



Time Allowed: 3 Hours

Full Marks: 100

The figures in the margin on the right side indicate full marks.

SECTION – A (Compulsory)

1) Choose the correct option:

[15 × 2=30]

(i) A company has estimated the following demand level of its product:

Sales Volume (units)	10000	12000	14000	16000	18000
Probability	0.10	0.15	0.25	0.30	0.20

It has assumed that the sales price of ₹ 6 per unit, marginal cost of ₹ 3.50 per unit, and fixed costs of ₹ 34,000. What is the probability that The company will make a profit of at least ₹ 10,000?

- a) 40%
- b) 75%
- c) 20%
- d) 35%
- (ii) A company has a breakeven point when sales are ₹ 3,20,000 and variable cost at that level of sales are ₹ 2,00,000. How much would contribution margin increase or decrease if variable expenses are dropped by ₹30,000?
- a) Increase by 9.375%
- b) Decrease by 9.375%
- c) Increase by 37.5%
- d) Increase by 37.5%
- (iii) The Tech Company has fixed costs of ₹400,000 and variable costs are 75% of the selling price. To realize profits of ₹100,000 from sales of 5,00,000 units, the selling price per unit
- a) must be ₹1.00
- b) must be ₹4.80
- c) must be ₹4.00
- d) cannot be determined
- (iv) P operates an activity-based costing (ABC) system to attribute its overhead costs to cost objects. In its budget for the year ending 31st March 2024, the company expected to place a total of 2,895 purchase orders at a total cost of ₹1,10,010. This activity and its related costs were budgeted to occur at a constant rate throughout the budget year, which is divided into 13 four-week periods. During the four-week period ended 30 June 2023, a total of 210 purchase orders were placed at a cost of ₹7,650. The over- recovery of these costs for the four-week period was:
- a) ₹330
- b) ₹350
- c) ₹370
- d) ₹390



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- (v) The information relating to the direct material cost of a company is as follows:
Standard price per unit ₹7.20
Actual quantity purchased in units 1600
Standard quantity allowed for actual production in units 1450
Material price variance on purchase (Favourable) ₹480 What is the actual purchase price per unit?
- a) ₹5.50
 - b) ₹8.40
 - c) ₹7.80
 - d) ₹6.90
- (vi) An Assignment problem is solved to minimise the total time required to complete three jobs on three different machines such that each job is processed by exactly one machine and each machine processes exactly one job. The minimum total processing time is found to be 480 minutes. After a few days of operation, there has been a change in the design of the second job. Due to this, the processing time of the second job is increased by 15 minutes in either of the machines. The revised minimum total processing time will be –
- a) 495 minutes
 - b) 465 minutes
 - c) 480 minutes
 - d) None of these
- (vii) If the value of the game is zero, then the game is known as
- a) Fair strategy
 - b) Pure strategy
 - c) Pure game
 - d) Mixed strategy
- (viii) How long will it take to produce the 4th unit with 80% learning if the first unit took 75 hours?
- a) 48 hours
 - b) 35 hours
 - c) 25 hours
 - d) 30 hours
- (ix) Tableau is a –
- a) Business Intelligence Tool
 - b) Visualisation Tool
 - c) Both (a) and (b)
 - d) None of the above
- (x) Which of the following is not a primary activity of Value Chain?
- a) Inbound Logistics
 - b) Operations
 - c) Service
 - d) Infrastructure



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- (xi) The shadow price of skilled labour for SD Ltd. is currently ₹10 per hour. What does this mean?
- The cost of obtaining additional skilled labour is ₹10 per hour.
 - There is a hidden cost of ₹10 for each hour of skilled labour actively worked.
 - Contribution will be increased by ₹10 per hour for each extra hour of skilled labour that can be obtained.
 - The total costs will be reduced by ₹10 for each additional hour of skilled labour that can be obtained.
- (xii) JIT relates to
- Time Management
 - Inventory and product handling
 - Delivery systems
 - None of the above
- (xiii) Which of the following may be the cause of Material Price Variance?
- Change in quantity of purchase or uneconomical size of purchase order.
 - Failure to take advantage of off-season price or failure to purchase when price is cheaper.
 - Change in basic purchase price of material.
 - All of the above
- (xiv) BPR involves a radical redesign of core business processes to improve:
- Employee morale and retention
 - Productivity, cycle time, and quality
 - Marketing and customer loyalty
 - Organizational hierarchy only
- (xv) A Ltd. Plans to introduce a new product and issuing the target cost approach. Projected sales revenue is ₹90,00,000 (₹45 per unit) and target costs are ₹64,00,000. What is the desired profit per unit?
- ₹13
 - ₹17
 - ₹32
 - ₹10

Answer:

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)
c	a	c	a	d	a	a	a	c	d	c	b	d	b	a



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SECTION – B

Answer any 5 questions out of 7 questions given. Each question carries 14 marks. [5 × 14 = 70]

- 2) MN Agarwal owns a Gift-Shop, a Restaurant and a Lodge in Shillong. Typically, he operates these only during the season period of 4 months in a year. For the past season the occupancy rate in the Lodge was 90% and level of activity in case of Gift-Shop and Restaurant was 80%. The relevant data for the past season were as under-

(Amounts in ₹)

	Gift-Shop		Restaurant		Lodge	
	Amount (₹)	%	Amount (₹)	%	Amount (₹)	%
1. Receipts/ Sales	48,000	100	64,000	100	1,80,000	100
2. Expenditure:						
Cost of Sales	26,400	55	35,200	55	-	-
Supplies	2,400	5	6,400	10	14,400	8
Insurance & Taxes	1,920	4	6,400	10	36,000	20
Depreciation	2,880	6	8,000	12.50	39,600	22
Salaries	4,800	10	4,800	7.50	25,200	14
Electricity Charges	960	2	3,200	5	13,500	7.50
Total	39,360	82	64,000	100	1,28,700	71.50
3. Profit	8,640	18	-	-	51,300	28.50

Additional information:

- Cost of Sales and Supplies vary directly with the occupancy rate in case of Lodge and level of activity in case of Gift Shop and Restaurant.
- Insurances and Taxes and Depreciation are for the entire period of twelve months.
- Salaries paid are for the season period except a Chowkidar for the Lodge who is paid for the full year at ₹400 per month.
- Electricity Charges include Fixed Charges of ₹640, ₹1,920 and ₹9,900 for Gift-shop, Restaurant and Lodge respectively.

The balance amount varies directly with occupancy rate in case of Lodge and level of activity in case of Gift- Shop and Restaurant. Fixed Electric Charges are for the season except in case of Lodge where ₹6,900 is for the season and ₹3,000 for the entire period of twelve months.

Mr. Agarwal is interested in increasing his Net Income. The following options are under consideration -

- To continue the operations during the season period only by inserting advertisement in newspapers thereby occupancy rate to reach 100% in case of Lodge and 90% level of activity in respect of Gift-Shop and Restaurant. The costs of advertisement are estimated at ₹12,000.
- To continue operations throughout the entire period of twelve months comprising season period of four months and off-season period of eight months. The occupancy rate is expected at 90% and 40% during season period and off-season period respectively in case of the Lodge. The room rents are bound to be reduced to 50% of the original rates during off-season period. The level of activity of



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Gift-Shop and Restaurant is expected at 80% and 30% during season and off-season period respectively but 5% discount on the original rates will have to be offered during off-season period.

Which option is profitable? As a Cost Accountant would you like to suggest him any other alternative based upon the above figures, which can be adopted to earn more net profit? (Use Incremental Revenue and Cost Approach.) [14]

Answer:

(i) Option 1: Operate during Season only

Incremental Revenues and Costs in ₹

Particulars	Gift- Shop	Restaurant	Lodge	Total
Incremental Revenue	Given ₹48,000 at 80%, Addl. Revenue for extra 10% = 48,000 × (10/80) = 6,000 Extra 10% = (90-80)%	Given ₹64,000 at 80%, Addl. Revenue for extra 10% = 64,000 × (10/80) = 8,000 Extra 10% = (90-80)%	Given ₹1,80,000 at 90%, Addl. Revenue for extra 10% = 180,000 × (10/90) = 20,000 Extra 10% = (90-80)%	34,000
Incremental Costs				
Cost of Sales	6,000 × 55% = 3,300	8,000 × 55% = 4,400	Nil	7,700
Supplies	6,000 × 5% = 300	8,000 × 10% = 800	20,000 × 8% = 1,600	2,700
Electricity Charges (Excluding Fixed Charges)	(960 - 640) × (10/ 80) = 40	(3,200 - 1,920) × (10/80) = 160	(13,500 - 9,900) × (10/90) = 400	600
Advertisement				12,000
Total of Incremental Costs				23,000
Incremental Profit				11,000

(ii) Option 2: Operate during all 12 months

Incremental Revenues and Costs in ₹

Particulars	Gift- Shop	Restaurant	Lodge	Total
Incremental Revenue	48,000 × 2 × (30% / 80%) × 95% = 34,200	64,000 × 2 × (30% / 80%) × 95% = 45,600	1,80,000 × 2 × (40% / 90%) × 50% = 80,000	1,59,800
Incremental Costs				
Cost of Sales	34200 × 55% = 18810	45600 × 55% = 25080	Nil	43,890
Supplies	34200 × 5% = 1710	45600 × 10% = 4560	80,000 × 8% = 6,400	12,670
Salaries	4800*2= 9600	4800*2 = 9600	25200-(400*12)*2=40,800	60,000
Electricity Charges Fixed	640 × 2 = 1,280	1,920 × 2 = 3,840	6,900 × 2 = 13,800	18,920
Electricity Charges Variable	(960-640) × 2 × (30%/80%) = 240	(3,200 -1,920) × 2 × (30%/80%) = 960	(13500- 9900) × 2 × (40%/90%) = 3,200	4,400



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Total of Incremental Costs	1,39,880
Incremental Profit	19,920

Suggestion: -

Both options are desirable since there is an Incremental Net Income. Option 2 is better than Option 1.

- 3) (a) XY Co. has Profit Centre Divisions X and Y, making products X and Y respectively. Each unit of Y requires one unit of X and Y can sell a maximum of 50,000 units in the external market at a selling price of ₹150 per unit. X has the capacity to produce 1,00,000 units of X. The variable cost per unit is 12. Fixed costs are ₹7,20,000. X can sell the following quantities in the external market:

Price per unit (₹)	Demand Units
18	84,000
20	76,000
22	70,000
24	64,000
26	54,000 or less

Assume no stock to build up for X or Y.

Y can purchase its requirement from the external market at ₹22 per unit, but has to incur a bulk transportation cost of ₹1,50,000 for any quantity, which will not be incurred on transfers from X.

Required:

- Assuming no demand from Y, discuss the best strategy for X?
- Calculate the minimum transfer price that X will agree to if X has to supply 50,000 units to Y? What price will Y offer as the maximum?
- If Y is acceptable to partial supplies, what will be X's best strategy under no compulsion to transfer, but with the option to transfer as many units that it wants to? What will be the quantity that X will agree to transfer and the corresponding price, assuming both divisions agree to share the benefits of transfer equally?
- What is the best strategy of the company? Will the company's overall strategy differ from the individual divisions' strategy? Compute the benefits/disadvantages/indifference between the divisional best and company best strategies.

Present relevant calculations to substantiate all your answers.

[7]

- (b) ABC Enterprises has prepared a draft budget for one of its products for the next year as follows:

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



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Budgeted fixed costs	14,00,000
Budgeted profit	1,00,000

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

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

In order to achieve the extra production capacity, however, the workforce must be able to reduce the time taken to make each unit of the product. It is proposed to offer a pay and productivity deal in which the wage rate per hour is increased to ₹40. The hourly rate for variable overhead will be unaffected. Calculate the target labour time required to achieve the target profit. [7]

Answer:

- (a) (i) Assuming no demand from Y, the best strategy for X

Computation of Contribution at different levels of Demand

Demand (Units)	Price (₹ per unit)	Contribution (₹ per unit)	Contribution Value (₹)
84,000	18	6	5,04,000
76,000	20	8	6,08,000
70,000	22	10	7,00,000
64,000	24	12	7,68,000
54,000	26	14	7,56,000

Advise: In the absence of demand from Y, the optimal strategy for X would be to manufacture 64,000 units for external demand whereby it can achieve the maximum contribution of ₹7,68,000.

Working Note: Contribution per unit has been worked out by deducting the variable cost of ₹12 from the respective price.

- (ii) X has to supply 50,000 units to Y

If X has to supply 50,000 units to Y, then, it can supply 50,000 units for external sales at ₹26 per unit, the contribution being ₹14 per unit.

Contribution from external sales will be ₹14 × 50,000 = 7,00,000

Shortfall in contribution from the maximum level = 7,68,000 – 7,00,000 = 68,000

Minimum contribution from Y = 68,000 ÷ 50,000 = ₹1.36 per unit

Hence, the Minimum Transfer Price = VC of 12 + Contribution of 1.36 = ₹13.36 per unit

However, if X is strong enough, it can demand a price of ₹22 which Y will be paying to outside suppliers.

Y will not pay anything more than its landed cost of ₹25 per unit comprising price of ₹22 + transportation cost of ₹3 (1,50,000 ÷ 50,000 = 3).



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(iii) **Partial supplies to Ys**

If X can choose, X will supply 64000 units for external demand and earn the maximum contribution ₹7,68,000. Balance of 36000 units can be offered to Y at the variable cost of ₹12.

Y will have to incur bulk transportation cost of ₹1,50,000 even for the balance of 14000 units it purchases from outside. Hence it will not pay anything above ₹22. X will not accept anything below ₹12.

Benefits to be shared equally between X and Y = $22 - 12 = 10$ per unit.

Hence, Transfer Price per unit will be $₹12 + 5 = ₹17$, so that Y benefits by ₹5 and X also gets additional contribution of ₹5 per unit transferred. Quantity transferred will be 36,000 units.

(iv) **Best strategy of the company**

For the company as a whole, Y is incurring a variable cost of ₹22 plus bulk transportation of ₹1,50,000.

Contribution of X as per best strategy = ₹7,68,000

Hence, for the company, best strategy will be to transfer 50,000 units to Y and sell 50,000 units to external sales.

Contribution lost by sub optimal strategy in Div. X = $768000 - (50000 \times 14) = ₹68,000$

Gain for the Division Y = $[(50,000 \times 25) - (50,000 \times 12)] = (12,50,000 - 6,00,000) = ₹6,50,000$

Net Gain = $(6,50,000 - 68,000) = ₹5,82,000$

(b) (i) **Target Conversion Cost per unit**

Serial	Particulars	Workings	(₹)
1	Target profit	Given	2,50,000
2	Add	Given	
	Fixed cost		14,00,000
	Additional Advertisement Sub Total		2,46,000
			16,46,000
3	Total contribution	(1 + 2)	18,96,000
4	Sales volume		12,000
5	Contribution per unit	$(18,96,000 \div 12,000)$	158.00
6	Target Selling price per unit	Given	316.75
7	Target variable cost per unit	(6 - 5)	158.75
8	Material cost per unit	Given	80.00
9	Target Conversion Cost per unit (i.e., Labour + Variable overhead)	(7 - 8)	78.75

(ii) **Target Labour Time**

Let Target Labour Time per unit be x hours

Revised Labour Rate being ₹40 per hour, Total Labour Cost = $40x$

Variable Overhead Rate being ₹5 per hour, Total Variable Cost = $5x$

Thus, Total Conversion Cost = $40x + 5x = 45x$

We also have Total Conversion Cost = $78.75 \times 12,000$ units = ₹9,45,000



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Therefore, $45x = 9,45,000$ or $x = 21,000$ hours

Target Labour Time per unit = $21,000 \div 12,000 = 1.75$ hours

Alternative

$45x = 78.75$

$x = 1.75$ hours

(iii) Target Reduction in Labour Time

Budgeted Labour Time per unit = 2.00 hours

Target Labour Time per unit = 1.75 hours

Target Reduction in Labour Time = $(2.00 - 1.75) = 0.25$ hours per unit

Hence, target labour time per unit, required to achieve the target profit, is 1.75 hours and target reduction in labour time is 0.25 hours per unit.

4) (a) T Ltd, produces a product which passes through two processes - cutting and finishing.

The following information is provided:

	Cutting	Finishing
Hours available per annum	50,000	60,000
Hours needed per unit of product	5	12
Fixed operating costs per annum excluding direct material (₹)	10,00,000	10,00,000

The selling price of the product is ₹1,000 per unit and the only variable cost per unit is direct material, which costs ₹400 per unit. There is demand for all units produced.

Evaluate each of the following proposals independent of each other:

- (i) An outside agency is willing to do the finishing operation of any number of units between 5,000 and 7,000 at ₹400 per unit.
- (ii) Another outside agency is willing to do the cutting operation of 2,000 units at ₹200 per unit
- (iii) Additional equipment for cutting can be bought for ₹10,00,000 to increase the cutting facility by 50,000 hours, with annual fixed costs increased by ₹2 lakhs. [7]

(b) What do you mean by lean accounting. Discuss the principles that guide lean accounting. [7]

Answer:

(a) Cutting process capacity = $50,000 \text{ hours} \div 5 = 10,000$ units

Finishing process capacity = $60,000 \text{ hours} \div 12 = 5,000$ units

Throughput contribution per unit = $(\text{Selling Price} - \text{Material Cost}) = (\text{₹}1,000 - \text{₹}400) = \text{₹}600$ per unit

Observation: Finishing capacity (5,000 units) is less than the cutting capacity (10,000 units). Therefore, Finishing Capacity is the bottleneck resource.

Alternative-I:

If an outside agency is willing to do the finishing operation of any number of units between 5,000 and 7,000

Increase in throughput contribution per unit = $(\text{Throughput contribution} - \text{Subcontracting charges})$

$$= (\text{₹}600 - \text{₹}400) = \text{₹}200$$



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Throughput Contribution for 5,000 units = $(5000 \times 200) = ₹ 10,00,000$

Throughput Contribution for 7,000 units = $(7000 \times 200) = ₹ 14,00,000$

Observation: Increase in throughput contribution is higher than the fixed operating costs of ₹10,00,000-per annum beyond 5,000 level of subcontracting. Therefore, subcontracting above the 5,000 level is beneficial.

Alternative-II:

If an outside agency is willing to do the cutting operation

The capacity of cutting process is 10,000 units as against the finishing capacity of 5,000 units. Cutting is not the bottleneck and hence outsourcing is not beneficial.

Alternative-III:

Installation of additional equipment for cutting process.

The cutting process has surplus capacity. It is, therefore, suggested not to increase non-bottleneck capacity.

- (b) Lean Accounting is the application of lean thinking to all accounting and finance processes and systems. It is an essential component of a successful lean transformation for any organization.

Lean accounting uses a method that categorizes costs by value stream rather than by department. This approach “provides the basis for sound management decisions”. The researchers define value stream accounting as “tracking revenue and the associated variable costs required to generate those sales.” It is experienced that value stream costing includes a simpler cost collection method and reduces the number of cost centers. They also list features of value stream accounting as:

- Costs calculated weekly
- No distinction made between direct or indirect costs – all costs of the value stream are considered direct costs
- Value stream costs include labour, materials, production support, machines and equipment, operation support, facilities and maintenance
- Value stream costing provides a more accurate picture by elimination of unnecessary costs outside control of value stream managers

Lean accounting groups together costs that fall outside of the value stream as “business sustaining costs” that do not get included in value stream costs. This, in turn, helps the businesses to find better price points for products and do further research into high-cost areas. The bottom line is that Lean accounting can help business leaders quickly know if they are heading in the right direction or need to make a change.

Three principles guide Lean Accounting and form the foundation for all of accounting’s work and interaction with the organization:

- i. Customer value: Delivering the relevant and reliable information in a timely manner to all users of the information inside the organization.
- ii. Continuous improvement: Improving accounting processes, cross-functional business processes and the information used inside the business for analysis and decision making.
- iii. Respect for people: Adopting a learning attitude by seeking to understand root causes of business problems and issues in a cross-functional, collaborative manner.



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Lean Accounting facilitates the changes that are required to a company's accounting, control, measurement, and management processes to support lean manufacturing and lean thinking.

Most of the companies embarking on lean manufacturing may soon find that their accounting processes and management methods are at odds with the lean changes they are making. The reason for this is that traditional accounting and management methods were designed to support traditional manufacturing; they are based upon mass production concept. Lean manufacturing breaks the rules of mass production, and so the traditional accounting and management methods warrant due modifications in tune with the lean changes that the company is embarking.

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

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

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

5. (a) A brass foundry making castings which are transferred to the machine shop of the company at standards in regard to material stocks which are kept at standard price are as follows:

Standard Mixture 70% Material C; 30% Material Z

Standard Price Material C ₹2,400 per ton; Material Z ₹650 per ton

Standard loss in melting 5% of input

Figures in respect of a costing period are as follows:

Commencing stocks	Material C	100 tons	
	Material Z	60 tons	
Finishing stocks	Material C	110 tons	
	Material Z	50 tons	
Purchases	Material C	300 tons	Cost ₹ 7,32,500
	Material Z	100 tons	Cost ₹ 62,500
Metal melted		400 tons	
Casting produced		375 tons	

Calculate Material Price, Mixture, and Yield Variance.

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(b) Calculate the missing data indicated by the Question marks from the following.

	Product 'R'	Product 'S'
Sales quantity		
Std.(units)	?	400
Actual (Units)	500	?
	Product 'R'	Product 'S'
Price (Unit)		
Standard	₹ 12	₹ 15
Actual	₹ 15	₹ 20
Sales price variance	?	?
Sales volume variance	₹ 1,200 F	?
Sales value variance	?	?

Sales mix variance for both the products together was ₹450 F. 'F' denotes Favourable.

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Answer:

(a)

Description	Material C		Material Z	
	Quantity	Value	Quantity	Value
Opening Stock at Standard Price	100	240000	60	39000
(+) Purchases (Actuals)	300	732500	100	62500
	400	972500	160	101500
(-) Closing Stock (Standard Price)	110	264000	50	32500
Consumption	290	708500	110	69000

	Standard			Actual		
	Qty.	Price	Value	Qty.	Price	Value
Material C	280	2400	672000	290		708500
Material Z	120	650	78000	110		69000
	400		750000	400		777500
(-) Standard Loss @ 5%	20			25		
	380		750000	375		777500

Standard Mix for Actual Production of 375 tons

Standard Consumption = $(400 \div 380) \times 375 = 394.737$ tons

Raw Material	Mix (%)	Quantity (Tons)	Standard Price (₹)	Value (₹)
Material C	70	276.316	2400	6,63,158
Material Z	30	118.421	650	76,974
Total		394.736		7,40,132



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$$SQSP = ₹ 7,40,132$$

$$RSQSP = ₹ 7,50,000$$

$$AQSP = 7,67,500$$

$$AQAP = (7,08,500 + 69,000) = 7,77,500$$

$$\text{Material Price Variance} = (AQSP - AQAP) = (7,67,500 - 7,77,500) = ₹ 10,000 (A)$$

$$\text{Material Mix Variance} = (RSQSP - AQSP) = (7,50,000 - 7,67,500) = 17500 (A)$$

$$\text{Material Yield Variance} = (SQSP - RSQSP) = (7,40,132 - 7,50,000) = 9868 (A)$$

(b) Let the standard units of product R be r

Actual units of product S be s

	Standard			Actual		
	Quantity	Price	Value	Quantity	Price	Value
R	R	12	12r	500	15	7500
S	400	15	6000	s	20	20s
	400 + r		6000 + 12r	500 + s		7500 + 20s

Given sales volume variance for R = ₹ 1200 (F) i.e., $AQSP - SQSP = ₹ 1200$

$$[(500 \times 12) - 12r] = 1200 \text{ or } 6000 - 12r = 1200$$

$$r = ₹ 400$$

	AQSP	RSQSP
R	12×500	$12 \times \{(500+s)/(400+r)\} \times 400 = 3000 + 6s$
S	$15 \times s$	$15 \times \{(500+s)/(400+r)\} \times 400 = 3750 + 7.5s$
	$6000 + 15s$	$6750 + 13.5s$

Given, Sales Mix Variance = $(AQSP - RSQSP) = ₹ 450(F)$

$$(6000 + 15s - 6750 - 13.5s) = 450$$

$$-750 + 1.5s = 450$$

$$\text{Then } s = 800$$

We, thus, have

Standard units of product R, $r = ₹ 400$

Actual units of product S, $s = ₹ 800$

Sales price variance for R = $AQ (AP - SP) = ₹ 1500(F)$

Sales price variance for S = $AQ (AP - SP) = 4000(F)$

Sales volume variance for S = $SP (AQ - SQ) = ₹ 6000(F)$

Sales value variance for R = $(AQAP - SQSP) = ₹ 2700(F)$

Sales value variance for S = $(AQAP - SQSP) = ₹ 10000(F)$



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6. (a) A retired person has plans to invest in shares. He has been suggested by one of his friends who plays in the share market to invest in two shares A and B which gives dividends @ 12% and 4% p.a. respectively. For an investment of ₹1, the growth in the market value of the shares A and B are respectively 10 paise and 40 paise in one year. The retired person wants to invest such that the dividend income is at least ₹600 p.a. and the growth of initial investment in one year is at least ₹1000.
- (i) Formulate it as a Linear Programming Problem.
- (ii) Write its Dual.
- (iii) Solve the Dual using Simplex Method. Interpret the solution. [7]
- (b) A company has taken on rent three floors (1st, 2nd and 3rd) of a multi storied building for their city office. It has been decided to locate Managers of Marketing, Purchase, HR, Finance and Company Secretary in the office. The management has earmarked in different floors five rooms having numbers 103, 201, 205, 302 and 304 for the above-mentioned Managers. But no particular room has been allotted for any particular Manager and rather they have given option to indicate their preference of rooms so that decision can be taken by the management using some scientific method and subsequently arrangement of sitting of the subordinates of various Managers can be made. Managerial preferences are provided in the table below with 1st preference appearing in the top for each and every Manager.

Preference of Rooms of different Managers				
Marketing Manager	Purchase Manager	HR Manager	Finance Manager	Company Secretary
302	302	103	302	201
103	304	201	205	302
304	205	304	304	304
	201	205	103	
		302		

It is evident that most of the Managers have not given preference for all the available rooms because they feel that all the rooms do not have the facility they are looking for. Assuming that the preferences can be quantified by numbers, assess which manager should be assigned with which room to minimise the preferential measure. [7]

Answer:

- (a) (i) Let x_1 and x_2 be the number of units of the shares A and B to be purchased by the retired person. The LP can be formulated as –
- Minimize $Z = x_1 + x_2$
- Subject to the Constraints
- $0.12x_1 + 0.04x_2 \geq 600$ (Constraint on the income from Dividend)
- $0.10x_1 + 0.40x_2 \geq 1000$ (Constraint on the income from Growth)
- $x_1, x_2 \geq 0$ (Non-negativity Constraint)
- This is the formulated Primal Problem



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(ii) To obtain the Dual, the data are summarized in the table below.

		PRIMAL (Minimization problem)			
DUAL (Maximization problem)	Decision Variables	x ₁	x ₂	Relation	RHS of Constraint
	y ₁	0.12	0.04	≥	600
	y ₂	0.10	0.40	≥	1000
	Relation	≤	≤	-	-
	RHS of Constraint	1	1	-	-

The Dual is given as –

To Maximize $Z^* = 600y + 1000y$

Subject to the Constraints

$0.12y_1 + 0.10y_2 \leq 1$

$0.04y_1 + 0.40y_2 \leq 1$

$y_1, y_2 \geq 0$

(iii) To solve the Dual using Simplex Method, we introduce non-negative Slack Variables (S_1 & S_2) to rewrite the Constraints as follows –

$0.12y_1 + 0.10y_2 + S_1 = 1$

$0.04y_1 + 0.40y_2 + S_2 = 1$

So the Dual LPP in standard form is written as

Minimize $Z^* = 600y + 1000y + 0.S_1 + 0.S_2$

Subject to the Constraints

$0.12y_1 + 0.10y_2 + S_1 = 1$

$0.04y_1 + 0.40y_2 + S_2 = 1$

$y_1, y_2, S_1, S_2 \geq 0$

Considering $y_1 = y_2 = 0$, the Initial Feasible Solution is $S_1 = 1$ & $S_2 = 1$. This is shown in the following Table.

Table – 1 showing Initial Feasible Solution

C _j			600	1000	0	0	Min. Ratio	
C _B	Basic Variables	Solution Values (X _B)	y ₁	y ₂	S ₁	S ₂		
0	S ₁	1	0.12	0.10	1	0	1/0.10 = 10	
0	S ₂	1	0.04	0.40*	0	1	1/0.04 = 2.5	Key Row
(Z _B) [*] = 0	-	(Z _j) [*]	0	0	0	0	y ₂ enters & S ₂ departs	
		C _j – (Z _j) [*]	600	1000	0	0		
				Key Col.				



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Table – 2 showing Improved Solution

C _j		600	1000	0	0	Min. Ratio		
C _B	Basic Variables	Solution Values (X _B)	y ₁	y ₂	S ₁			S ₂
0	S ₁	0.75	0.11*	0	1	- 0.25	0.75/0.11 = 6.82	Key Row
1000	y ₂	2.5	0.10	1	0	2.5	2.5/0.10 = 25	
(Z _B) [*] = 2500	-	(Z _J) [*]	100	1000	0	2500	y ₁ enters & S ₁ departs	
		C _J – (Z _J) [*]	500	0	0	- 2500		
			Key Col.					

Table – 3 showing Optimal Solution

C _j		600	1000	0	0	Min. Ratio
C _B	Basic Variables	Solution Values (X _B)	y ₁	y ₂	S ₁	
600	y ₁	6.82	1	0	9.1	- 2.27
1000	y ₂	1.82	0	1	- 0.91	2.73
(Z _B) [*] = 5912	-	(Z _J) [*]	600	1000	4550	1368
		C _J – (Z _J) [*]	0	0	- 4550	- 1368

As all the values in the Index Row are zero or negative, optimality condition has been attained. The optimum solution is –

Maximum value of Z* = 5912 and it corresponds to y₁ = 6.82 and y₂ = 1.82

Here the values of y₁ and y₂ indicates the marginal worth of one unit of Shares A and B respectively. Also, the shadow prices (that is the optimum values of the dual variables) are the coefficients of the surplus variables in the Objective Function of the Primal problem.

Also, the values, with sign changed, in the Index Row of the optimum Dual solution corresponding to the non- basic variables (that is S₁ and S₂) indicate the optimum values of the decision variables (x₁ and x₂) of the Primal problem. Thus, the optimum number of Shares A to be purchased (x₁) = 4550 and that of Share B to be purchased (x₂) = 1368

Also, optimum values of Objective Function in both Primal and Dual should be same i.e., (Z)_{Minimum} = (Z*)_{Maximum} = 5912

- (b) Let the preferential ranking of the rooms be quantified as 1, 2, 3, 4 and 5 as well as M for no preference. In fact the managers who have given no preference for certain rooms do not want those rooms to be allotted to them i.e., assignment of certain Rooms to some Managers are restricted. For this a very high value (M) is assigned to those specific cells of the matrix. Following table shows the numerical figures for various combinations of Manager and Room.



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Table -1 showing Preferential Scores of different Rooms as awarded by various Managers

Managers	Preferential scores of different Rooms by different Managers				
	Room -103	Room - 201	Room -205	Room - 302	Room -304
Marketing Manager	2	M	M	1	3
Purchase Manager	M	4	3	1	2
HR Manager	1	2	4	5	3
Finance Manager	4	M	2	1	3
Company Secretary	M	1	M	2	3

Table -2 showing reduced matrix after Row subtraction operation

Managers	Room -103	Room - 201	Room -205	Room - 302	Room -304
Marketing Manager	1	M	M	0	2
Purchase Manager	M	3	2	0	1
HR Manager	0	1	3	4	2
Finance Manager	3	M	1	0	2
Company Secretary	M	0	M	1	2

Table – 3 showing reduced matrix after Column subtraction operation

Managers	Room -103	Room - 201	Room -205	Room - 302	Room -304
Marketing Manager	1	M	M	0	1
Purchase Manager	M	3	1	0	0
HR Manager	0	1	2	4	1
Finance Manager	3	M	0	0	1
Company Secretary	M	0	M	1	1

Here minimum number of horizontal and vertical straight lines to cover all the zeros = 5 = Order of the matrix. So, the solution is optimal and assignments are made using standard procedure of Hungarian Method as below.

Table - 4 showing matrix with Optimal assignments

Managers	Room -103	Room - 201	Room -205	Room - 302	Room -304
Marketing Manager	1	M	M	0	1
Purchase Manager	M	3	1	0	0
HR Manager	0	1	2	4	1
Finance Manager	3	M	0	0	1
Company Secretary	M	0	M	1	1

Thus, the required assignment of Rooms should be –

Room 103 to HR Manager, Room 201 to Company Secretary, Room 205 to Finance Manager, Room 302 to Marketing Manager and Room 304 to Purchase Manager.



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7. (a) A Small retailer has studied the weekly receipts and payments over the past 200 weeks and has developed the following set of information

Weekly Receipts (₹)	Probability	Weekly Payments (₹)	Probability
3000	0.20	4000	0.30
5000	0.30	6000	0.40
7000	0.40	8000	0.20
12000	0.10	10000	0.10

Using the following set of random numbers, simulate the weekly pattern of receipts and payments for the 12 weeks of the next quarter, assuming further that the beginning bank balance is Rs. 8000. What is the estimated balance at the end of the 12-week period? What is the highest weekly balance during the quarter? Calculate the average weekly balance for the quarter?

Random Numbers

For Receipts	03	91	38	55	17	46	32	43	69	72	24	22
For Payments	61	96	30	32	03	88	48	28	88	18	71	99

- (b) A civil engineering firm has to bid for the construction of a dam. The activities and time estimates are given below:

Activity	DURATION		
	Optimistic	Most likely	Pessimistic
1—2	14	17	25
2—3	14	18	21
2—4	13	15	18
2—8	16	19	28
3—4 (dummy)			
3—5	15	18	27
4—6	13	17	21
5—7 (dummy)			
5—9	14	18	20
6—7 (dummy)			
6—8 (dummy)			
7—9	16	20	41
8—9	14	16	22

The policy of the firm with respect to submitting bids is to bid the minimum amount that will provide a 95% probability of at best breaking even. The fixed costs for the project are 8 lakhs and the variable costs are 9,000 everyday spent working on the project. The duration is in days and the costs are in terms of rupees.

Calculate the amount the firm should bid under this policy. (You may perform the calculations on duration etc. up to two decimal places.) [7]



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Answers:

(a) Table showing Range of Random Numbers for Receipts and Payments

Receipt (₹)	Probability	Cumulative Probability	Range	Payment (₹)	Probability	Cumulative Probability	Range
3000	0.20	0.20	00-19	4000	0.30	0.30	00-29
5000	0.30	0.50	20-49	6000	0.40	0.70	30-69
7000	0.40	0.90	50-89	8000	0.20	0.90	70-89
12000	0.10	1.00	90-99	10000	0.10	1.00	90-99

Simulated values of Receipts & Payments for the next 12 weeks and Calculation of week end Balances

Week	Random No. for Receipts	Expected Receipts (₹)	Random No. for Payments	Expected Payments (₹)	End of week Balance (₹)
Opening balance					8000
1	03	3000	61	6000	5000
2	91	12000	96	10000	7000
3	38	5000	30	6000	6000
4	55	7000	32	6000	7000
5	17	3000	03	4000	6000
6	46	5000	88	8000	3000
7	32	5000	48	6000	2000
8	43	5000	28	4000	3000
9	69	7000	88	8000	2000
10	72	7000	18	4000	5000
11	24	5000	71	8000	2000
12	22	5000	99	10000	(3000)
Total					45000

[N.B - End of week Balance for a particular week = End of week Balance for the previous week + Receipt during the week – Payment made in the week]

Estimated balance at the end of 12 th week	= ₹ (3,000)
Highest weekly balance during the quarter	= ₹ 7,000
Average weekly balance for the quarter	= 45,000/12 = ₹ 3750

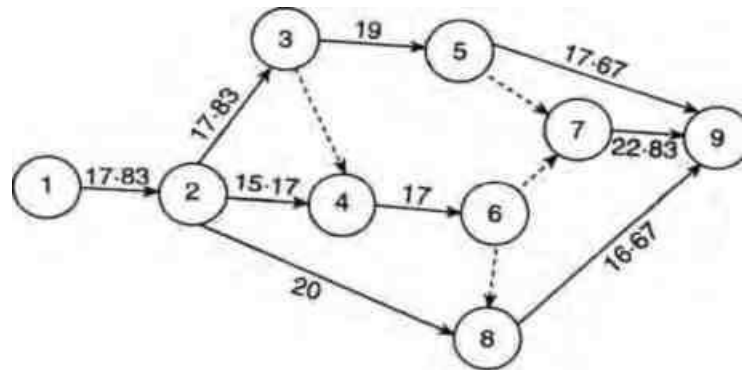


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- (b) Expected Duration of each activity is calculated using the formula $t_E = (a+4m+b)/6$ and Variance of Duration of each activity is calculated using the formula $\sigma^2 = [(b - a)/6]^2$ where a = Optimistic Duration, m = Most Likely Duration and b = Pessimistic Duration
Calculated values are shown in the Table follows:

Activity	DURATION in Days			Expected duration (t_E Days)	Variance (σ^2 Sq. Days)
	Optimistic (a)	Most likely (m)	Pessimistic (b)		
1—2	14	17	25	17.83	3.36
2—3	14	18	21	17.83	1.36
2—4	13	15	18	15.17	0.69
2—8	16	19	28	20	4
3—4 (dummy)	0	0	0	0	0
3—5	15	18	27	19	4
4—6	13	17	21	17	1.78
5—7 (dummy)	0	0	0	0	0
5—9	14	18	20	17.67	1
6—7 (dummy)	0	0	0	0	0
6—8 (dummy)	0	0	0	0	0
7—9	16	20	41	22.83	17.36
8—9	14	16	22	16.67	1.78

The Network Diagram for the given set of activities is shown below:



Various paths of the Network and their corresponding lengths are as follows –

Sl.	Path	Duration (Days)
I.	1-2-3-5-7-9	77.49*
II.	1-2-3-5-9	72.33
III.	1-2-3-4-6-7-9	75.49
IV.	1-2-3-4-6-8-9	69.33
V.	1-2-8-9	54.50
VI.	1-2-4-6-8-9	66.67
VII.	1-2-4-6-7-9	72.83



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From above, the longest path or the path of longest duration of 77.49 Days is 1-2-3-5-7-9. So, it is the Critical Path.

Variance of duration = σ^2 = Sum of the Variances of the Critical activities = $3.36 + 1.36 + 4 + 0 + 17.36 = 26.08$ Sq. Days

S.D of Project duration = $\sigma = \sqrt{26.08} = 5.11$ Days

To calculate the project duration which will have 95% chance of completion, we find the value of Z corresponding to 95% area under the Standard Normal curve and this value is 1.645.

Therefore, $P(\text{Project duration} \leq t_g) = 95\%$ Or, $P[Z \leq (t_g - 77.49)/5.11] = P(Z \leq 1.645)$

So, $(t_g - 77.49)/5.11 = 1.645$ Or, $t_g = 86$ Days

Hence the company should bid considering project completion time to be 86 Days.

Amount to bid = Fixed Cost + Variable Cost (@ ₹ 9000 per Day) = ₹ 800000 + ₹ 9000 × 86 = ₹ 15,74,000

8. (a) A company produces two products x and y. The total Profit (in ₹'000) earned by the company is expressed algebraically by the function $P = 100x - x^2 - 2xy + 200y - 3y^2$. Find the Profit maximizing quantities of the products. Also calculate the maximum Profit. [7]

- (b) Apply the Moving Average Method to find trend values of the following year wise data of Goods carried by a fleet of trucks of a Transport Company having pan India network using the Moving Average Method. [Assume a 4 yearly cycle]

Year	2012	2013	2014	2015
Goods carried (Tons)	2204	2500	2360	2680
Year	2016	2017	2018	2019
Goods carried (Tons)	2424	2634	2904	3098
Year	2020	2021	2022	2023
Goods carried (Tons)	3172	2952	3248	3172

[7]

Answer:

- (a) Profit function is given as:- $P = 100x - x^2 - 2xy + 200y - 3y^2$ Differentiating the function partially with respect to x we get, $P = 100 - 2x - 2y$ (I)

Also differentiating the function partially with respect to y we get

$$P = -2x + 200 - 6y \quad \text{(II)}$$

To determine the Critical Point, we have $P = 0$ and $P = 0$

$$\text{So, } 100 - 2x - 2y = 0 \text{ Or, } x + y = 50 \text{ ----- (1) and } -2x + 200 - 6y = 0 \text{ Or, } x + 3y = 100 \quad \text{(2)}$$

$$(2) - (1) \text{ gives, } 2y = 50 \text{ Or, } y = 25 \text{ Putting } y = 25 \text{ in (1) we get } x = 25 \text{ Thus Critical Point is (25, 25)}$$

To check whether this point is a local Maxima, we have to find out the values of the 2nd Order Partial Derivatives at this point.

Again differentiating (I) partially with respect to x we get $P = -2$ Or, $A = -2$ (Let) Or, $A < 0$ Similarly differentiating (II) partially with respect to y we get $P = -6$ Or, $C = -6$ (Let) Or, $C < 0$ Also differentiating (I) partially with respect to y we get $P = -2$ Or, $B = -2$ (Let)



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$$\text{So } D = AC - B^2 = (-2) \times (-6) - (-2)^2 = 8 > 0$$

Hence $D > 0$ and $A, C < 0$

Thus there is a local Maxima at the already determined Critical Point (25, 25). Required Profit maximizing quantities of the products are $x = 25$ units and $y = 25$ units.

Also, Maximum Profit = Value of the function P at $x = 25$ & $y = 25 = 100 \times 25 - 25^2 - 2 \times 25 \times 25 + 200 \times 25 - 3 \times 25^2 = ₹ 3,750$ (₹000)

(b) Calculations for 4 Yearly Moving Average Trend values

Year	Goods carried (Tons)	4 Yearly Moving Total	4 Yearly Moving Average (Not centred)	2 item Moving Total (Centred)	4 Yearly Moving Average (Centred)
(1)	(2)	(3)	(4) = (3)/ 4	(5)	(6) = (5)/ 2
2012	2204	-	-	-	-
2013	2500	-	-	-	-
		9744	2436		
2014	2360			4927	2463.50
		9964	2491		
2015	2680			5015.5	2507.75
		10098	2524.5		
2016	2424			5185	2592.50
		10642	2660.5		
2017	2634			5425.5	2712.75
		11060	2765		
2018	2904			5717	2858.50
		11808	2952		
2019	3098			5983.5	2991.75
		12126	3031.5		
2020	3172			6149	3074.5
		12470	3117.5		
2021	2952			6253.5	3126.75
		12544	3136		
2022	3248	-	-	-	-
2023	3172	-	-	-	-