye cost (14) (13) × (5)	2,000	6,000	2,250	10,250

Conventional Accounting System

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

Cost Management

Activity Based System

	A	B	C
Sales – units /	25,000	56,000	27,000
Production (good units)			
Gross Margin (Rs.)	1,47,600	2,78,200	1,07,280
Production overheads (Rs.)	57,000	94,000	74,250
Selling Overhead (Rs.)	5,787	1,22,963	33,250
Sub-Total Overhead (Rs.)	62,787	2,16,963	1,07,500
Net profit (Rs.)	84,813	61,237	(220)
Ranking	I	II	III

Question 15

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

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

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

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

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

The total production overheads are analysed as under:

Machine set up costs	20%
Machine operation costs	30%
Inspection costs	40%
Material procurement related costs	10%

Activity Based Management

Required:

- (i) Calculate the cost per unit of each product using traditional method of absorbing all production overheads on the basis of machine hours.
- (ii) Calculate the cost per unit of each product using activity based costing principles.

(Nov 2008, 7 Marks)

Answer

- (i) Cost per unit using traditional method of absorbing all production overheads on the basis of machine hours:

Products	P	Q	R
	Rs.	Rs.	Rs.
Direct materials	90	80	120
Direct labour (4:12:8 hours) × Rs. 20	80	240	160
Production Overheads (10:18:14 hours) × Rs. 6	<u>60</u>	<u>108</u>	<u>84</u>
Cost per unit	<u>230</u>	<u>428</u>	<u>364</u>

- (ii) 1. Cost per unit of each product using activity based costing:

Products	P	Q	R	Total
A. Production (units)	3,000	5,000	20,000	
B. Batch size (units)	150	500	1000	
C. Number of batches [A ÷ B]	20	10	20	50
D. Number of purchase order per batch	3	10	8	
E. Total purchase orders [C × D]	60	100	160	320
F. Number of inspections per batch	5	4	3	
G. Total inspections [C × F]	100	40	60	200

2. Total Production overhead

A. Machine hours per unit	10	18	14	
B. Production units	3,000	5,000	20,000	
C. Total machine hours [A × B]	30,000	90,000	2,80,000	
Total machine hours	= 4,00,000			
Total production overheads	= 4,00,000 × Rs. 6 = Rs. 24,00,000.			

3. Cost driver rates:

Cost Pool	%	Overheads Rs.	Cost Driver Units	Cost Driver Rate Rs.
Set up	20%	4,80,000	50	9,600 per set up
Inspection	40%	9,60,000	200	4,800 per inspection

Cost Management

Purchases	10%	2,40,000	320	750 per purchase
Machine hours	30%	7,20,000	4,00,000	1.80 per Machine Hour

4. Cost per unit of P, Q and R:

Products	P	Q	R
Production (units)	3,000	5,000	20,000
	Rs.	Rs.	Rs.
Direct Materials (90:80:120)	2,70,000	4,00,000	24,00,000
Direct Labour (80:240:160)	2,40,000	12,00,000	32,00,000
Overheads:			
Machine related costs @ Rs. 1.80/hour (30,000:90,000:2,80,000)	54,000	1,62,000	5,04,000
Set-up costs @ Rs. 9600 / set up (20 : 10 : 20)	1,92,000	96,000	1,92,000
Inspection costs @ Rs. 4800 / inspection (100 :40 : 60)	4,80,000	1,92,000	2,88,000
Purchase related costs @ Rs. 750 / purchase (60 : 100 : 160)	45,000	75,000	1,20,000
Total costs	12,81,000	21,25,000	67,04,000
Cost per unit (Total cost ÷ units)	427.00	425.00	335.20

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.

Cost Management

Question 2

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

<i>Direct Materials X</i>	<i>:</i>	<i>8 sq. metre at Rs 40 per square metre</i>
<i>Machine Time</i>	<i>:</i>	<i>0.6 Running hours</i>
<i>Machine cost per gross hour</i>	<i>:</i>	<i>Rs. 400</i>
<i>Selling price</i>	<i>:</i>	<i>Rs. 1,000</i>

Carlton 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.

Carlton 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.

<i>Before the implementation of QMP</i>	<i>After the implementation</i>
<i>1. 5% of incoming material from suppliers scrapped due to poor receipt and storage organisation.</i>	<i>1. Reduced to 3%.</i>
<i>2. 4% of material X input to the machine process is wasted due to processing problems.</i>	<i>2. Reduced to 2.5%</i>
<i>3. Inspection and storage of Material X costs Re. 1 per square metre purchased.</i>	<i>3. No change in the unit rate</i>
<i>4. Inspection during the production cycle, calibration checks on inspection equipment vendor rating and other checks cost Rs. 2,50,000 per period</i>	<i>4. Reduction of 40% of the existing cost.</i>
<i>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.</i>	<i>5. Reduction to 7.5%</i>
<i>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.</i>	<i>6. Reduction to 2.5%</i>
<i>7. Product liability and other claims by customers is estimated at 3% of sales revenue from standard product sale.</i>	<i>7. Reduction to 1%.</i>

Total Quality Management

- | | |
|--|--|
| <p>8. Machine idle time is 20% of Gross machine hrs used (i.e. running hour = 80% of gross/hrs.).</p> <p>9. Sundry costs of Administration, Selling and Distribution total – Rs. 6,00,000 per period.</p> <p>10. Prevention programme costs Rs. 2,00,000</p> | <p>8. Reduction to 12.5%.</p> <p>9. Reduction by 10% of the existing.</p> <p>10. Increase to Rs. 6,00,000.</p> |
|--|--|

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	750		416
$\frac{12.5}{87.5} \times 5,250$		$\frac{7.5}{92.5} \times 5,125$	
Total units before inspection	6,000		5,541
ii Purchase of material 'X'(Sq Mtr)			
Material required to meet pre inspection production requirement $6,000 \times 8$ SqMtr	48,000 SqMtr	$5,541 \times 8$ SqMtr	44,328 SqMtr
Processing loss $\frac{4}{96} \times 48,000$	2,000	$\frac{2.5}{97.5} \times 44,328$	1,137

Cost Management

Input to the process	50,000		45,465
Scrapped material $\frac{5}{95} \times 50,000$	2,632		1,406
		$\frac{3}{97} \times 45,465$	
Total purchases	52,632		46,871
iii Gross Machine Hours			
Initial requirements $6,000 \times 0.6$	3,600	$5,541 \times 0.5$	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 $\times$ Rs 1,000	50,00,000		50,00,000
Sales downgraded 750 Units $\times$ Rs 700	5,25,000	416 Units $\times$ Rs 700	2,91,200
	55,25,000		52,91,200
Costs:			
Material 52,632 Sq Mtr $\times$ Rs 40	21,05,280	46,871 Sq Mtr $\times$ Rs 40	18,74,840
Inspection and storage costs 52,632 Sq Mtr $\times$ Re 1	52,632	46,871 Sq Mtr $\times$ Re 1	46,871
Machine cost 4,500 Hrs $\times$ Rs 400	18,00,000	3,167 Hrs $\times$ Rs 400	12,66,800
Inspection and other cost	2,50,000	$2,50,000 \times 60\%$	1,50,000
Product liability ($3\% \times 50,00,000$)	1,50,000	$1\% \times 50,00,000$	50,000
Sundry cost of selling, distribution and administration.	6,00,000	$6,00,000 \times 90\%$	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

Total Quality Management

Question 3

What are the essential requirements for successful implementation of TQM?

(May 2007, 6 Marks)

Answer

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

Culture: Proper training must be given to effect changes in culture and attitude.

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

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

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

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

Question 4

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

(Nov 2008, 4 Marks)

Answer

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

- (i) There will be increased awareness of quality culture in the organization.
- (ii) It will lead to commitment to continuous improvement.
- (iii) It will focus on customer satisfaction.
- (iv) A greater emphasis on team work will be achieved.

Cost Management

NOTE

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

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 propositions 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?

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.

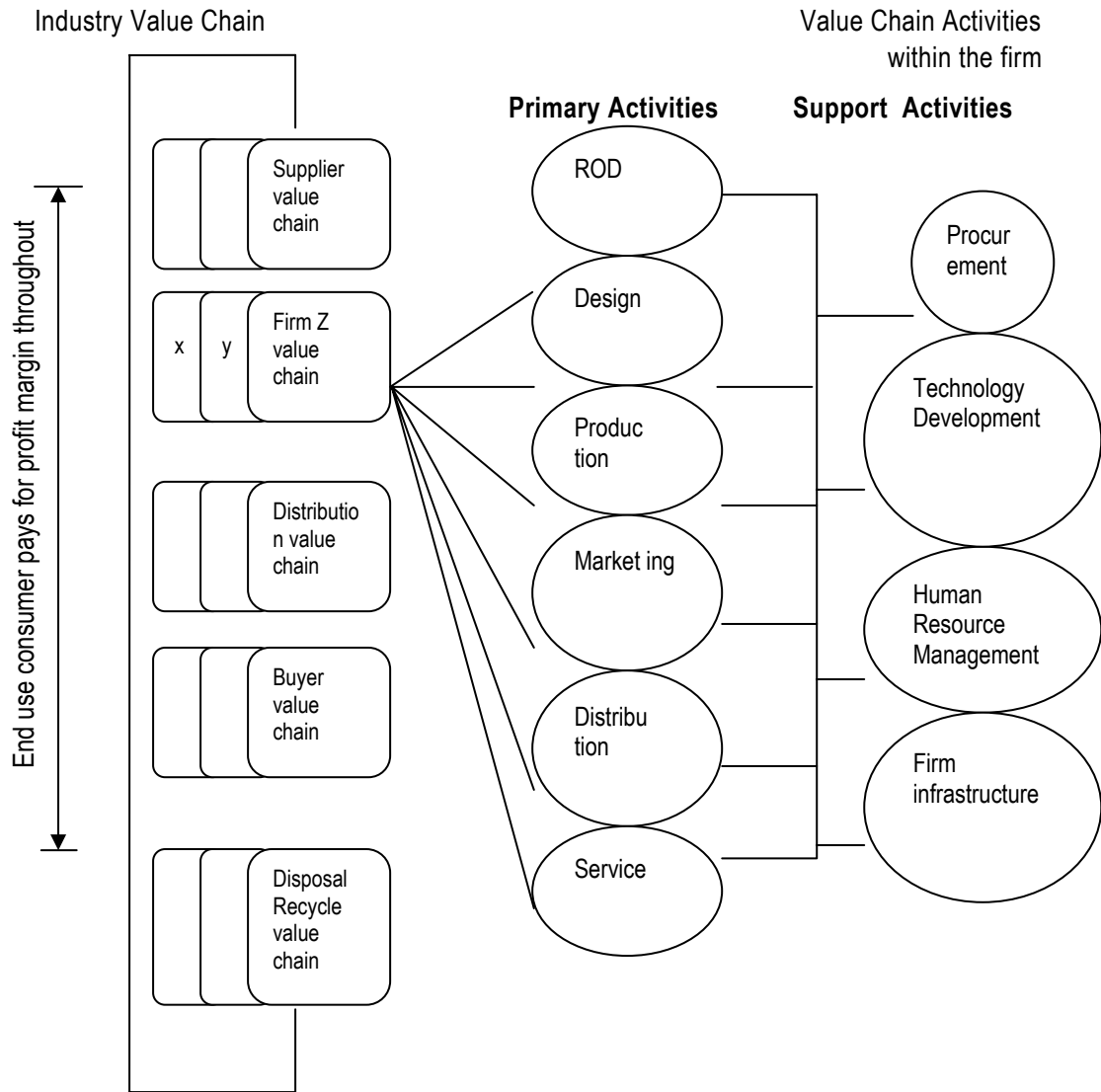
By analyzing costs, revenues and assets in each activity systematically a company can achieve low cost. Thus value chain helps managers in deciding how to apply the organization's valuable physical and human resources to each linked process so as to achieve cost effectiveness.

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.

Value Chain Analysis

Answer



Cost Management

NOTE

[illegible]

BUDGETING CONTROL AND PERFORMANCE MANAGEMENT

Question 1

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 made to maintain the same level of profit by suitably increasing the selling price.

The Vice President-Marketing states that the market will not absorb any increase in the selling price. On the other hand, he proposes that publicity involving 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.

Cost Management

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	<u>68</u>	<u>67.70</u>

3. Contribution per unit during 1999-2000

$$= \text{Selling price per unit} - \text{Variable cost p.u.}$$

$$= \text{Rs.125} - \text{Rs.67.70} = \text{Rs.57.30}$$

4. Profit in 1998-1999

$$\text{Contribution per unit} = \text{S. P. (p. u.)} - \text{V. C. (p. u.)}$$

$$= \text{Rs.125} - \text{Rs.68} = \text{Rs.57 p. u.}$$

$$\text{Total contribution} = \text{Rs.11,40,000}$$

$$(20,000 \text{ units} \times \text{Rs.57/- p.u.})$$

$$\text{Less: Fixed expenses} = 6,75,000$$

$$\text{Profit} = 4,65,000$$

Budgeting Control and Performance Management

(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: $\frac{\text{Rs.130.95} - \text{Rs.125}}{\text{Rs.125}} \times 100 = 4.76\%$

(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)

Cost Management

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		<u>16,24,800</u>
Contribution		13,75,2000
Less: Advertisement expenses	Rs.1,94,000	
Fixed expenses	<u>Rs.8,00,000</u>	<u>9,94,000</u>
Profit		<u>3,81,200</u>

Question 2

- (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.

Budgeting Control and Performance Management

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 scarce 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

Benchmarking 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 benchmarking, 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

Cost Management

(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

	<i>Products A (units)</i>	<i>Products B (units)</i>	<i>Total material usage units</i>	<i>Cost per unit (Rs)</i>	<i>Total cost of materials (Rs)</i>
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

	<i>X Units</i>	<i>Y Units</i>	<i>Total</i>
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	25,000		
3,000 units (B) × 5 units (X) = 15,000 units of X.			

Budgeting Control and Performance Management

Product B:		9,000
1,000 units (A) × 3 units (Y) = 3,000 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	16,400
1,680 units (B) × 5 units (X) = 8,400 units of X	

Product B	
800 units (A) × 3 units (Y) = 2,400 units of Y	5,760
1,680 units (B) × 2 units (Y) = 3,360 units of Y.	

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

	<i>Product A</i>	<i>Product B</i>
	<i>Units</i>	<i>Units</i>
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.

$$\text{Product A} = \frac{5,000 \times 12}{60} = 1,000 \text{ units}$$

$$\text{Product B} = \frac{10,000 \times 18}{60} = 3,000 \text{ units}$$

Cost Management

(iii) Wages budget for direct workers

	Product A (hrs)	Product B (hrs)	Total (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 3

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

	Product X	Product Y	Standard hours produced 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 × 8 hours × 22 days = 17,600

Budgeted hours per month

1,86,000/12 = 15,500

$$\text{Capacity Ratio} = \frac{\text{actual hours}}{\text{Budgeted hours}} \times 100 = \frac{17,600}{15,500} = 113.55 \%$$

Budgeting Control and Performance Management

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

$$\text{Activity Ratio} = \frac{\text{Standard Hours Produced}}{\text{Budget hours}} \times 100 = \frac{19,200}{15,500} \times 100 = 123.87\%$$

Relationship : Activity Ratio = Efficiency Ratio $\times$ Capacity Ratio

$$\text{or} \quad 123.87 = \frac{109.09 \times 113.55}{100}$$

Question 4

“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 from business to business. A well designed balanced scorecard combines financial measures of past 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.

Cost Management

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 measures are:- employee education & skills levels, employee turnover ratio, information system availability, percentage of employee suggestion implemented etc.

Question 5

"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 actual performance with an adjusted budget to reflect the circumstance under which managers actually operated.

Question 6

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 of 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

Budgeting Control and Performance Management

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:

	<i>(Amount in 000 Rs.)</i>	
	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}

Cost Management

$$= \text{Rs}1,000 (42,000 \text{ units} - 40,000 \text{ units}) = \text{Rs}20,00,000 \text{ (F)}$$

- (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}

$$(i) \text{ Direct Material} = \text{Rs}100 [1,20,000\text{sqft} - 1,20,000\text{sqft} \times \frac{42,000 \text{ units}}{40,000 \text{ units}}]$$

$$= \text{Rs}6,00,000 \text{ (A)}$$

- (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

$$\text{Conversion cost} = 200(50000 - 50000) = 0$$

$$\text{S \& Customer Service} = 25000 (300 - 300) = 0$$

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]

$$= 42,000\text{units} (\text{Rs}1,100 - \text{Rs}1,000) = \text{Rs}42,00,000 \text{ (F)}$$

- (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}

$$(a) \text{ Direct material} = 1,26,000\text{sqft} (\text{Rs}100/\text{sqft} - \text{Rs}110/\text{sqft}) = \text{Rs}12,60,000 \text{ (A)}$$

$$(b) \text{ Conversion Cost} = 50,000 \text{ units} (\text{Rs}200/\text{unit} - \text{Rs}220/\text{unit}) \\ = \text{Rs}10,00,000 \text{ (A)}$$

$$(c) \text{ S \& Custr Service} = 300 \text{ customers} (\text{Rs}24,000 - \text{Rs}25,000) \\ = \text{Rs}3,00,000 \text{ (A)} = \text{Rs}25,60,000 \text{ (A)}$$

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}

$$(i) \text{ Direct Material: Rs}110/\text{sqft} (1,26,000 \text{ units} - 1,23,000 \text{ units}) = \text{Rs}3,30,000 \text{ (F)}$$

$$(ii) \text{ Conversion Cost: Rs}200/\text{unit} (50,000 \text{ units} - 50,000 \text{ units}) = 0$$

$$(iii) \text{ Selling \& Customer} = \text{Rs}25,000 (300 \text{ customers} - 290 \text{ customers}) = \text{Rs}2,50,000 \text{ (F)} \\ = \text{Rs}5,80,000 \text{ (F)}$$

Budgeting Control and Performance Management

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 7

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 8

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:

Cost Management

	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:

- Prepare a Budget of production and requirements of components during next year.
- 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

Budgeting Control and Performance Management

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
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(b) The company is advised to adopt EOQ system.

P	Q
$EOQ \sqrt{\frac{2 \times 3,00,000 \times 1,500}{20 \times 20\%}}$	$\sqrt{\frac{2 \times 4,80,000 \times 1,500}{8 \times 20\%}}$
= 15,000 components	= 30,000 components

Question 9

Explain briefly the major components of a balanced score card. (May 2007, 4 Marks)

Answer

An ideal Balanced score card combines financial measures of past performance with measures of the firm's drivers of future performance. The following perspectives are evaluated:

- (i) Customer perspective – Measures of price / delivery / quality / support.
- (ii) Internal perspective – Measures of efficiency / sales penetration and new product introduction.
- (iii) Innovation and learning perspective – Measures of technology / cost leadership.
- (iv) Financial perspective – Sales / Cost of sales / Return on capital employed etc.

Question 10

Describe the process of zero-base budgeting. (May 2007, 4 Marks)

Answer

The zero Base Budgeting involves the following steps:

- (i) Corporate objectives should be established and laid down in details.
- (ii) Decide about the techniques of ZBB to be applied.
- (iii) Identify those areas where decisions are required to be taken.
- (iv) Develop decision programmes and rank them in order of preferences.
- (v) Preparation of budget, that is translating decision packages into practicable units/items and allocating financial resources.

Question 11

“In many organisations, initiatives to introduce balanced score card failed because efforts were made to negotiate targets rather than to build consensus.”

Cost Management

Required:

Elucidate the above statement.

(Nov 2007, 8 Marks)

Answer

Balanced score card is a set of financial and non-financial measures relating to a company's critical success factors. It is an approach which provides information to management to assist in strategy implementation. Therefore, the components to be included in the balanced score card must flow from strategy. The targets should be measurable and must flow from strategy and corporate plan of the company. It is necessary that managers should agree to the components and targets because in absence of a consensus, managers may not commit to the targets established by the top management / the board of directors. Moreover, the functions are interdependent and results in one functional area/perspective (e.g. innovation and learning) have direct bearing on the results in other functional area / perspective (e.g. customer perspective). Therefore, it is not sufficient that individual managers agree to their targets. Successful implementation requires that the top management builds an overall consensus on the components and targets of the balanced score card. Negotiation undermines the fundamental principle that the components and targets should flow from strategy. As a result, an approach to establish targets through negotiation defeats the very purpose of balanced score card.

Question 12

What do you mean by a flexible budget? Give an example of an industry where this type of budget is typically needed?

(May 2008, 2 Marks)

Answer

A flexible budget is a budget which, by recognizing the difference between fixed, semi-variable and variable costs, is designed to change in relation to the level of activity attained.

E.g. seasonal products – e.g. soft drink industry

industries in make to order business like ship building

industries influenced by change in fashion.

Industries which keep on introducing new products / new designs.

Question 13

Describe the four types of bench marking of critical success factors.

(Nov 2008, 4 Marks)

Budgeting Control and Performance Management

Answer

The Benchmarking is of following types:

- (i) **Competitive benchmarking:** It involves the comparison of competitors products, processes and business results with own.
- (ii) **Strategic benchmarking:** It is similar to the process benchmarking in nature but differs in its scope and depth.
- (iii) **Global benchmarking:** It is a benchmarking through which distinction in international culture, business processes and trade practices across companies are bridged and their ramification for business process improvement are understood and utilized.
- (iv) **Process benchmarking:** It involves the comparison of an organisation critical business processes and operations against best practice organization that performs similar work or deliver similar services.
- (v) **Functional Benchmarking or Generic Benchmarking:** This type of benchmarking is used when organisations look to benchmark with partners drawn from different business sectors or areas of activity to find ways of improving similar functions or work processes.
- (vi) **Internal Benchmarking:** It involves seeking partners from within the same organization, for example, from business units located in different areas.
- (vii) **External Benchmarking:** It involves seeking help of outside organisations that are known to be best in class. External benchmarking provides opportunities of learning from those who are at the leading edge, although it must be remembered that not every best practice solution can be transferred to others.

Cost Management

NOTE

[illegible]

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.

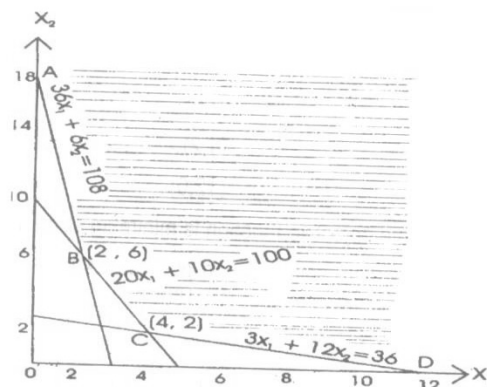
Formulate the above as a linear programming problem to minimize the total cost and solve this problem by using graphic method. (May 2002)

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:



Cost Management

Minimize $Z = 20x_1 + 40x_2$ subject to the constraints

$$36x_1 + 6x_2 \geq 108$$

$$3x_1 + 12x_2 \geq 36$$

$$20x_1 + 10x_2 \geq 100$$

$$\text{and } x_1, x_2 \geq 0$$

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:

$$36x_1 + 6x_2 = 108$$

$$3x_1 + 12x_2 = 36$$

$$20x_1 + 10x_2 = 100$$

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

$$A = (0,18), B = (2,6), C = (4,2) \text{ and } D = (12,0)$$

The value of the objective function at each of these points can be evaluated as follows:

Extreme Point	(x_1, x_2)	$Z = 20x_1 + 40x_2$	
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).

Linear Programming

Hence, the optimum solution is 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.

$$\text{Minimize } Z = 20x + 40y$$

Subject to the conditions

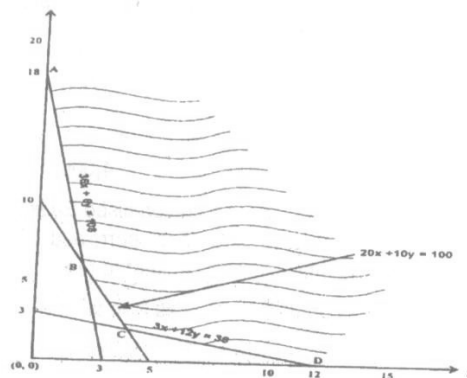
$$36x + 6y \geq 108$$

$$3x + 12y \geq 36$$

$$20x + 10y \geq 100$$

$$\text{and } x, y \geq 0$$

For finding the solution, we plot above equations on x – y plane as shown below



Cost Management

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 of $z = 20x + 40y$ 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:

Linear Programming

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 cost per unit (Rs.)	2,000	4,000	8,000
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:

$$\text{Maximize } Z = 1,000X_1 + 1,000X_2 + 7,000X_3 - (\text{Rs.}15,000 + 3,000 + \text{Rs.}1,500)$$

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:

$$20X_1 + 15X_2 + 12X_3 \leq 1,000 \text{ (Machine Time Restriction)}$$

$$5X_1 + 4X_2 + 3X_3 \leq 1,500 \text{ (Assembly Time Restriction)}$$

Cost Management

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:

$$2,000 X_1 + 4,000 X_2 + 8,000 X_3 \quad \text{.....(1)}$$

The cash availability for the next month from the balance sheet is as below:

$$\begin{aligned} \text{Cash availability (Rs.)} &= \text{Cash balance (Rs.2,10,000)} \\ &\quad - \text{Loan to repay to Nationalized Bank (Rs.50,000)} \\ &\quad - \text{Interest on loan from XYZ Cooperative bank and Nationalized bank (Rs.1,500)} \\ &\quad - \text{Interest on long term loans } \left(\frac{0.18 \times 2,00,000}{12} \right) \\ &\quad - \text{Salary to staff (Rs.15,000)} \\ \text{or, Cash availability} &= \text{Rs.2,10,000} - (\text{Rs.50,000} + \text{Rs.1,500} + \text{Rs.3,000} + \text{Rs.15,000}) \\ &= \text{Rs.1,40,500} \quad \text{.....(2)} \end{aligned}$$

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.

$$\text{Hence, } X_1 \geq 3, X_2 \geq 2, X_3 \geq 5$$

The LP formulation of the given problem is as follows:

$$\text{Maximize } Z - 1,000 X_1 + 1,000 X_2 + 7,000 X_3 - (\text{Rs.15,000} + \text{Rs.3,000} + \text{Rs.1,500})$$

Subject to the constraints:

$$20 X_1 + 15 X_2 + 12 X_3 \leq 1,000$$

$$5 X_1 + 4 X_2 + 3 X_3 \leq 1,500$$

$$2,000 X_1 + 4,000 X_2 + 8,000 X_3 \leq \text{Rs.1,40,500}$$

$$X_1 \geq 3, X_2 \geq 2, X_3 \geq 5$$

X_1, X_2 and X_3 can take only positive integral values.

Linear Programming

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 , $\frac{1}{2}$ kg of X_1 , $\frac{1}{4}$ kg of X_2 and $\frac{1}{4}$ kg of X_3 are required. Similarly to produce 1 kg of Y_2 , $\frac{3}{7}$ kg of X_1 , $\frac{2}{7}$ kg of X_2 and $\frac{2}{7}$ kg of X_3 and to produce 1 kg Y_3 , $\frac{2}{3}$ kg of X_2 and $\frac{1}{3}$ 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			Selling price (per kg)
	X_1	X_2	X_3	
Y_1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	Rs.90
Y_2	$\frac{3}{7}$	$\frac{2}{7}$	$\frac{2}{7}$	Rs.100
Y_3	--	$\frac{2}{3}$	$\frac{1}{3}$	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:

$$\begin{aligned}
 \text{Cost to produce 1 kg of } Y_1 &= \frac{1}{2} \text{ Rs.30} + \frac{1}{4} \text{ Rs.50} + \text{Rs.120} \\
 &= \text{Rs.15} + \text{Rs.12.50} + \text{Rs.30} \\
 &= \text{Rs.57.50}
 \end{aligned}$$

$$\therefore \text{Profit per kg of } Y_1 = \text{Rs.90} - \text{Rs.57.50} = \text{Rs.32.50}$$

$$\begin{aligned}
 \text{Similarly, cost to produce 1 kg of } Y_2 &= \frac{3}{7} \text{ Rs.30} + \frac{2}{7} \text{ Rs.50} + \text{Rs.120} \\
 &= \frac{1}{7} (\text{Rs.90} + \text{Rs.100} + \text{Rs.240}) \\
 &= \text{Rs.430/7} = \text{Rs.61.43}
 \end{aligned}$$

$$\text{Profit per kg of } Y_2 = \text{Rs.100} - \text{Rs.61.43} = \text{Rs.38.57}$$

$$\text{and cost to produce 1 kg of } Y_3 = \frac{2}{3} \text{ Rs.50} + \frac{1}{3} \text{ Rs.120} = \text{Rs.220/3} = \text{Rs.73.33}$$

$$\text{Profit per kg of } Y_3 = \text{Rs.120} - \text{Rs.73.33} = \text{Rs.46.67}$$

Let the manufacturer produce y_1 , y_2 and y_3 units of the products Y_1 , Y_2 and Y_3 respectively.

Cost Management

Since the manufacturer wants to maximise the profit, the objective function is given by

$$\text{Maximise } Z = 32.50 y_1 + 38.57 y_2 + 46.67 y_3$$

$$\frac{1}{2} y_1 + \frac{3}{7} y_2 \leq 20 \text{ or } 7 y_1 + 6 y_2 \leq 280$$

$$\frac{1}{4} y_1 + \frac{2}{7} y_2 + \frac{2}{3} y_3 \leq 15 \text{ or } 21 y_1 + 24 y_2 + 56 y_3 \leq 1,260$$

$$\frac{1}{4} y_1 + \frac{2}{7} y_2 + \frac{1}{3} y_3 \leq 10 \text{ or } 21 y_1 + 24 y_2 + 28 y_3 \leq 840$$

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

Linear Programming

still have to be produced if only one of the two products were produced. However, the total material requirements if both products are produced is less than the sum of requirements 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 using 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 x_1 , 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

$$2x_1 + 5x_2$$

Cost Management

Since there are 18 h available in first operation and 21 h in second operation, the restrictions become

$$3x_1 + 4x_2 \leq 18 \quad \text{..... (1)}$$

$$3x_1 + 5x_2 \leq 21 \quad \text{..... (2)}$$

Since the maximum number of units of C that can be sold is 5, therefore,

$$X_3 \leq 5 \quad \text{..... (3)}$$

Further, the company gets three units of by product C for every unit of product B produced, therefore

$$X_3 = 3x_2 \quad \text{..... (4)}$$

Now, the allocation problem of the industry can be finally put in the following linear programming problem:

$$\text{Maximise } Z = 3x_1 + 8x_2 + 2x_3$$

Subject to the constraints

$$3x_1 + 4x_2 \leq 18$$

$$3x_1 + 5x_2 \leq 21$$

$$x_3 \leq 5, x_3 = 3x_2$$

$$x_1, x_2, x_3 = 0$$

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

Linear Programming

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 is given by

$$\text{Maximise } Z = (7,50,000 + 1,50,000) x_1 + (40,000 + 2,60,000) x_2$$

$$\text{or Maximise } Z = 9,00,000 x_1 + 3,00,000 x_2$$

One programme of T.V. advertising costs Rs.50,000 and that of Radio advertising costs Rs.20,000. The total advertising budget is Rs.2,00,000.

$$\text{Hence, } 50,000 x_1 + 20,000 x_2 \leq 2,00,000$$

$$\text{Or } 5x_1 + 2x_2 \leq 20$$

Contract conditions require that there should be at least 3 programmes on T.V. and the number of programmes on Radio must not exceed 5.

$$\text{Therefore, } x_1 \geq 3$$

$$x_2 \leq 5$$

The linear programming model for the given problem is

$$\text{Maximise } Z = 9,00,000 + 3,00,000 x_2$$

Subject to the constraints

$$5x_1 + 2x_2 \leq 20$$

$$x_1 \geq 3$$

$$x_2 \leq 5$$

where $x_1, x_2 \geq 0$

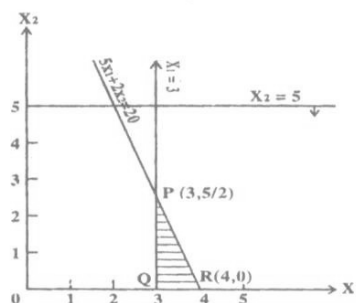
Point of intersection for lines $x_1 = 3$ and $5x_1 + 2x_2 = 20$ is P (3, 5/2).

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



ion is given by the shaded area below

Cost Management

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 at 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

$$9,00,000 \times 4 = 36,00,000$$

It can be seen that the value of Z is maximum at point R (4,0). Thus, the solution to the given problem is:

$$X_1 = 4, x_2 = 0 \text{ and Maximum } Z = 36,00,000.$$

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:

$$\text{Maximise } Z = 0.1x_1 + 0.2x_2$$

The maximum amount available for investment is Rs.1,00,000.

$$\text{Hence, } x_1 + x_2 \leq 1,00,000 \quad \text{..... (1)}$$

Further, the maximum investment allowed in either portfolio set is Rs.75,000.

$$\text{Therefore, } x_1 \leq 75,000 \quad \text{..... (2)}$$

Linear Programming

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, $0.1x_1 + 0.2x_2 \geq 0.12(x_1 + x_2)$ (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)

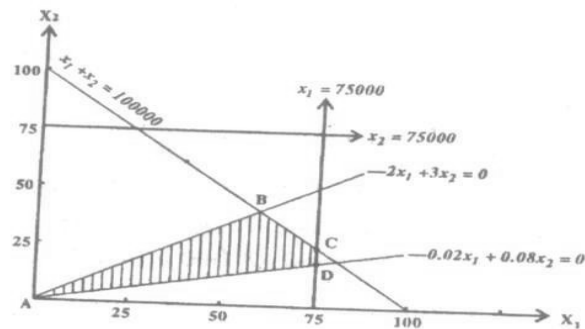
$x_2 \leq 75,000$ (3)

$4x_1 + 9x_2 \leq 6(x_1 + x_2)$
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 $x_1 + x_2 = 1,00,000$

Cost Management

is given by B (60,000, 40,000)

The point of intersection for the lines

$$X_1 = 75,000$$

$$\text{and } x_1 + x_2 = 1,00,000$$

is given by C (75,000, 25,000)

Similarly, the lines

$$x_1 = 75,000$$

$$\text{and } -0.02x_1 + 0.08x_2 = 0$$

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, $Z=0.1 \times 60,000 + 0.2 \times 40,000$

$$= 6,000 + 8,000 = \text{Rs.}14,000$$

At C, $Z=0.1 \times 75,000 + 0.2 \times 25,000$

$$= 7,500 + 5,000 = \text{Rs.}12,500$$

At D, $Z=0.1 \times 75,000 + 0.2 \times 18,750$

$$= 7,500 + 3,750 = \text{Rs.}11,250$$

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

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

Linear Programming

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

Cost Management

From the data given for time required for various models and the total number of hours available for machine time and assembly time, we get the following constraints:

$$20x_1 + 15x_2 + 12x_3 \leq 1,000 \text{ (Machine Time Restriction)}$$

$$5x_1 + 4x_2 + 3x_3 \leq 1,500 \text{ (Assembly Time Restriction)}$$

The level of operations in the company is subject to availability of cash next month i.e.; the cash required for manufacturing various models should not exceed the cash available for the next month.

The cash requirements for x_1 units of P III, x_2 units of P II and x_3 units of Celeron computers are:

$$2,000x_1 + 4,000x_2 + 8,000x_3 \dots\dots (1)$$

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 $\left[\frac{0.18 \times 2,00,000}{12} \right]$

Salary to staff (Rs. 15,000)

Or, Cash availability = Rs. 2,10,000-(Rs. 50,000 + Rs. 1,500 + Rs. 3,000 + Rs. 15,000)
= Rs. 1,40,500 (2)

Thus, from (1) and (2),

$$2000 X_1 + 4000 X_2 + X_3 < \text{Rs. } 1,40,500$$

The company has also promised to deliver 3 P III, 2 P II and 5 Celeron computers to M/s. Kingspen Ltd.

Hence, $X_1 > 3$, $X_2 > 2$, $X_3 > 5$

Since the company wants to maximize the profit, hence the objective function is given by:
 Maximize $Z = 1000X_1 + 1000X_2 + 7000X_3$ - (Rs. 15000 + Rs. 3000 + Rs. 1500) The LP
 formulation of the given problem is as follow:

Maximize $Z = 1000 X_1 + 1000X_2 + 7000 X_3 - (\text{Rs. } 15000 + \text{Rs. } 15000)$ Subject to the constraints:

$$20X_1 + 15X_2 + 12X_3 < 1000$$

$$5X_1 + 4X_2 + 3X_3 < 1500$$

$$2000 X_1 + 4000 x_2 + 8000 X_3 < \text{Rs. } 1,40,500$$

Linear Programming

$$X_1 > 3, X_2 > 2, X_3 > 5$$

X_1, X_2 and X_3 can take only positive integral values.

Question 10

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.

$$\text{Maximise } Z = 50x_1 + 75x_2$$

Subject to

$$1.2x_1 + 1.6x_2 \leq 1,600 \text{ or } 12x_1 + 16x_2 \leq 16,000 \quad \text{-(i)}$$

$$0.8x_1 + 0.9x_2 \leq 700 \text{ or } 8x_1 + 9x_2 \leq 7,000 \quad \text{-(ii)}$$

$$0.2x_1 + 0.2x_2 \leq 300 \text{ or } 2x_1 + 2x_2 \leq 3,000 \quad \text{-(iii)}$$

$$x_1 \geq 150 \quad \text{-(iv)}$$

$$x_2 \geq 90 \quad \text{-(v)}$$

Let

$$x_1 = y_1 + 150$$

$$x_2 = y_2 + 90 \text{ where } y_1, y_2 \geq 0$$

$$\text{Maximize } Z = 50(y_1 + 150) + 75(y_2 + 90) \text{ or } Z = 50y_1 + 75y_2 + 14,250$$

Subject to :

$$12(y_1 + 150) + 16(y_2 + 90) \leq 16,000$$

$$8(y_1 + 150) + 9(y_2 + 90) \leq 7,000$$

$$2(y_1 + 150) + 2(y_2 + 90) \leq 3,000$$

Cost Management

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

$$x_1 = 0 + 150 = 150$$

$$x_2 = 90 + 554.44 = 644.44 \text{ and the value of objective function is}$$

$$Z = 50 \times 150 + 75 \times 644.44$$

$$= \text{Rs. } 55,833$$

Linear Programming

Question 11

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 $x + 2y \leq 720$

$$5x + 4y \leq 1800$$

$$3x + y \leq 900$$

$$x \geq 0, y \geq 0$$

where $x = \text{No. of units of A}$

$y = \text{No. of units of B}$

By the addition of slack variables s_1, s_2 and s_3 the inequalities can be converted into equations. The problems thus become

$$z = 80x + 100y \text{ subject to } x + 2y + s_1 = 720$$

$$5x + 4y + s_2 = 1800$$

$$3x + y + s_3 = 900$$

$$\text{and } x \geq 0, y \geq 0, s_1 \geq 0, s_2 \geq 0, s_3 \geq 0$$

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	
$1800 - 720 \times 4/2 = 360$			$900 - 720 \times 1/2 = 540$					
$5 - 1 \times 2 = 3$			$3 - 1 \times \frac{1}{2} = \frac{5}{2}$					

Cost Management

$$\begin{array}{ll}
 4 - 2 \times 2 = 0 & 1 - 2 \times 1/2 = 0 \\
 0 - 1 \times 2 = -2 & 0 - 1 \times 1/2 = -1/2 \\
 1 - 0 \times 2 = 1 & 0 - 0 \times 1/2 = 0 \\
 0 - 0 \times 2 = 0 & 1 - 0 \times 1/2 = 1
 \end{array}$$

Table 2:

			80	100	0	0	0	
Program	Profit/unit	Qty.	X	Y	S ₁	S ₂	S ₃	
Y	100	360	1/2	1	1/2	0	0	$360 \div 1/2 = 720$
S ₂	0	360	3	0	-2	1	0	$360 \div 3 = 120$
S ₃	0	540	5/2	0	-1/2	0	1	$540 \div 5/2 = 216$
Net evaluation row			30	0	-50	0	0	

$$\begin{array}{ll}
 360 - 360 \times 1/6 = 300 & 540 - 360 \times 5/6 = 240 \\
 1/2 - 3 \times 1/6 = 0 & 5/2 - 3 \times 5/6 = 0 \\
 1 - 0 \times 1/6 = 1 & 0 - 0 \times 5/6 = 0 \\
 1/2 - 2 \times 1/6 = 5/6 & -1/2 - 2 \times 5/6 = 7/6 \\
 0 - 1 \times 1/6 = -1/6 & 0 - 1 \times 5/6 = -5/6 \\
 0 - 0 \times 1/6 = 0 & 1 - 0 \times 5/6 = 1
 \end{array}$$

Table 3:

			80	100	0	0	0	
Program	Profit/unit	Qty.	X	Y	S ₁	S ₂	S ₃	
Y	100	300	0	1	5/6	-1/6	0	
X	80	120	1	0	-2/3	1/3	0	
S ₃	0	240	0	0	7/6	-5/6	1	
Net evaluation row			0	0	-500/6	+100/6		
					+160/3	-80/3	0	
					$= \frac{180}{6}$	$= -\frac{60}{6}$		

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

$$= 80 \times 120 + 100 \times 300 = 9600 + 30,000$$

$$= \text{Rs. } 39,600.$$

Linear Programming

Question 12

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%

$$.02 X_1 + .04 X_2 + 0.03 X_3 \leq .03 (X_1 + X_2 + X_3)$$

$$2X_1 + 4 X_2 + 3X_3 \leq 3 (X_1 + X_2 + X_3) \text{ or } -X_1 + X_2 \leq 0$$

(ii) Ash content must not exceed 3%

$$3X_1 + 2 X_2 + 5 X_3 \leq 3 (X_1 + X_2 + X_3) \text{ or } -X_2 + 2X_3 \leq 0$$

(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

$$\text{Maximize } Z = 12 X_1 + 15X_2 + 14 X_3$$

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

Cost Management

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 $Z = 1360$.

Question 13

What are the practical applications of Linear programming? (May 2007, 7 Marks)

Answer

Linear programming can be used to find optimal solutions under constraints.

In production:

- pdt. mix under capacity constraints to minimise costs/maximise profits along with marginal costing.
- Inventory management to minimise holding cost, warehousing / transporting from factories to warehouses etc.

Sensitivity Analysis: By providing a range of feasible solutions to decide on discounts on selling price, decisions to make or buy.

Blending: Optional blending of raw materials under supply constraints.

Finance: Portfolio management, interest/receivables management.

Linear Programming

Advertisement mix: In advertising campaign – analogous to pdn. management and pdt. mix.

Assignment of personnel to jobs and resource allocation problems.

However, the validity will depend on the manager's ability to establish a proper linear relationship among variables considered.

Question 14

Transport Ltd. Provides tourist vehicles of 3 types – 20-seater vans, 8-seater big cars and 5-seater small cars. These seating capacities are excluding the drivers. The company has 4 vehicles of the 20-seater van type, 10 vehicles of the 8-seater big car types and 20 vehicles of the 5-seater small car types. These vehicles have to be used to transport employees of their client company from their residences to their offices and back. All the residences are in the same housing colony. The offices are at two different places, one is the Head Office and the other is the Branch. Each vehicle plies only one round trip per day, if residence to office in the morning and office to residence in the evening. Each day, 180 officials need to be transported in Route I (from residence to Head Office and back) and 40 officials need to be transported in Route II (from Residence to Branch office and back). The cost per round trip for each type of vehicle along each route is given below.

You are required to formulate the information as a linear programming problem, with the objective of minimising the total cost of hiring vehicles for the client company, subject to the constraints mentioned above. (only formulation is required. Solution is not needed).

	Figs. – Rs. /round trip		
	20-seater vans	8-seater big cars	5-seater small cars
Route I –			
Residence — Head Office and Back	600	400	300
Route II –			
Residence — Branch Office and Back	500	300	200

(May 2008, 8 Marks)

Answer

Type	I	II	III	Total no. of passengers
	20 – Seater vans	8 – Seater Big cars	5 – Seater Small cars	
Route I Residence H.O. Residence	600	400	300	180
Route II Residence Br. Residence	500	300	200	40

Cost Management

No. of vehicles	4	10	20	
Max. capacity	80	80	100	220
No. of passengers			260	

Let i be the i th route,

and j be the type of vehicle, so that

S_{11} = no. of vans (vehicles on Route I, Type I)

S_{12} = no. of 8 seater cars on Route I

S_{13} = no. of 5 seater cars on Route I

S_{21} = no. of vans — on Route II

S_{22} = no. of 8 seater cars on Route II

S_{23} = no. of 5 seater cars on Route II

Objective:

Minimise

$$\text{Cost } Z = 600 S_{11} + 400 S_{12} + 300 S_{13} + 500 S_{21} + 300 S_{22} + 200 S_{23}$$

Subject to

$$20 S_{11} + 8 S_{12} + 5 S_{13} = 180$$

$$20 S_{21} + 8 S_{22} + 5 S_{23} = 40$$

$$S_{11} + S_{21} \leq 4$$

$$S_{21} + S_{22} \leq 10$$

$$S_{31} + S_{32} \leq 20$$

$$\text{All } s_{ij} \geq 0$$

Question 15

Explain the concept and aim of theory of constraints. What are the key measures of theory of constraints? (May 2008, 7 Marks)

Answer

The theory of constraints focuses its attention on constraints and bottlenecks within organisation which hinder speedy production. The main concept is to maximize the rate of manufacturing output is the throughput of the organisation. This requires to examine the bottlenecks and constraints. A bottleneck is an activity within the organization where the demand for that resource is more than its capacity to supply.

A constraint is a situational factor which makes the achievement of objectives / throughput more difficult than it would otherwise, for example of constraint may be lack of skilled labour, lack of customer orders, or the need to achieve high quality in product output.

Linear Programming

For example let meeting the customers' delivery schedule be a major constraint in an organisation. The bottleneck may be a certain machine in the factory. Thus bottlenecks and constraints are closely examined to increase throughput.

Key measures of theory of constraints:

- (i) **Throughput contribution:** It is the rate at which the system generates profits through sales. It is defined as, sales less completely variable cost, sales – direct are excluded. Labour costs tend to be partially fixed and conferred are excluded normally.
- (ii) **Investments:** This is the sum of material costs of direct materials, inventory, WIP, finished goods inventory, R & D costs and costs of equipment and buildings.
- (iii) **Other operating costs:** This equals all operating costs (other than direct materials) incurred to earn throughput contribution. Other operating costs include salaries and wages, rent, utilities and depreciation.

Question 16

The costs and selling prices per unit of two products manufacturing by a company are as under:

Product	A (Rs.)	B (Rs.)
Selling Price	500	450
Variable costs:		
Direct Materials @ Rs. 25 per kg.	100	100
Direct Labour @ Rs. 20 per hour	80	40
Painting @ Rs. 30 per hour	30	60
Variable overheads	190	175
Fixed costs @ Rs. 17.50/D.L.Hr.	70	35
Total costs	470	410
Profit	30	40

In any month the maximum availability of inputs is limited to the following:

Direct Materials	480 kg.
Direct Labour hours	400 hours
Painting hours	200 hours

Required:

- (i) Formulate a linear programme to determine the production plan which maximizes the profits by using graphical approach.
- (ii) State the optimal product mix and the monthly profit derived from your solution in (i) above.
- (iii) If the company can sell the painting time at Rs. 40 per hour as a separate service, show what modification will be required in the formulation of the linear programming problem. You are required to re-formulate the problem but not to solve. (Nov 2008, 11 Marks)

Cost Management

Answer

Contribution analysis:

Products	A (Rs.)	B (Rs.)
Selling price (A)	<u>500</u>	<u>450</u>
Variable costs:		
Direct Materials	100	100
Direct Labour	80	40
Painting	30	60
Variable Overheads	<u>190</u>	<u>175</u>
Total variable costs (B)	<u>400</u>	<u>375</u>
Contribution (A – B)	<u>100</u>	<u>75</u>
Direct Material per unit	100/25 = 4 kg.	100/25 = 4 kg.
Direct Labour hour per unit	80/20 = 4 hours	40/20 = 2 hours
Painting hour per unit	30/30 = 1 hour	60/30 = 2 hours

Let A be the units to be produced of product A and B be the units to be produced of product B.

LP Problem formulation:

Z Max $100A + 75B$ Maximisation of contribution

Subject to:

$4A + 4B \leq 480$ Raw material constraint
 $4A + 2B \leq 400$ Direct Labour hour constraint
 $A + 2B \leq 200$ Painting hour constraint
 $A, B \geq 0$ Non negativity constraint

Raw Material Constraint : Put B = 0, A = 120

Put A = 0, B = 120

Direct Labour Constraint : Put B = 0, A = 100

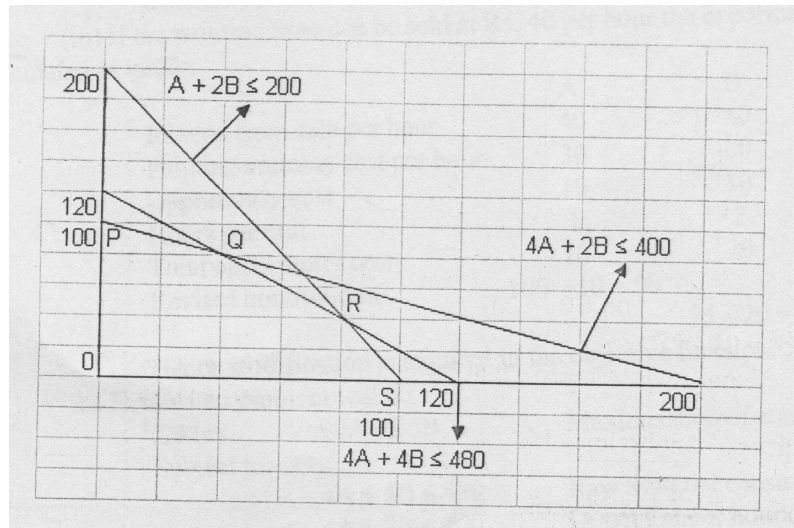
Put A = 0, B = 200

Painting Constraint : Put B = 0, A = 200

Put A = 0, B = 100

The graphical representation will be as under:

Linear Programming



Q Intersects $4A + 2B = 400$ (1)

and $4A + 4B = 480$ (2)

Subtracting (2) from (1), we get $-2B = -80$

$$\Rightarrow B = 80/2 = 40$$

Putting value of B in (1), we get $4A + 2 \times 40 = 400$

$$\Rightarrow A = \frac{400 - 80}{4} = 80$$

R Intersects $4A + 4B = 480$ (3)

and $A + 2B = 200$ (4)

Multiplying (4) by (2) and then subtracting from (3), we get

$$2A = 80$$

$$\Rightarrow A = 40$$

Putting the value of A in (4), we get $2B = 200 - 40$

$$\Rightarrow B = 80.$$

Evaluation of corner points:

Point	Products		Contribution		Total Contribution
	A	B	A (Rs.)	B (Rs.)	Rs.
			100 per unit	75 per unit	
P	0	100	0	7,500	7,500
Q	80	40	8,000	3,000	11,000

Cost Management

R	40	80	4,000	6,000	10,000
S	100	0	10,000	0	10,000

Optimal product mix is Q

Product	Units	Contribution Rs.
A	80	8,000
B	40	3,000
Total contribution		11,000
Less: Fixed costs 400 D.L. Hrs. $\times$ Rs. 17.50		7,000
Optimal Profit		4,000

(iii) If the painting time can be sold at Rs. 40 per hour the opportunity cost is calculated as under:

	A (Rs.)	B (Rs.)
Income from sale per hour	40	40
Painting variable cost per hour	30	30
Opportunity cost	10	10
Painting hours per unit	1	2
Opportunity cost	10	20
Revised contribution	$100 - 10 = 90$	$75 - 20 = 55$

Hence, modification is required in the objective function.

Re-formulated problem will be:

Z Max.	$90A + 55B$	Maximisation of contribution
Subject to:		
	$4A + 4B \leq 480$	Raw Material constraint
	$4A + 2B \leq 400$	Direct Labour hour constraint
	$A + 2B \leq 200$	Painting hour constraint
	$A, B \geq 0$	Non-negativity constraint

THE TRANSPORTATION PROBLEM

Question 1

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 Per unit	Factory				Sales price Per unit	Requirement
	F_1	F_2	F_3	F_4		
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	

Cost Management

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				80		80	2
	6	-2	3	8	0		
S_2	10	90		20		120	1 1 3 2
	6	-2	2	5	0		
S_3		60	50		40	150	1 1 1 2
	1	-4	2	3	0		
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	3	4	80	5	3
	6	-2	3	8	0	
S_2	10	90	2	20	2	0
	6	-2	2	5	0	
S_3	3	60	50	0	40	-2
	1	-4	2	3	0	
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:

The Transportation Problem

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 by 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	0	8	80/0	2 _ _ _
S_2	10	50	20	40	8	120/110/90/50/0	1 1 3 2
S_3	7	100	50	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_i s and v_j s such that $\Delta_{ij} = c_{ij} - (u_i + v_j)$ where $(i = 1, 2, 3)$ and $(j = 1, 2, \dots, 5)$ for non basic cells. Let us assume $u_2 = 0$. Remaining u_i s, v_j s and Δ_{ij} s are calculated below

	F_1	F_2	F_3	F_4	Dummy	u_i
S_1	3	3	4	80	3	-3
	2	10	5	0	8	
S_2	10	50	20	40	-	
	2	10	6	3	8	0
S_3	3	100	50	0	-2	2
	7	12	6	5	8	
v_j	2	10	4	3	8	

Cost Management

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	3	4	80	5	-3
	2	10	5	0	8	
10		90	2	20	2	0
	2	10	6	3	8	
3		60	50	0	40	2
	7	12	6	5	8	
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 one of the $\Delta_{ij} = 0$, alternative solution exists.

Question 2

A product is manufactured by four factories A, B, C and D. The Unit production costs are Rs.2, Rs.3, Rs.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
Factory	A	2	4	6	11
	B	10	8	7	5
	C	13	3	9	12
	D	4	6	8	3

The Transportation Problem

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				Supply
		P	Q	R	S	
Factories	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
	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 find 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
			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	-		

Cost Management

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, $i = (1, 2, \dots, 4)$ and $j = (1, 2, \dots, 5)$ $\Delta_{ij} = c_{ij} - (u_i + v_j)$ for allocated cells. We assume that $u_4 = 0$ and remaining u_i 's, v_j 's and Δ_{ij} 's are calculated below"

	P	Q	R	S	Dummy	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 note 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 $\Delta_{ij} = c_{ij} - [(u_i + v_j)]$

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

$$\begin{aligned}
 \text{Total cost} &= 4 \times 25 + 6 \times 5 + 8 \times 20 + 10 \times 70 + 4 \times 30 + 13 \times 15 + 8 \times 20 + 0 \times 15 \\
 &= 100 + 30 + 160 + 700 + 120 + 195 + 160 \\
 &= \text{Rs. } 1,465/-
 \end{aligned}$$

Question 3

A compressed Natural Gas (CNG) company has three plants producing gas and four outlets. The cost of transporting gas from different production plants to the outlets, production capacity of each plant and requirement at different outlets is shown in the following cost-matrix table:

Plants	Outlets				Capacity of Production
	A	B	C	D	
X	4	6	8	6	700
Y	3	5	2	5	400
Z	3	9	6	5	600
Requirement	400	450	350	500	1,700

The Transportation Problem

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)

Plants	Outlets				Capacity	Difference
	A	B	C	D		
X	4 400	6 400	8 300	6 300	700/300/0	2 2 0 0
Y	3 50	5 350	2 400	5 50	400/50/0	1 2 0 0
Z	3 400	9 200	6 600	5 200	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:

Plants	Outlets				Capacity
	A	B	C	D	
X	4 400	6 400	8 300	6 300	700
Y	3 50	5 350	2 400	5 50	400
Z	3 400	9 200	6 600	5 200	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 ($j=1,2,3,4$) such that $\Delta_{ij} = C_{ij} - (u_i + v_j)$ for allocated cells. We assume $u_1=0$, and rest of the u_i 's, v_j 's and Δ_{ij} 's are calculated as below:

Cost Management

Plants	Outlets				U_i
	A	B	C	D	
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 Δ_{ij} 's for non-allocated cells, we found that all the $\Delta_{ij} \geq 0$, hence the initial solution obtained above is optimal.

The optimal allocations are given below.

Plants	Outlet	Units		Cost		Total Cost
X	→B	400	x	6	=	2,400
X	→D	300	x	6	=	1,800
Y	→B	50	x	5	=	250
Y	→C	350	x	2	=	700
Z	→A	400	x	3	=	1,200
Z	→D	200	x	5	=	<u>1,000</u>
						<u>7,350</u>

The minimum cost = 7,350 thousand rupees.

Since some of the Δ_{ij} 's = 0, the above solution is not unique. Alternative solutions exist.

Question 4

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	

The Transportation Problem

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:

Plants	Ware House				Production	Difference
	A	B	C	Dummy		
X	8	16	16	0	152/0	8 8 _ _
Y	32	48	32	0	164/124/42/0	32 0 0 16
Z	16	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

Cost Management

Plants	Ware House				Production
	A	B	C	Dummy	
X	8	152	16	0	152
Y	32	42	82	40	164
Z	144	10	32	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_i 's v_j 's and Δ_{ij} 's are calculated as below:

Plants	Ware House				U_i
	A	B	C	Dummy	
X	8	152	16	32	-32
Y	0	42	82	40	0
Z	144	10	32	16	-16
V_j	32	48	32	0	

On calculating Δ_{ij} 's=0, the solution is not unique. Alternate solution exists.

Question 5

Following is the profit matrix based on four factories and three sales depots of the company:

		S_1	S_2	S_3	Availability
Towns	F_1	6	6	1	10
	F_2	-2	-2	-4	150
	F_3	3	2	2	50
	F_4	8	5	3	100
Requirement		80	120	150	

The Transportation Problem

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 step, we will balance this transportation problem, by adding a dummy factory, assuming no profit in case of surplus production

		Sales Depots			Availability
		S_1	S_2	S_3	
Factories	F_1	6	6	1	10
	F_2	-2	-2	-4	150
	F_3	3	2	2	50
	F_4	8	5	3	100
	Dummy	0	0	0	40
Requirement		80	120	150	

We shall now convert the above transportation problem (a profit matrix) into a loss matrix by subtracting all the elements from the highest value in the table i.e. 8. Thereafter, we shall apply the VAM to find an initial solution.

		Sales Depots			Availability	Difference
		S_1	S_2	S_3		
Factories	F_1	2	10	7	10/0	0 5 _ _
	F_2	10	40	110	150/110/0	0 2 2 2
	F_3	5	50	6	50/0	1 0 0 0
	F_4	80	20	5	100/20/0	3 2 2 _
	Dummy	8	8	40	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		

Cost Management

The initial solution obtained by VAM is given below:

		Sales Depots		
		S_1	S_2	S_3
Factories	F_1	2	10 2	7
	F_2	10	40 10	110 12
	F_3	5	50 6	6
	F_4	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 ($i=1, 2, \dots, 5$) and v_j 's ($j=1, 2, 3$) such that $\Delta_{ij} = c_{ij} - (u_i + v_j)$. Let us assume $u_2 = 0$, remaining u_i 's, v_j 's and Δ_{ij} 's are calculated below:

		Sales Depots			
		S_1	S_2	S_3	U_j
Factories	F_1	3 2	10 2	3 7	-8
	F_2	3 10	40 10 +θ	110 12	0
	F_3	2 5	50 6 -θ	-2 6 +θ	-4
	F_4	80 0	20 3	5	-7
	Dummy	11 8	2 8	40 8	-4
	V_j	7	10	12	

The Transportation Problem

Since one of the Δ_{ij} negative, the initial solution is not optimal. Let us introduce in the cell with $-\vee \Delta_{ij}$ { i.e. the cell (F_3, S_3) }, an assignment θ . The value of θ in the reallocated solution as obtained from about is given below. The values of u_i 's, v_j 's and Δ_{ij} 's are also calculated.

$$\theta = \min \{(50-0) = 0 \text{ } (110-\theta)=0\} = 50$$

		Sales Depots						
		S_1		S_2		S_3		U_j
Factories	F_1	3	2	10	2	3	7	-8
	F_2	3	10	90	10	60	12	0
	F_3	2	5	50	- θ	-2	+ θ	-4
	F_4	80	0	20	3		5	-7
	Dummy	11	8	2	8	40	8	-4
	V_i	7		10		12		

Since all Δ_{ij} 's for non basic cells are positive, the solution as calculated in the above table is optimal solution. The distribution schedule from factories to sales depots along with profit is given below:

Factory	Sales Depot	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	<u>100</u>
				<u>480</u>

(Note : Since one of the Δ_{ij} 's=0 alternate schedule with a profit of Rs.480 exists)

Question 6

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:

Cost Management

		1	2	3	4	5
Plant	1	0.05	0.07	0.10	0.15	0.15
	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
Plant	1	0.05	1.07	1.10	1.15	1.15	0	5000
	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
Plant	1	105	107	110	115	115	0	50
	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						Capacity	Difference
		1	2	3	4	5	Dummy		
Plant	1	25					25	50/25/0	105/2/2/2/5/10
			105		107		110		
	2	5		30		25		100/70/45/5	96/2/2/2/1/6
						40			

The Transportation Problem

		98	96	99	102	104	0		
3				75	50			125/75/0	88/1/1/_
		90	89	88	90	95	0		
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					25	50
		105	107	110	115	115	0	
Plant	2	5	30	25		40		100
		98	96	99	102	104	0	
3				75	50			125
		90	89	88	90	95	0	
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, ($j=1,2,3,\dots,6$) 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	4	4	7	4	25	7
		105	107	110	115	115	0	
Plant	2	5	30	25	1	40	7	0
		98	96	99	102	104	0	
3		3	4	75	50	2	18	-11
		90	89	88	90	95	0	
V_j 's		98	96	99	101	104	-7	

Cost Management

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

$$\begin{aligned}
 \text{Profit} &= \text{Rs.}2.50 \times 22500 - \text{Rs.}23,730 \\
 &= \text{Rs.}56,250 - \text{Rs.}23,730 \\
 &= \text{Rs.}32,520
 \end{aligned}$$

(**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 7

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
Warehouse	A	5	2	4	3	22
	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 from A to IV

The Transportation Problem

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				Supply
		I	II	III	IV	
Warehouse	A	5	12 2	1 4	9 3	22
	B	4	8	15 1	6	15
	C	7 4	6	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	12	1	9	0
		5	2	4	3	
		6	9	15	6	
B		4	8	1	6	-3
		7	1	1	-1	
		4	6	7	5	
V_j		1	2	4	3	

Cost Management

Since one of the Δ_{ij} 's is negative, the schedule worked out by the clerk is not the optimal solution.

- (ii) Introduce in the cell with – 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.

$$\theta = \min (9 - \theta = 0 \text{ \& } 1 - \theta = 0) = 1$$

	I	II	III	IV	U_i
A	3 5	12 2	2 4	8 3	0
B	5 4	9 8	15 1	6 6	-3
C	7 4	2 6	1 7	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

The Transportation Problem

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 8

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. These 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
Customer	A	5	7	8
	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
Customer	A	5	7	8	70
	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.

Cost Management

		Warehouse			Requirements	Difference
		W ₁	W ₂	W ₃		
Customer	A	65	5	8	70/5/0	2 2 1 7
	B	4	30	6	30/0	0 _ _ _
	C	6	7	43	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			Requirements
		W ₁	W ₂	W ₃	
Customer	A	65	5	8	70
	B	4	30	6	30
	C	6	7	43	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 $u_1 = 0$ and remaining u_i 's, v_j 's and Δ_{ij} 's are calculated below:

		Warehouse			u _i 's
		W ₁	W ₂	W ₃	
Customer	A	65	5	1	0
	B	2	30	2	-3
	C				

The Transportation Problem

		4	4	6	
C	1	7	43	7	50
	6	7			
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	<u>Rs.301</u>
			Total	<u>Rs.830</u>

Question 9

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

Cost Management

<i>B</i>	6	4	6	80
<i>C</i>	3	2	5	15
<i>Dummy</i>	1	2	3	40
<i>Demand</i>	75	20	50	145

		Destination			Supply	Difference
		(1)	(2)	(3)		
Factory	A		10		100	4 _ _
		5	1	7		
	B	20	10	50	80/70/50/0	2 2 2
		6	4	6		
	C	15			15/0	1 1 1
Dummy		3	2	5		
		40			40/0	1 1 _
		1	2	3		
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			Supply
		(1)	(2)	(3)	
Factory	A		10		10
		5	1	7	
	B	20	10	50	80
		6	4	6	
	C	15			15
Dummy		3	2	5	
		40			40
		1	2	3	
Demand		75	20	50	

The Transportation Problem

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 independent. 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
Factory	A	2 5	10 1	4 7	-3
	B	20 6	10 4	50 6	0
	C	15 3	1 2	2 5	-3
	Dummy	40 1	3 2	2 3	-5
	v_j '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	Transportation Cost
B	(1)	20	Rs.6	Rs.120	
B	(2)	10	Rs.4	Rs.40	
B	(3)	50	Rs.6	Rs.300	
C	(1)	15	Rs.3	Rs.45	Penalty Cost
Dummy	(1)	40	Re 1	Rs.40	
				Rs.555	

Question 10

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

Cost Management

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.

$$\text{Maximise } Z = 50x_1 + 75x_2$$

Subject to

$$1.2x_1 + 1.6x_2 \leq 1,600 \text{ or } 12x_1 + 16x_2 \leq 16,000 \quad \text{-(i)}$$

$$0.8x_1 + 0.9x_2 \leq 700 \text{ or } 8x_1 + 9x_2 \leq 7,000 \quad \text{-(ii)}$$

$$0.2x_1 + 0.2x_2 \leq 300 \text{ or } 2x_1 + 2x_2 \leq 3,000 \quad \text{-(iii)}$$

$$x_1 \geq 150 \quad \text{-(iv)}$$

$$x_2 \geq 90 \quad \text{-(v)}$$

Let

$$x_1 = y_1 + 150$$

$$x_2 = y_2 + 90 \text{ where } y_1, y_2 \geq 0$$

$$\text{Maximize } Z = 50(y_1 + 150) + 75(y_2 + 90) \text{ or } Z = 50y_1 + 75y_2 + 14,250$$

Subject to :

$$12(y_1 + 150) + 16(y_2 + 90) \leq 16,000$$

$$8(y_1 + 150) + 9(y_2 + 90) \leq 7,000$$

$$2(y_1 + 150) + 2(y_2 + 90) \leq 3,000$$

$$\text{and } y_1, y_2 \geq 0$$

Adding slack variables s_1, s_2, s_3 , we get

$$\text{Maximize } Z = 50y_1 + 75y_2 + 14,250 \text{ subject to}$$

$$12y_1 + 16y_2 + s_1 = 12,760$$

$$8y_1 + 9y_2 + s_2 = 4,990$$

$$2y_1 + 2y_2 + s_3 = 2,520$$

The Transportation Problem

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

$$x_1 = 0 + 150 = 150$$

$$x_2 = 90 + 554.44 = 644.44 \text{ and the value of objective function is}$$

$$Z = 50 \times 150 + 75 \times 644.44$$

$$= \text{Rs. } 55,833$$

Question 11

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

Cost Management

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

$$x + 2y \leq 720$$

$$5x + 4y \leq 1800$$

$$3x + y \leq 900$$

$$x \geq 0, y \geq 0$$

where

x = No. of units of A
 y = No. of units of B

By the addition of slack variables s_1 , s_2 and s_3 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 $x \geq 0, y \geq 0, s_1 \geq 0, s_2 \geq 0, s_3 \geq 0$

Table I:

	Profit/unit	Qty.	80	100	0	0	0	
			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	
$1800 - 720 \times 4/2 = 360$			$900 - 720 \times 1/2 = 540$					
$5 - 1 \times 2 = 3$			$3 - 1 \times \frac{1}{2} = \frac{5}{2}$					
$4 - 2 \times 2 = 0$			$1 - 2 \times 1/2 = 0$					
$0 - 1 \times 2 = -2$			$0 - 1 \times 1/2 = -1/2$					
$1 - 0 \times 2 = 1$			$0 - 0 \times 1/2 = 0$					
$0 - 0 \times 2 = 0$			$1 - 0 \times 1/2 = 1$					

The Transportation Problem

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	

$$360 - 360 \times 1/6 = 300$$

$$540 - 360 \times 5/6 = 240$$

$$\frac{1}{2} - 3 \times 1/6 = 0$$

$$5/2 - 3 \times 5/6 = 0$$

$$1 - 0 \times 1/6 = 1$$

$$0 - 0 \times 5/6 = 0$$

$$\frac{1}{2} - 2 \times 1/6 = 5/6$$

$$-1/2 - 2 \times 5/6 = 7/6$$

$$0 - 1 \times 1/6 = -1/6$$

$$0 - 1 \times 5/6 = -5/6$$

$$0 - 0 \times 1/6 = 0$$

$$1 - 0 \times 5/6 = 1$$

Table 3:

			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	+100/6	
					+160/3	-80/3	0
					$= \frac{180}{6}$	$= -\frac{60}{6}$	

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

$$= 80 \times 120 + 100 \times 300 = 9600 + 30,000$$

$$= \text{Rs. } 39,600.$$

Cost Management

Question 12

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%

$$.02 X_1 + .04 X_2 + 0.03 X_3 \leq .03 (X_1 + X_2 + X_3)$$

$$2X_1 + 4 X_2 + 3X_3 \leq 3 (X_1 + X_2 + X_3) \text{ or } -X_1 + X_2 \leq 0$$

(ii) Ash content must not exceed 3%

$$3X_1 + 2 X_2 + 5 X_3 \leq 3 (X_1 + X_2 + X_3) \text{ or } -X_2 + 2X_3 \leq 0$$

(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

$$\text{Maximize } Z = 12 X_1 + 15X_2 + 14 X_3$$

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 $X_4 > 0$, $X_5 > 0$, $X_6 > 0$

$$\begin{array}{ccccccc} 12 & 15 & 14 & 0 & 0 & 0 \end{array}$$

The Transportation Problem

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 $Z = 1360$.

Question 13

The initial allocation of a transportation problem, alongwith the unit cost of transportation from each origin to destination is given below. You are required to arrive at the minimum transportation cost by the Vogel's Approximation method and check for optimality.

(Hint : Candidates may consider $u_1 = 0$ at Row 1 for initial cell evaluation)

Requirement

Cost Management

11	2	8	6	4	18
9	9	12	9	6	10
7	6	3	7	7	8
9	3	5	6	11	4
<u>Availability</u>					
12	8	8	8	4	40

(May 2007, 6 marks)

Answer

The concept tested in this problem is Degeneracy with respect to the transportation problem. Total of rows and columns = $(4 + 5) = 9$. Hence, the number of allocations = $9 - 1 = 8$. As the actual number of allocation is 7, a 'zero' allocation is called for. To resolve this, an independent cell with least cost should be chosen. R4C2 has the least cost (cost = 3), but this is not independent. The next least cost cell R4C3 (cost = 5) is independent.

	9	2	5	6	2	Total
	C1	C2	C3	C4	C5	
0R1	11	2	8	6	4	18
0R2	9	9	12	9	6	10
-2R3	7	6	3	7	7	8
0R4	9	3	5	6	11	4
Total	12	8	8	8	4	40

The Transportation Problem

Forming Equations through allocated cells

Basic equation	Setting R1 = 0 other values
$R1 + C2 = 2$	Setting R1 = 0, C2 = 2
$R1 + C4 = 6$	C4 = 6
$R1 + C5 = 2$	C5 = 2
$R2 + C1 = 9$	R2 = 0
$R3 + C3 = 3$	R3 = -2
$R4 + C1 = 9$	C1 = 9
$R4 + C3 = 5$	C3 = 5
$R4 + C4 = 6$	R4 = 0

Evaluate unallocated cells

$R1C1 = 11 - 0 - 9 = 2$	$R3C1 = 7 + 2 - 9 = 0$
$R1C3 = 8 - 0 - 5 = 3$	$R3C2 = 6 + 2 - 2 = 6$
$R2C2 = 9 - 0 - 2 = 7$	$R3C4 = 7 + 2 - 6 = 7$
$R2C3 = 12 - 0 - 5 = 7$	$R3C5 = 7 + 2 - 2 = 7$
$R2C4 = 9 - 0 - 6 = 3$	$R4C2 = 3 - 0 - 2 = 1$
$R2C5 = 6 - 0 - 2 = 4$	$R4C5 = 11 - 0 - 2 = 9$

Since all the evaluation is 0 or +ve, the optimal solution is obtained.

Optimal cost = $(8 \times 2) + (6 \times 6) + (4 \times 2) + (10 \times 9) + (8 \times 3) + (2 \times 9) + (0 \times 5) + (2 \times 6) = 16 + 36 + 8 + 90 + 24 + 18 + 10 + 12 = \text{Rs. } 204$.

Note: As regards allocation of the zero values, the solution to the above problem is also obtained by allocating the zero value in other independent cells such as R1C3, R2C2, R2C3, R3C1, R3C2, R3C4, R3C5. In such situation there will be one more iteration.

Question 14

Goods manufactured at 3 plants, A, B and C are required to be transported to sales outlets X, Y and Z. The unit costs of transporting the goods from the plants to the outlets are given below:

Plants	A	B	C	Total Demand
Sales outlets				

Cost Management

X	3	9	6	20
Y	4	4	6	40
Z	8	3	5	60
Total supply	40	50	30	120

You are required to:

- Compute the initial allocation by North-West Corner Rule.
- Compute the initial allocation by Vogel's approximation method and check whether it is optional.
- State your analysis on the optionality of allocation under North-West corner Rule and Vogel's Approximation method. (May 2008, 10 Marks)

Answer

	20	—	—	20
3		9	6	
	20	20	—	40
4		4	6	
	—	30	30	60
8		3	5	
	40	50	30	120

- (i) Initial allocation under NW corner rule is as above.

$$\begin{aligned}
 \text{Initial cost : } & 20 \times 3 = 60 \\
 & 20 \times 4 = 80 \\
 & 20 \times 4 = 80 \\
 & 30 \times 3 = 90 \\
 & 30 \times 5 = 150 \\
 & \underline{460}
 \end{aligned}$$

- (ii) Initial solution by VAM:

	20	—	—	20	3		
3		9	6				
	20	—	20	40	0	0	2
4		4	6				
		50	10	60	2	2	2

The Transportation Problem

8	3	5
40	50	30
1	1	1
4	1	1
	1	1

$$\begin{array}{rcl}
 \text{Initial solution:} & 20 \times 3 & = 60 \\
 & 20 \times 4 & = 80 \\
 & 50 \times 3 & = 150 \\
 & 20 \times 6 & = 120 \\
 & 10 \times 5 & = \underline{100} \\
 & & \underline{460}
 \end{array}$$

Checking for optimality

3			$u_1 = 0$
4		6	$u_2 = 1$

	3	5	$u_3 = 0$
$v_1 = 3$	$v_2 = 3$	$v_3 = 5$	

$u_i + v_j$

	3	5	0
	4		1
3			0
3	3	5	

$$\Delta_{ij} = c_{ij} - (u_i + v_j)$$

	6	1
	0	
5		

$$\Delta_{ij} \geq 0 \quad \therefore \text{Solution is optimal}$$

Cost Management

Conclusion:

The solution under VAM is optimal with a zero in R_2C_2 which means that the cell C_2R_2 which means that the cell C_2R_2 can come into solution, which will be another optimal solution. Under NWC rule the initial allocation had C_2R_2 and the total cost was the same Rs. 460 as the total cost under optimal VAM solution. Thus, in this problem, both methods have yielded the optimal solution under the 1st allocation. If we do an optimality test for the solution, we will get a zero for Δ_{ij} in C_3R_2 indicating the other optimal solution which was obtained under VAM.

Question 15

State the methods in which initial feasible solution can be arrived at in a transportation problem.
(Nov 2008, 3 Marks)

Answer

The methods by which initial feasible solution can be arrived at in a transportation model are as under:

- (i) North West Corner Method.
- (ii) Least Cost Method.
- (iii) Vogel's Approximation Method (VAM).

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 3 are 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.

The Assignment Problems

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	0
2	0	20	60
3	0	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

Cost Management

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					
<i>Mechanist</i>	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					
<i>Mechanist</i>	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					
<i>Mechanist</i>	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

The Assignment Problems

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.

<i>Jobs</i>					
<i>Mechanist</i>	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:

<i>Jobs</i>					
<i>Mechanist</i>	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

The optimal assignment is given below:

Mechanist	Job	Wages
A	2	3
B	4	2
C	5	4
D	1	3
E	3	<u>9</u>
		<u>21</u>

The total least cost associated with the optimal mechanist-job assignment = 21

Cost Management

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.

Contractors	Jobs			
	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

Contractors	Jobs			
	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.

Contractors	Jobs			
	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:

The Assignment Problems

Contractors	Jobs			
	A	B	C	D
1	30	10	0	10
2	0	10	40	0
3	0	30	20	0
4	0	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 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
Towns	V	3	5	10	15	8
	W	4	7	15	18	8
	X	8	12	20	20	12
	Y	5	5	8	10	6
	Z	10	10	15	25	10

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 each row from all the elements of that row, we get the following table:

Cost Management

		Depots				
		A	B	C	D	E
Towns	V	0	2	7	12	5
	W	0	3	11	14	4
	X	0	4	12	12	4
	Y	0	0	3	5	1
	Z	0	0	5	15	0

Subtracting the smallest element of each column from the elements of that column, we get the following:

		Depots				
		A	B	C	D	E
Towns	V	0	2	4	7	5
	W	0	3	8	9	4
	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
Towns	V	0	0	2	5	3
	W	0	1	6	7	2
	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.

The Assignment Problems

		Depots				
		A	B	C	D	E
Towns	V	0	0	0	3	1
	W	0	1	4	5	0
	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
Towns	V	1	0	0	3	2
	W	0	0	3	4	0
	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
Towns	V	1	0	0	3	2
	W	0	0	3	4	0
	X	0	1	4	2	0
	Y	5	2	0	0	2
	Z	4	1	1	9	0

The optimal assignment is

Town	Depot	Distance (in kms)
V	C	10
W	B	7
X	A	8

Cost Management

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

The Assignment Problems

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	0	3
A ₂	13	12	7	0
A ₃	0	1	6	1
A ₄	1	0	7	12

Cost Management

The optimal assignment is

<i>From Flight No.</i>	<i>To Flight No.</i>	<i>Layover time</i>
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:

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>
<i>A</i>	9	22	58	11	19	27
<i>B</i>	43	78	72	50	63	48
<i>C</i>	41	28	91	37	45	33
<i>D</i>	74	42	27	49	39	32
<i>E</i>	26	11	57	22	25	18
<i>F</i>	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:

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>
<i>A</i>	0	13	49	2	10	18
<i>B</i>	0	35	29	7	20	5
<i>C</i>	13	0	63	9	17	5
<i>D</i>	47	15	0	22	12	5
<i>E</i>	25	0	46	11	14	7
<i>F</i>	0	53	50	28	14	25

The Assignment Problems

Subtracting the smallest element of each column from all the elements of that column, we get the following:

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>
<i>A</i>	0	13	49	0	0	10
<i>B</i>	0	35	29	5	10	0
<i>C</i>	13	0	63	7	7	0
<i>D</i>	47	15	0	20	2	0
<i>E</i>	25	0	46	9	4	2
<i>F</i>	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 two lines, we get the following matrix:

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>
<i>A</i>	2	15	51	0	0	15
<i>B</i>	0	35	29	3	8	0
<i>C</i>	13	0	63	5	5	0
<i>D</i>	47	15	0	18	0	0
<i>E</i>	25	0	46	7	2	2
<i>F</i>	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

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>F</i>
<i>A</i>	4	17	51	0	0	17
<i>B</i>	0	35	27	1	6	0
<i>C</i>	13	0	61	3	3	0
<i>D</i>	49	17	0	18	0	2
<i>E</i>	25	0	44	5	0	2
<i>F</i>	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:

Cost Management

	a	b	c	d	e	f
A	2	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

The assignment is

- (i) $A \rightarrow d, B \rightarrow f, C \rightarrow b, D \rightarrow c, E \rightarrow e, F \rightarrow a$

And total effect = $11+48+28+27+25+3=142$

Alternate solutions exist. One of the alternate solutions is given by

- (ii) $A \rightarrow d, B \rightarrow a, C \rightarrow f, D \rightarrow c, E \rightarrow b$ and $F \rightarrow e$ 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:

The Assignment Problems

	<i>Leasing</i>	<i>Portfolio Management</i>	<i>Private Mutual Fund</i>	<i>Swaps & Options</i>	<i>Dummy</i>
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:

	<i>Leasing</i>	<i>Portfolio Management</i>	<i>Private Mutual Fund</i>	<i>Swaps & Options</i>	<i>Dummy</i>
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.

	<i>Leasing</i>	<i>Portfolio Management</i>	<i>Private Mutual Fund</i>	<i>Swaps & Options</i>	<i>Dummy</i>
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:

Cost Management

	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

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	<u>10</u>
		<u>70</u>

Thus, the total number of students who will be missing at least one seminar = 70

Question 8

A project consists of four (4) major jobs, for which four (4) contractors have submitted tenders. The tender amounts, in thousands of rupees, are given below:

	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)

The Assignment Problems

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

<i>Contractors</i>	<i>Jobs</i>			
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
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 its elements in turn. Draw the minimum number of lines horizontal or vertical so as to cover all zeros.

<i>Contractors</i>	<i>Jobs</i>			
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
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.

<i>Contractors</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
1	30	40	0	10
2	0	10	40	0
3	0	30	20	0
4	0	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.

Cost Management

Question 9

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

The Assignment Problems

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	=	<u>20</u>
				<u>82 hours</u>

Minimum time taken = 82 hours

Question 10

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.

Cost Management

Answer

Reducing minimum from each column element (figure in '000s)

Step 1					Step 2				
	R ₁	R ₂	R ₃	R ₄		R ₁	R ₂	R ₃	R ₄
C ₁	1	1	—	—	C ₁	0	0	—	—
C ₂	—	0	—	0	C ₂	—	0	—	0
C ₃	0	—	0	—	C ₃	0	—	0	—
C ₄	—	—	2	1	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					Step 2				
	R ₁	R ₂	R ₃	R ₄		R ₁	R ₂	R ₃	R ₄
C ₁	0	1	—	—	C ₁	0	1	—	—
C ₂	—	0	—	0	C ₂	—	0	—	0
C ₃	1	—	0	—	C ₃	0	—	0	—
C ₄	—	—	0	1	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 C₁ – R₁ 4,000; C₂ – R₂ 4,000; C₃ – R₃ 2,000; C₄ – R₄ 5,000; (Total) = 15,000.

Question 11

A gear manufacturing company makes two types of gears – A and B. Both gears are processed on 3 machines, Hobbing M/c, Shaping M/c and Grinding M/c. The time required by each gear and total time available per week on each M/c is as follows:

	Gear (A)	Gear (B)	Available
Machine	(Hours)	(Hours)	Hours
Hobbing M/c	3	3	36
Shaping M/c	5	2	60
Grinding M/c	2	6	60
Other data:			
Selling price (Rs.)	820	960	
Variable cost (Rs.)	780	900	

The Assignment Problems

Determine the optimum production plan and the maximum contribution for the next week by simplex method. The initial table is given below:

		C_j	40	60	0	0	0
		Qty.					
C_j	Variable		X_1	X_2	X_3	X_4	X_5
0	X_3	36	3	3	1	0	0
0	X_4	60	5	2	0	1	0
0	X_5	60	2	6	0	0	1

(May 2007, 7 Marks)

Answer

Table 1

		C_j	40	60	0	0	0	Ratio	
		Qty							
c_j	Variable		X_1	X_2	X_3	X_4	X_5		
0	X_3	36	3	3	1	0	0	12	
0	X_4	60	5	2	0	1	0	30	
0	X_5	60	2	6	0	0	1	10	←
	Z_j	0	0	0	0	0	0		
	$Z_j - C_j$		-40	-60	0	0	0		

Table 2

		C_j	40	60	0	0	0	Ratio	
		Qty							
c_j	Variable		X_1	X_2	X_3	X_4	X_5		
0	X_3	6	2	0	1	0	$-\frac{1}{2}$	3	←
0	X_4	40	$\frac{13}{3}$	0	0	1	$-\frac{1}{3}$	$\frac{120}{13}$	
60	X_2	10	$\frac{1}{3}$	1	0	0	$\frac{1}{6}$	30	
	Z_j	600	20	60	0	0	10		
	$Z_j - C_j$		-20	0	0	0	10		

Cost Management

Table 3

		C_j	40	60	0	0	0
	Qty						
c_j	Variable		X_1	X_2	X_3	X_4	X_5
40	X_1	3	1	0	$\frac{1}{2}$	0	$-\frac{1}{4}$
0	X_4	27	0	0	$-\frac{13}{6}$	1	$\frac{3}{4}$
60	X_2	9	0	1	$-\frac{1}{6}$	0	$\frac{1}{4}$
	Z_j	660	40	60	10	0	5
	$Z_j - C_j$		0	0	10	0	5

Since all $Z_j - C_j$ are positive or zero, this is the optimum solution with. $X_1 = 40$ and $X_2 = 60$ and optimum $Z = 660$.

Note : Alternatively, $C_j - Z_j$ may be used whereby maximum positive value may be considered.

Question 12

A company has four zones open and four marketing managers available for assignment. The zones are not equal in sales potentials. It is estimated that a typical marketing manager operating in each zone would bring in the following Annual sales:

Zones	Rs.
East	2,40,000
West	1,92,000
North	1,44,000
South	1,20,000

The four marketing managers are also different in ability. It is estimated that working under the same conditions, their yearly sales would be proportionately as under:

Manager M	:	8
Manager N	:	7
Manager O	:	5
Manager P	:	4

Required:

If the criterion is maximum expected total sales, find the optimum assignment and the maximum sales.
(Nov 2007, 11 Marks)

The Assignment Problems

Answer

Sum of the proportion = $(8 + 7 + 5 + 4) = 24$

Assuming Rs. 1,000 as one unit, the effective matrix is as follows:

Effective Matrix

Managers	Zones			
	East	West	North	South
M	$(8/24) \times 240 = 80$	$(8/24) \times 192 = 64$	$(8/24) \times 144 = 48$	$(8/24) \times 120 = 40$
N	$(7/24) \times 240 = 70$	$(7/24) \times 192 = 56$	$(7/24) \times 144 = 42$	$(7/24) \times 120 = 35$
O	$(5/24) \times 240 = 50$	$(5/24) \times 192 = 40$	$(5/24) \times 144 = 30$	$(5/24) \times 120 = 25$
P	$(4/24) \times 240 = 40$	$(4/24) \times 192 = 32$	$(4/24) \times 144 = 24$	$(4/24) \times 120 = 20$

Convert the maximization problem to minimization problem

The resultant loss matrix is as follows:

Loss Matrix

Managers	East	West	North	South
M	0	16	32	40
N	10	24	38	45
O	30	40	50	55
P	40	48	56	60

Row operation

Managers	East	West	North	South
M	0	16	32	40
N	0	14	28	35
O	0	10	20	25
P	0	8	16	20

Column operation

Managers	East	West	North	South
M	0	8	16	20
N	0	6	12	15
O	0	2	4	5
P	0	0	0	0

Cost Management

Managers	East	West	North	South
M	0	6	14	18
N	0	4	10	13
O	0	0	2	3
P	2	0	0	0

Managers	East	West	North	South
M	0	2	10	14
N	0	0	6	9
O	4	0	2	3
P	6	0	0	0

Managers	East	West	North	South
M	0	2	8	12
N	0	0	4	7
O	4	0	0	1
P	8	2	0	0

Assignment

Sales

	Rs.
M – East	80,000
N – West	56,000
O – North	30,000
P – South	<u>20,000</u>
	<u>1,86,000</u>

NOTE

[illegible]

18 & 19

CPM & PERT

Question 1

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:

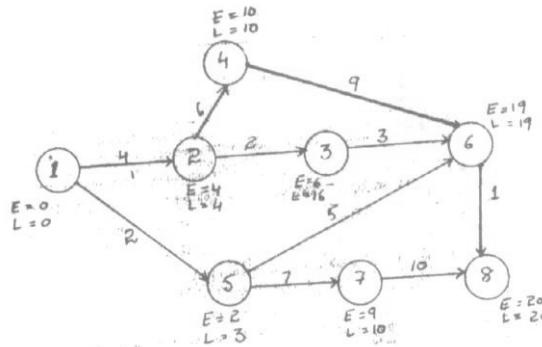
- (i) Critical path
- (ii) Expected cost of construction of the plant
- (iii) Expected time required to build the plant
- (iv) The standard deviation of the expected time.

(May 2001)

Cost Management

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 2

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

CPM & PERT

Construct the PERT network and compute.

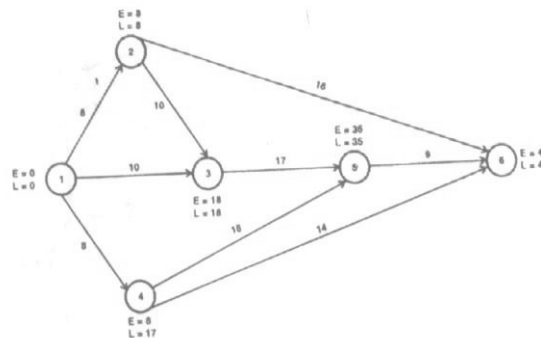
(i) Critical path and its duration.

(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 Float (TF) (LST-EST) or (LFT-EFT)	Free Float (TF- Head event slack)
		Earliest (EST)	Latest (LST)	Earliest (EFT)	Latest (LFT)		
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

Cost Management

Question 3

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		

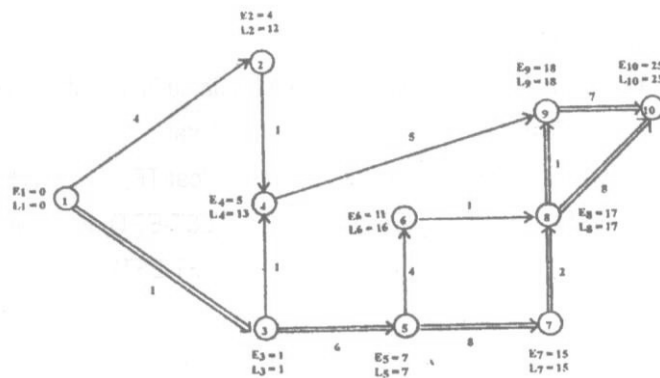
Construct a PERT network and compute:

- T_E and T_L for each event;
- Float for each activity; and
- Critical path and its duration.

(May 2000)

Answer

The network is constructed as given in figure below:



- 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

CPM & PERT

(ii) Activity floats are computed using the following formula:

$$\text{Float} = T_L (\text{Head event}) - T_E (\text{Tail event}) - \text{Duration}$$

<i>Activity</i>	<i>Duration</i>	<i>T_E (Tail Event)</i>	<i>T_L(Head Event)</i>	<i>Float</i>
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 4

A project has the following time schedule:

<i>Time in Weeks</i>		<i>Activity</i>	<i>Time in Weeks</i>
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

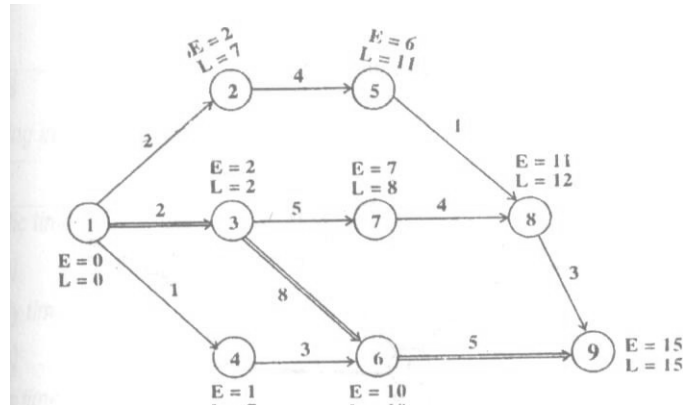
Cost Management

(ii) critical path and its duration.

(Nov 1999)

Answer

The required PERT network is given below:



(ii) Total float of each activity is calculated below:

Activity	Duration (in weeks)	Start		Finish		Total (LST-EST)
		Earliest (EST)	Latest (LST)	Earliest (EST)	Latest (LFT)	
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 5

Given the following information:

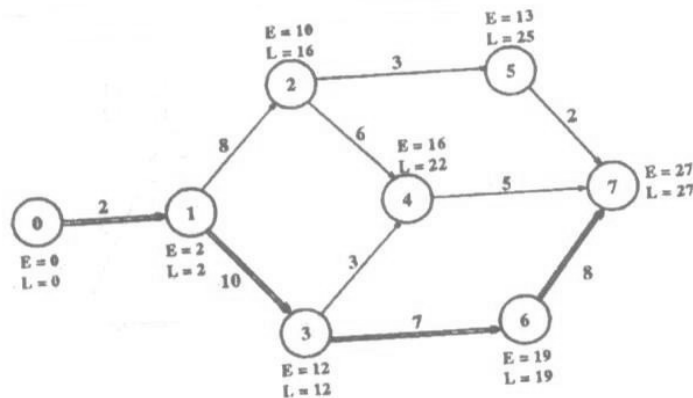
Activity:	0-1	1-2	1-3	2-4	2-5	3-4	3-6	4-7	5-7	6-7
Duration:	2	8	10	6	3	3	7	5	2	8

(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

Cost Management

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 6

A small project consists of jobs as give in the table below. Each job is listed with titts 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 (in days)	Minimum (crash) Duration (in days)	Cost of Crashing (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

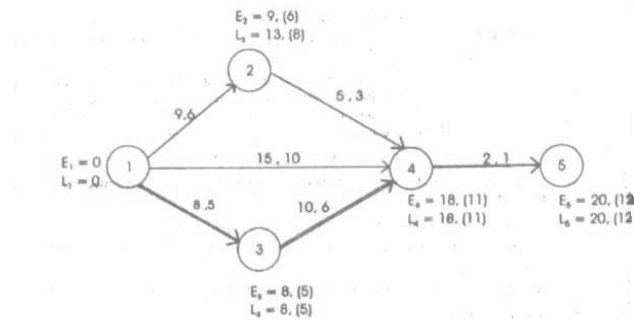
- What is the normal project length and the minimum project length?
- Determine the minimum crashing cost of schedules ranging from normal length down to, and including the minimum length schedule. That is, if L = Length of the schedule, find the costs of schedules which are L , $L - 1$, $L - 2$ and so on.
- 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

- The required network is given below:

CPM & PERT



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 consumes 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

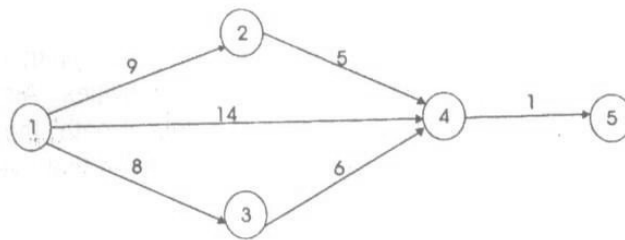
Cost Management

15	3-4, 1-4	$4 \times 15 + 1 \times 40 + 1 \times 30 = 130$	15×60	1,030
14	1-3, 1-4, 2-4	$130 + 1 \times 30 + 1 \times 25 + 1 \times 10 = 195$	15×60	1,035
13	1-3, 1-4, 2-4	$195 + 1 \times 25 + 1 \times 30 + 1 \times 10 = 260$	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 $1 \rightarrow 2 \rightarrow 4 \rightarrow 5 = 9 + 5 + 1 = 15$ days

Path $1 \rightarrow 4 \rightarrow 5 = 14 + 1 = 15$ days

Path $1 \rightarrow 3 \rightarrow 4 \rightarrow 5 = 8 + 6 + 1 = 15$ days.

Hence, the optimum duration of the project is 15 days.

Question 7

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

CPM & PERT

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 8

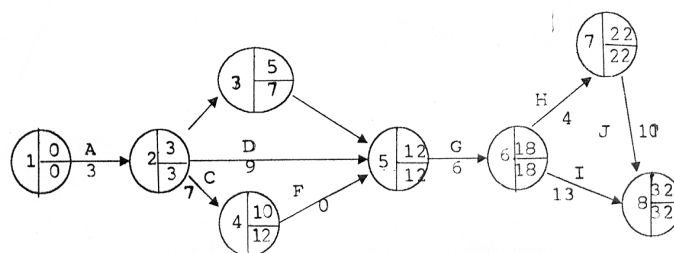
A product comprised of 10 activities whose normal time and cost are given as follows:

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



Cost Management

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

$$3 + 9 + 6 + 4 + 10 = 32 \text{ days}$$

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 9

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 (I-j)	Estimated durations (in days)		
	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

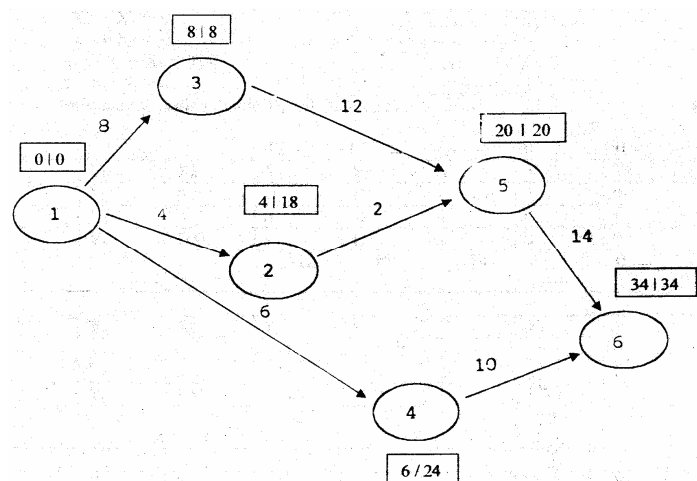
CPM & PERT

- (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) =			$\sigma^2 = \left(\frac{b-a}{6} \right)^2$	
(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 $\sigma^2 = 4 + 16 + 16 = 36$

Cost Management

The standard normal deviate is:

$$Z = \frac{\text{due date} - \text{expected date of completion}}{\sqrt{\text{variance}}}$$

$$Z = \frac{26 - 34}{6} = -\frac{8}{6} = -1.33 \text{ probability of meeting the due date is } 0.0918 \text{ or } 9.18\%$$

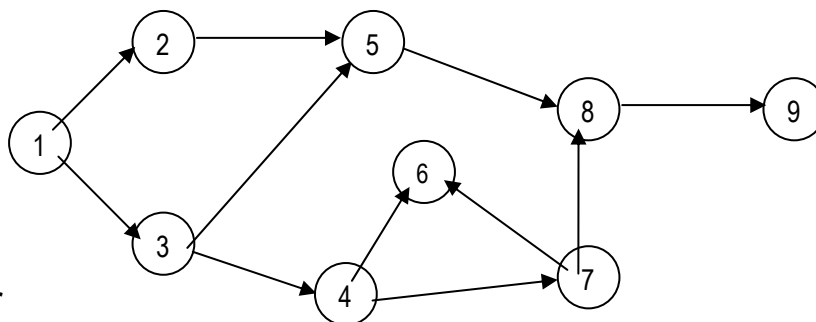
(d) When due date is 38 days

$$Z = \frac{38 - 34}{6} = \frac{4}{6} = 0.67 \text{ Probability meeting the date is } 0.2514 \text{ or } 25.14\%.$$

Question 10

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 (1, 3, 5, 8, 9) 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 1, 2, 5, 8, 9, 1, 3, 4, 6, 7, 8, 9 and 1, 3, 4, 7, 8, 9. This has 16 combinations.

CPM & PERT

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 |
| | 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.)

Question 11

A company had planned its operations as follows:

<i>Activity</i>	<i>Duration (days)</i>
1–2	7
2–4	8
1–3	8
3–4	6
1–4	6
2–5	16
4–7	19
3–6	24
5–7	9

Cost Management

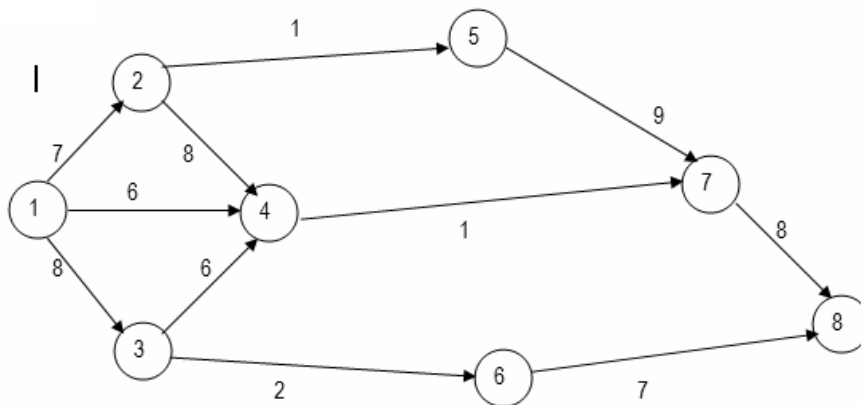
6–8	7
7–8	8

- (i) Draw the network and find the critical paths.
- (ii) After 15 days of working, the following progress is noted:
- Activities 1–2, 1–3 and 1–4 completed as per original schedule.
 - Activity 2–4 is in progress and will be completed in 4 more days.
 - Activity 3–6 is in progress and will need 17 more days to complete.
 - The staff at activity 3–6 are specialised. They are directed to complete 3–6 and undertake an activity 6–7, which will require 7 days. This rearrangement arose due to a modification in a specialisation.
 - Activity 6–8 will be completed in 4 days instead of the originally planned 7 days.
 - There is no change in the other activities.

Update the network diagram after 15 days of start of work based on the assumption given above. Indicate the revised critical paths alongwith their duration. (May 2007, 11 Marks)

Answer

(i)



Paths	Duration
1 – 2 – 5 – 7 – 8	$7 + 16 + 9 + 8 = 40$
1 – 2 – 4 – 7 – 8	$7 + 8 + 19 + 8 = 42$
1 – 4 – 7 – 8	$6 + 19 + 8 = 33$
1 – 3 – 4 – 7 – 8	$8 + 6 + 19 + 8 = 41$

CPM & PERT

1 – 3 – 6 – 8

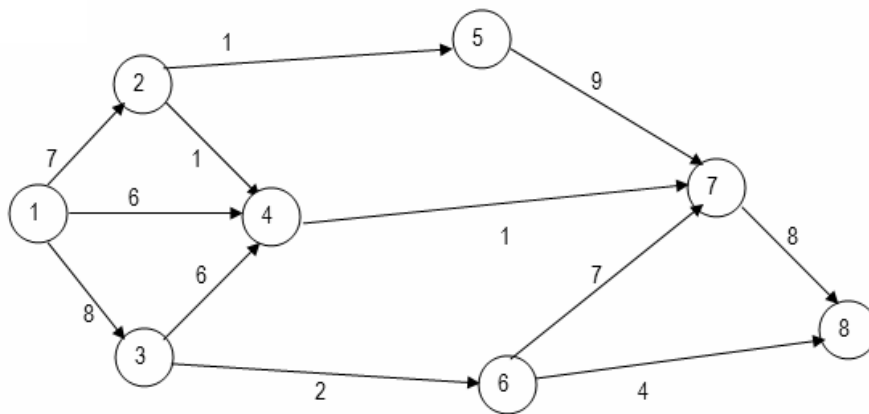
$$8 + 24 + 7 = 39$$

Critical path 1 – 2 – 4 – 7 – 8 = 42 days.

Revised Duration of activities 2 – 4 and 3 – 6 after 15 days for update.

Activity	Preceding Activity	Date of completion	Revised Duration
2 – 4	1 – 2	$15 + 4 = 19$ days	$19 - 7 = 12$ days
3 – 6	1 – 3	$15 + 17 = 32$ days	$32 - 8 = 24$ days
6 – 7 (new activity)	3 – 6		7 days
6 – 8	3 – 6		4 days

(ii)



Paths	Duration
1 – 2 – 5 – 7 – 8	$7 + 16 + 9 + 8 = 40$
1 – 2 – 4 – 7 – 8	$7 + 12 + 19 + 8 = 46$
1 – 4 – 7 – 8	$6 + 19 + 8 = 33$
1 – 3 – 4 – 7 – 8	$8 + 6 + 19 + 8 = 41$
1 – 3 – 6 – 7 – 8	$8 + 24 + 7 + 8 = 47$
1 – 3 – 6 – 8	$8 + 24 + 4 = 36$

Critical path = 1 – 3 – 6 – 7 – 8 = 47 days.

Question 12

The following table gives the activities in a construction project and the time duration of each activity:

Cost Management

Activity	Preceding activity	Normal Time (Days)
A	—	16
B	—	20
C	A	8
D	A	10
E	B, C	6
F	D, E	12

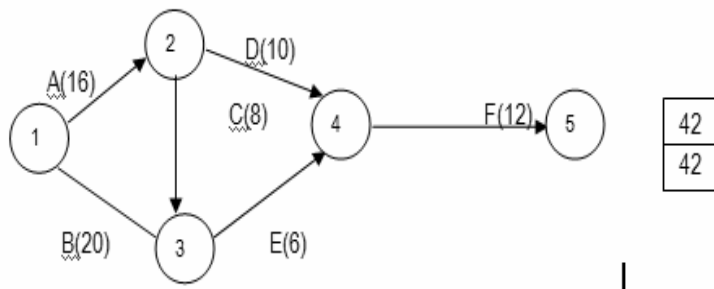
Required:

- Draw the activity network of the project.
- Find critical path.
- Find the total float and free-float for each activity.

(Nov 2007, 6 Marks)

Answer

(i)



$$A \rightarrow D \rightarrow F = 16 + 10 + 12 = 38$$

$$B \rightarrow E \rightarrow F = 20 + 6 + 12 = 38$$

$$(ii) \quad A - C - E - F = 16 + 8 + 6 + 12 = 42$$

Critical path

(iii) Total float and free float for each activity

Activity	Normal time (Days)	Earliest start	Time finish	Latest start	Time finish	Float total	Free
A	16	0	16	0	16	0	0
B	20	0	20	4	24	4	4
C	8	16	24	16	24	0	0
D	10	16	26	20	30	4	4
E	6	24	30	24	30	0	0
F	12	30	42	30	42	0	0

CPM & PERT

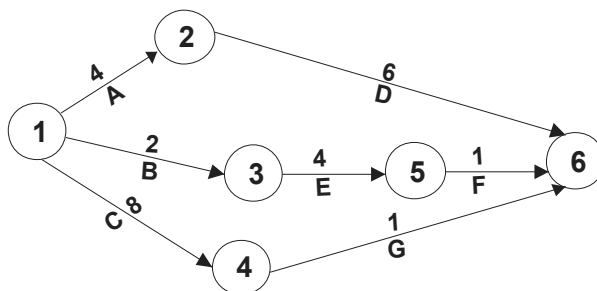
Question 13

The following information is available:

	Activity	No. of days	No. of men required per day
A	1—2	4	2
B	1—3	2	3
C	1—4	8	5
D	2—6	6	3
E	3—5	4	2
F	5—6	1	3
G	4—6	1	8

- Draw the network and find the critical path.
- What is the peak requirement of Manpower? On which day(s) will this occur?
- If the maximum labour available on any day is only 10, when can the project be completed? (May 2008, 9 Marks)

Answer



Path	Days
AD	10 → CP
BEF	7
CG	9

Critical Path = 1— 2 — 6

i.e. AD = 10 days.

Peak requirement is 11 men, required on days 7 and 9.

If only 10 men are available on any day, shift F,G to days 10 and 11 and the project can be completed in 11 days.

Cost Management

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	A ₂	A ₂	A ₂	A ₂										
					D ₃	D ₃	D ₃	D ₃	D ₃	D ₃				
	B ₃	B ₃	E ₂	E ₂	E ₂	E ₂								
							F ₃							
	C ₅	C ₅	C ₅	C ₅	C ₅	C ₅	C ₅	C ₅						
									G ₈					
	10	10	9	9	10	10	11	8	11	3				
If s/o shift										F ₃	G ₈			
New	10	10	9	9	10	10	8	8	3	6	8			

Question 14

What do you mean by a dummy activity? Why is it used in networking?

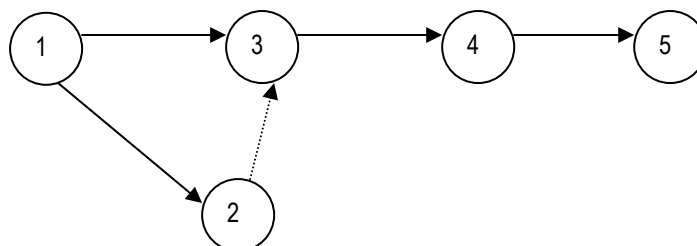
(May 2008, 4 Marks)

Answer

Dummy activity is a hypothetical activity which consumes no resource or time. It is represented by dotted lines and is inserted in the network to clarify an activity pattern under the following situations.

- To make activities with common starting and finishing events distinguishable.
- To identify and maintain the proper precedence relationship between activities that are not connected by events.
- To bring all "loose ends" to a single initial and single terminal event.

e.g.



Dummy (2) – (3) is used to convey that can start only after events numbered (2) and (3) are over:

Question 15

A project consists of seven activities and the time estimates of the activities are furnished as under:

CPM & PERT

Activity	Optimistic Days	Most likely Days	Pessimistic Days
1–2	4	10	16
1–3	3	6	9
1–4	4	7	16
2–5	5	5	5
3–5	8	11	32
4–6	4	10	16
5–6	2	5	8

Required:

- (i) Draw the network diagram.
- (ii) Identify the critical path and its duration.
- (iii) What is the probability that the project will be completed in 5 days earlier than the critical path duration?
- (iv) What project duration will provide 95% confidence level of completion ($Z_{0.95} = 1.65$) ?

Given

Z	1.00	1.09	1.18	1.25	1.33
Probability	0.1587	0.1379	0.1190	0.1056	0.0918

(Nov 2008, 11 Marks)

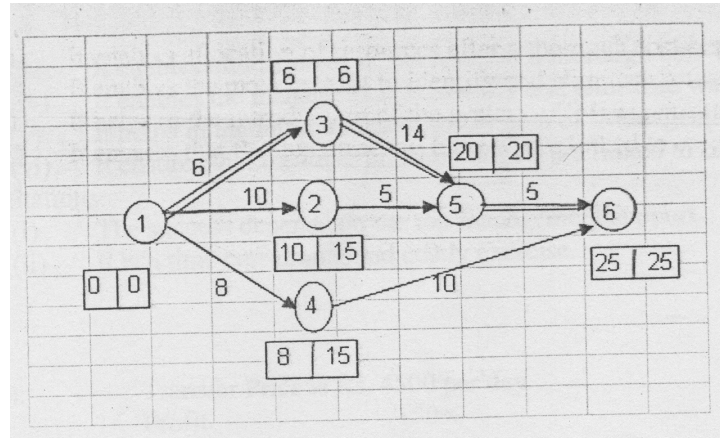
Answer

Calculation of expected time and variance of each activity:

Activity	Optimistic Days	Most likely Days	Pessimistic Days	Expected Duration	Variance
1–2	4	10	16	10	4
1–3	3	6	9	6	1
1–4	4	7	16	8	4
2–5	5	5	5	5	0
3–5	8	11	32	14	16
4–6	4	10	16	10	4
5–6	2	5	8	5	1

Cost Management

The network diagram is as under:



Critical Path:	1-3	3-5	5-6	
Duration (days)	6	14	5	= 25 days
Standard deviation:	1	+	16	+ 1 = 18
				$\sqrt{18} = 4.24$

Probability that the project will be completed five days earlier:

$$Z = \frac{20 - 25}{4.24} = -1.18.$$

According to probability values given in the question probability is 11.9%

To obtain 95% confidence level:

$$1.65 = \frac{X - 25}{4.24}$$

$$X - 25 = 6.996$$

$$X = 32 \text{ days}$$

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:

$$\text{Return (\%)} = \frac{\text{Profit} \times \text{Number of units demanded}}{\text{Investment}} \times 100$$

Cost Management

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

<i>Units in thousands</i>	<i>Probability</i>	<i>Cum. Probability</i>	<i>Random Numbers Assigned</i>
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

<i>Profit</i>	<i>Probability</i>	<i>Cum. Probability</i>	<i>Random Numbers Assigned</i>
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)

<i>Investment</i>	<i>Probability</i>	<i>Cum. Probability</i>	<i>Random Numbers Assigned</i>
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:

<i>Trials</i>	<i>Random number of demand</i>	<i>Simulated demand (0'000) units</i>	<i>Random No. for profit per unit</i>	<i>Simulated profit per unit</i>	<i>Random number for investment</i>	<i>Simulated investment ('000) Rs.</i>	<i>Simulated return (%) (Demand × profit per unit × 1,000) ÷ Investment</i>
1	30	35	12	5.00	16	2750	6.36

Simulation

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 (in sec.)	Time Frequency For Param	Time frequency 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

Cost Management

- (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

Simulation

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

Cost Management

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	$37 \times 1 - 3 \times 2 = 31$	$37 \times 1 - 2 \times 2 = 33$
2	98	42	$40 \times 1 - 2 \times 1 = 38$	$39 \times 1 - 3 \times 1 = 36$
3	64	40	$40 \times 1 = 40$	$39 \times 1 - 1 \times 1 = 38$
4	98	42	$40 \times 1 - 2 \times 1 = 38$	$39 \times 1 - 3 \times 1 = 36$
5	94	41	$40 \times 1 - 1 \times 1 = 39$	$39 \times 1 - 2 \times 1 = 37$
6	01	37	$37 \times 1 - 3 \times 2 = 31$	$37 \times 1 - 2 \times 2 = 33$
7	78	40	$40 \times 1 = 40$	$39 \times 1 - 1 \times 1 = 38$
8	10	38	$38 \times 1 - 2 \times 2 = 34$	$38 \times 1 - 1 \times 2 = 36$
9	15	38	$38 \times 1 - 2 \times 2 = 34$	$38 \times 1 - 1 \times 2 = 36$
10	19	38	$38 \times 1 - 2 \times 2 = 34$	$36 \times 1 - 1 \times 2 = 36$

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:

<i>Annual Demand</i>							
(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

Simulation

<i>Investment required</i>			
<i>(in thousands of Rupees):</i>	2,750	3,000	3,500
<i>Probability :</i>	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:

$$\text{Return (\%)} = \frac{\text{Profit} \times \text{Number of units demanded}}{\text{Investment}} \times 100$$

First of all, random number 00-99 are allocated in proportion to the probabilities associated with each of the three variables as given under:

Annual Demand

<i>Units in thousands</i>	<i>Probability</i>	<i>Cum. Probability</i>	<i>Random Number assigned</i>
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

<i>Profit</i>	<i>Probability</i>	<i>Cum. Probability</i>	<i>Random Number assigned</i>
3.00	0.10	0.10	00-09
5.00	0.20	0.30	10-29

Cost Management

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 Demand	Simulated demand ('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 × 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.

Simulation

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.

Cost Management

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

$$\begin{aligned}
 &= (400 + 40 + 220) - (60 + 200) \\
 &= 660 - 260 \\
 &= \text{Rs.}400
 \end{aligned}$$

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 manager of the book-store wishes to compare two options for his inventory decision:

- A. Order 5 books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books.
- B. Order 8 books, when the inventory at the beginning of the day plus orders outstanding is less than 8 books.

Currently (beginning of the 1st day) the store has stock of 8 books plus 6 books 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)

Simulation

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:

<i>Demand</i>	<i>Probability</i>	<i>Cum. Probability</i>	<i>Random Nos.</i>
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:

<i>Day</i>	<i>Random No.</i>	<i>Sales Demand</i>	<i>Op. Stock in hand</i>	<i>Qty. Order</i>	<i>Qty. Recd. At end of the day</i>	<i>Total Qty. on order</i>	<i>Closing Stock</i>
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.

Cost Management

	<i>Random No.</i>	<i>Sales Demand</i>	<i>Opening Stock in hand</i>	<i>Qty. Order</i>	<i>Qty. Recd. At end of the day</i>	<i>Total Qty. on order</i>	<i>Closing Stock</i>
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 the 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)

	<i>Random No.</i>	<i>Sales Demand</i>	<i>Opening Stock in hand</i>	<i>Qty. Order</i>	<i>Qty. Recd. At end of the day</i>	<i>Total Qty. on order</i>	<i>Closing Stock</i>
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 = $39 \times 0.50 = \text{Rs.}19.50$

Simulation

Ordering Cost = $4 \times 10 = \text{Rs.}40.00$

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 = $45 \times 0.50 = \text{Rs.}22.50$

Ordering Cost = $2 \times 10 = \text{Rs.}20.00$

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)

Cost Management

Answer

The numbers 00-99 are allocated in proportion to the probabilities associated with each event as given below:

<i>Daily Demand</i>	<i>Probability</i>	<i>Cumulative Probability</i>	<i>Random Numbers Allocated</i>
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.

<i>Day</i>	<i>Random Number</i>	<i>Simulated Demand</i>	<i>Stock if 30 breads are prepared every day</i>
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
	<i>Total</i>	<i>220</i>	

Daily average demand of the basis of simulated data = 220

Question 8

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)

Simulation

<i>Demand (unit per day)</i>	<i>Probability</i>
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

<i>Demand</i>	<i>Probability</i>	<i>Cumulative prob.</i>	<i>Random numbers</i>
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

<i>Day</i>	<i>Random numbers</i>	<i>Opening Stock</i>	<i>Demand</i>	<i>Closing Stock</i>	<i>Order placed</i>	<i>Order in</i>	<i>Average stock</i>
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

Cost Management

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 (94.5×2.50) =Rs.236.25

Ordering cost (2×20) =Rs.40.00
Rs.276.25

Option 9

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 (75.5×2.50) = Rs.118.75

Ordering cost (2×20) = 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:

Simulation

<i>Demand Copies</i>	<i>Probability</i>
$0 < 300$	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

<i>Demand</i>	<i>Probability</i>	<i>Cumulative probability</i>	<i>Allocated RN</i>
$0 < 300$	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

<i>Month</i>	<i>RN</i>	<i>Demand</i>	<i>Sold</i>	<i>Return</i>	<i>Profit on sales (Rs.)</i>	<i>Loss on return (Rs.)</i>	<i>Net (Rs.)</i>	<i>Loss on lost units</i>
1	27	450	450	300	3375	12000	2175	
2	15	150	150	600	1125	2400	-1275	
3	56	750	750	--	5625	--	5625	

Cost Management

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 $2100 \times 7.5 = \text{Rs}15750$.

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.

Question 12

How would you use the Monte Carlo Simulation method in inventory control?

(May 2008, 4 Marks)

Answer

The Monte Carlo Simulation:

It is the earliest mathematical Model of real situations in inventory control:

Steps involved in carrying out Monte Carlo simulation are:

- ◆ Define the problem and select the measure of effectiveness of the problem that might be inventory shortages per period.
- ◆ Identify the variables which influence the measure of effectiveness significantly for example, number of units in inventory.
- ◆ Determine the proper cumulative probability distribution of each variable selected with the probability on vertical axis and the values of variables on horizontal axis.
- ◆ Get a set of random numbers.
- ◆ Consider each random number as a decimal value of the cumulative probability distribution with the decimal enter the cumulative distribution plot from the vertical axis. Project this point horizontally, until it intersects cumulative probability distribution curve. Then project the point of intersection down into the vertical axis.
- ◆ Then record the value generated into the formula derived from the chosen measure of effectiveness. Solve and record the value. This value is the measure of effectiveness for that simulated value. Repeat above steps until sample is large enough for the satisfaction of the decision maker.

Question 13

A single counter ticket booking centre employs one booking clerk. A passenger on arrival immediately goes to the booking counter for being served if the counter is free. If, on the other hand, the counter is engaged, the passenger will have to wait. The passengers are served on first come first served basis. The time of arrival and the time of service varies from one minute to six minutes. The distribution of arrival and service time is as under:

<i>Arrival / Service Time (Minutes)</i>	<i>Arrival (Probability)</i>	<i>Service (Probability)</i>
1	0.05	0.10
2	0.20	0.20
3	0.35	0.40
4	0.25	0.20
5	0.10	0.10
6	0.05	—

Cost Management

Required:

- (i) Simulate the arrival and service of 10 passengers starting from 9 A.M. by using the following random numbers in pairs respectively for arrival and service. Random numbers 60 09 16 12 08 18 36 65 38 25 07 11 08 79 59 61 53 77 03 10.
- (ii) Determine the total duration of
 - (1) Idle time of booking clerk and
 - (2) Waiting time of passengers.

(Nov 2008, 8 Marks)

Answer

Random allocation tables are as under:

Time (Mts)	Arrival (Probability)	Arrivals Cumulative Probability	Random No. allocated	Time (Mts)	Service (Probability)	Service Cumulative (Probability)	Random No. allocated
1	0.05	0.05	00-04	1	0.10	0.10	00-09
2	0.20	0.25	05-24	2	0.20	0.30	10-29
3	0.35	0.60	25-59	3	0.40	0.70	30-69
4	0.25	0.85	60-84	4	0.20	0.90	70-89
5	0.10	0.95	85-94	5	0.10	1.00	90-99
6	0.05	1.00	95-99				

Simulation of ten trails:

R. No.	Arrival Mts.	Time	Start	R. No.	Time Mts.	Finish Time	Waiting Time	
							Clerk	Passanger
60	4	9.04	9.04	09	1	9.05	4	
16	2	9.06	9.06	12	2	9.08	1	
08	2	9.08	9.08	18	2	9.10	—	
36	3	9.11	9.11	65	3	9.14	1	
38	3	9.14	9.14	25	2	9.16	—	
07	2	9.16	9.16	11	2	9.18	—	
08	2	9.18	9.18	79	4	9.22	—	
59	3	9.21	9.22	61	3	9.25	—	1
53	3	9.24	9.25	77	4	9.29		1
03	1	9.25	9.29	10	2	9.31	—	<u>4</u>
Total							<u>6</u>	<u>6</u>

In half an hour trial, the clerk was idle for 6 minutes and the passengers had to wait for 6 minutes.

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.

Cost Management

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
Variable Overhead	20% of 577.55
Fixed Overhead	Dept A 20 Hrs @8= 160 Dept B 25.17 Hrs @5=125.85
Total cost	1,478.91
Profit 25%	369.73
Selling price per unit	1,848.64

Learning Curve Theory

(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	533.60
	Dept B 22.24 @ 15 = 333.60	
Variable Overhead	20% of 533.60	106.72
Fixed Overhead	Dept A 20 Hrs @ 8 = 160	271.20
	Dept B 22.24 Hrs @ 5 = 111.20	
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.

Cost Management

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.

Question 3

Discuss the application of the learning curve.

(May 2007, 4 Marks)

Answer

Application of Learning curve: Learning curve helps to analyse cost-volume profit relationships during familiarisation phase of product or process to arrive at cost estimates.

It helps in budgeting and profit planning.

It helps in pricing and consequent decision making – e.g. acceptance of an order, negotiations in establishing contract prices etc. with the advantage of the knowledge of decreasing unit cost.

It helps in setting standards in the learning phase.

Question 4

What are the distinctive features of learning curve theory in manufacturing environment? Explain the learning curve ratio.

(Nov 2007, 9 Marks)

Answer

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. As the quantity produced doubles, the absolute amount of cost increase will be successively smaller but the rate of decrease will remain fixed. It occurs due to the following distinctive features of manufacturing environment:

- (i) Better tooling methods are developed and used.
- (ii) More productive equipments are designed and used to make the product.
- (iii) Design bugs are detected and corrected.
- (iv) Engineering changes decrease over time.
- (v) Earlier teething problems are overcome.
- (vi) Rejections and rework tend to diminish over time.

In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in

Learning Curve Theory

advance. The effect of experience on cost is summarized in the learning curve ratio or improvement ratio.

$$\text{Learning curve ratio} = \frac{\text{Average labour cost of first } 2N \text{ units}}{\text{Average labour cost of first } N \text{ units}}$$

For example, if the average labour cost for the first 500 units is Rs. 25 and the average labour cost for the first 1,000 units is Rs. 20, the learning curve ratio is (Rs. 20/25) or 80%. Since the average cost per unit of 1,000 units is Rs. 20, the average cost per unit of first 2,000 units is likely to be 80% of Rs. 20 or Rs. 16.

Question 5

M Ltd. Manufactures a special product purely carried out by manual labour. It has a capacity of 20,000 units. It estimates the following cost structure:

Direct material 30 Rs. / unit

Direct labour (1 hour / unit) 20 Rs. / unit

Variable overhead 10 Rs. / unit

Fixed overheads at maximum capacity is Rs. 1,50,000.

It is estimated that at the current level of efficiency, each unit requires one hour for the first 5,000 units. Subsequently it is possible to achieve 80% learning rate. The market can absorb the first 5,000 units at Rs.100 per unit. What should be the minimum selling price acceptable for an order of 15,000 units for a prospective client? (May 2008, 7 Marks)

Answer

	5,000 units	20,000 units
Material	1,50,000	6,00,000
Direct Labour	1,00,000	2,56,000
		Refer to W Note i
Variable Overhead	<u>50,000</u>	<u>2,00,000</u>
Total Variable Cost	3,00,000	10,56,000
Fixed Cost	<u>1,50,000</u>	<u>1,50,000</u>
Total Cost	4,50,000	12,06,000
Total cost / unit	90	60.3
Sales $100 \times 5,000$	5,00,000	<u>5,00,000</u>
$15,000 \times x$ (assumed selling price)		15,000 x
(Total Sales less Total Cost) = Profit	50,000	$15,000 x - 7,06,000$
Or minimum selling price = 50.4 (refer to Working Note ii)		

Cost Management

Working Note: I

<i>Units</i>	<i>Hours</i>
5,000	5,000
10,000	$10,000 \times 1 \times .8 = 8,000$ hours
20,000	$20,000 \times 1 \times .8 \times .8 = 12,800$ hours

Working Note: II

$$15,000x - 7,06,000 > 50,000$$

$$15,000x > 7,56,000$$

$$\text{or } x > 50.4$$

Alternative Solution:

$$\text{Total cost / unit of capacity } 20,000 = 60.3$$

$$\text{Weighted average selling price} > 80.4$$

$$\text{i.e. } \frac{5,000 \times 100 + 15,000x}{20,000} > 60.3$$

$$= 5,00,000 + 15,000x > 60.3 \times 20,000$$

$$= 15,000x > 12,06,000 - 5,00,000$$

Or

$$15,000x > 7,06,000$$

$$x > 47.06$$

$$\text{Minimum price to cover production Cost} = 47.06$$

$$\text{Minimum price to cover same amount of profit} = 50.40 \text{ (refer to Working Note 1)}$$

Working Note 1

$$(-47.06 + 50.04) \times 15,000 \text{ units}$$

$$= \text{Rs. } 50,000$$

Question 6

A company which has developed a new machine has observed that the time taken to manufacture the first machine is 600 hours. Calculate the time which the company will take to manufacture the second machine if the actual learning curve rate is (i) 80% and (ii) 90%. Explain which of the two learning rates will show faster learning. (Nov 2008, 3 Marks)

Learning Curve Theory

Answer

- (i) Actual learning curve rate is 80%.

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= $600 \times 80\%$ hours
	= 480 hours.
Cumulative time taken to produce two machines	= 480×2 hours
	= 960 hours.
Time taken to produce the second machine	= $(960 - 600)$ hours
	= 360 hours.

- (ii) *Actual learning curve rate is 90%.*

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= $600 \times 90\%$ hours
	= 540 hours.
Cumulative time taken to produce two machines	= 540×2 hours
	= 1080 hours.
Time taken to produce the second machine	= $(1080 - 600)$ hours
	= 480 hours.

The time taken to produce the second machine is lower at 80% learning rate and hence 80% learning rate shows faster learning rate.

Cost Management

NOTE

This image shows a full page of blank white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page, providing a template for writing or drawing. There are no margins, text, or other markings present.



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