STRATEGIC COST MANAGEMENT

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 x 2=30]**

(i) Which of the following is not a secondary activity of Value Chain?

a) Procurement
b) Human Resource Development
c) Service
d) Technology Development

(ii) The break-even point of a manufacturing company is ₹1,60,000. Fixed cost is ₹48,000. Variable cost is ₹12 per unit. The PV ratio will be:

a) 20%
b) 40%
c) 30%
d) 25%

(iii) The higher the actual hours worked ____________________.

a) The lower the capacity usage ratio.
b) The higher the capacity usage ratio.
c) The lower the capacity utilization ratio.
d) The higher the capacity utilization ratio.

(iv) 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

(v) X Ltd. has 1000 units of an obsolete item which are carried in inventory at the original price of ₹ 50,000. If these items are reworked for ₹ 20,000, they can be sold for ₹ 36,000. Alternatively, they can be sold as a scrap for ₹ 6,000 in the market. In a decision model used to analyse the reworking proposal, the opportunity cost should be taken as ____________.

a) ₹ 16,000
b) ₹ 6,000
c) ₹ 30,000
d) ₹ 20,000

(vi) 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?
a) ₹ 13
b) ₹ 17
c) ₹ 32
d) ₹ 10

(vii) AP Products sells product A at a selling price of ₹₹40 per unit. AP's cost per unit based on the full capacity of 5,00,000 units is as follows:

Direct material	6
Direct Labour	3
Indirect Manufacturing Expense 60% of which is fixed	10
Total	19

A one-time only special order offering to buy 50,000 units was received from an overseas distributor. The only other costs that would be incurred on this order would be ₹ 4 per unit for shipping. AP has sufficient existing capacity to manufacture the additional units. In negotiating a price for the special order, AP should consider that the minimum selling price per unit should be _______________.
a) ₹ 17
b) ₹ 19
c) ₹ 21
d) ₹ 23

(viii) Ankit Ltd., operates throughput accounting system. The details of product A per unit are as under:
Selling Price: ₹ 75
Material Cost: ₹ 30
Conversion Cost: ₹20
Time to bottleneck resources: 10 minutes
What is the throughput contribution per bottleneck resource per hour?
a) ₹ 270
b) ₹ 150
c) ₹ 120
d) ₹ 90

(ix) Efficiency Ratio is ____.

a) Available working days ÷ Budgeted working days × 100
b) Budgeted hours ÷ Maximum hours in budgeted period × 100
c) Standard hours ÷ Actual hours × 100
d) None of the above

(x) Which of the following statement is incorrect?

a) Microsoft Excel is most popular among all the available spreadsheets.
b) Zoho Analytics is a tool used for Financial Data analysis.
c) Visualisation Tools are the Reporting Tools.
d) None of the above.

(xi) Prescriptive Analytics is very important because –

a) It tells about the action to be taken.
b) It tells about what is likely to happen.
c) It tells about how something has happened.
d) It tells about what has happened.

(xii) 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) ₹ 7.50
b) ₹ 6.40
c) ₹ 6.5
d) ₹ 6.90

(xiii) The Normal duration and Normal cost of an activity are respectively 10 days and ₹ 350. The cost slope is ₹ 75 per day. If the Crash duration is 8 days, then what is the Crash cost of the activity?

a) ₹ 400
b) ₹ 500
c) ₹ 600
d) ₹ 650

(xiv) Optimization is the method of finding ________________.

a) The maximum point
b) The minimum point
c) The critical point
d) All of the above

(xv) The actual demand for a period is 100 units. But forecast demand was 90 units. The forecast error is –

a) – 10

b) 10

c) 5

d) None of the above

Answers:

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

SECTION – B

(Answer any 5 questions out of 7 questions given. Each question carries 14 marks.)

[5 x 14 = 70]

2. A manufacturing company currently operating at 80% capacity has received an export order from Middle East, which will utilise 40% of the capacity of the factory. The order has to be either taken in full and executed at 10% below the current domestic prices or rejected totally. The current sales and cost data are given below:

[14]

Sales	₹ 16.00 lakhs
Direct Material	₹ 5.80 lakhs
Direct Labour	₹ 2.40 lakhs
Variable Overheads	₹ 0.60 lakhs
Fixed Overheads	₹ 5.20 lakhs

The following alternatives are available to the management:

A. Continue with domestic sales and reject the export order.

B. Accept the export order and allow the domestic market to starve to the extent of excess of demand.

C. Increase capacity so as to accept the export order and maintain the domestic demand by:

(i) Purchasing additional plant and increasing 10% capacity and thereby increasing fixed overheads by ₹ 65,000, and

(ii) Working overtime at one and half time the normal rate to meet balance of the required capacity.

Required: Evaluate each of the above alternatives and suggest the best one.

Answer:

Alternative (A): Continue with domestic sales and reject the export order.

Serial	Description	Workings	₹Lakhs
1	Capacity	Given – 80%	
2	Sales	Given	16.00
3	Variable Costs a. Direct Material b. Direct Labour c. Variable Overheads d. Sub Total	Given	 5.80 2.40 .60 8.80
4	Contribution	(2-3)	7.20
5	Fixed Costs	Given	5.20
6	Profit	(4-5)	2.00

Alternative (B): Accept the export order and allow the domestic market to starve to the extent of excess of demand

This alternative envisages utilization of 40% of the capacity for the export order and 60% of the capacity for domestic market. Further, the export order is to be executed at 10% below the current domestic prices i.e.., (100- 10) % = 90% of the price. Accordingly:

Sales at 100% Capacity = (16 ÷ 80%) = ₹20 Lakhs

Value of the export order = (40% of Capacity × 90% of the Price) = (20 × 40% × 90%) = ₹ 7.20 lakhs.

Value of the domestic sales = (20 × 60%) = ₹ 12.00 lakhs.

Serial	Description	Workings	₹Lakhs
1	Capacity	Export40%+Domestic 60%	
2	Sales	7.20+12.00	19.20
3	Variable Costs a. Direct Material b. Direct Labour c. Variable Overheads d. Sub Total	 (5.80 / 80%) × 100% (2.40 / 80%) × 100% (0.60 / 80%) × 100%	 7.25 3.00 0.75 11.00
4	Contribution	(2-3)	8.20
5	Fixed Costs	Given	5.20
6	Profit	(4-5)	3.00

Alternative (C): Increase capacity so as to accept the export order and maintain the domestic demand by:

(i) Purchasing additional plant and increasing 10% capacity and thereby increasing fixed overheads by ₹ 65,000, and

(ii) Working overtime at one and half time the normal rate to meet balance of the required capacity.

Serial	Description	Workings	₹Lakhs
1	Capacity	Export40%+Domestic 80%	
2	Sales	7.20+16.00	23.20
3	Variable Costs a. Direct Material b. Direct Labour c. Variable Overheads d. Overtime Premium [Balance capacity of 10%] e. Sub Total	 (5.80 / 80%) × 120% (2.40 / 80%) × 120% (0.60 / 80%) × 120% (2.40 / 80%) × 10% × 50%	 8.70 3.60 0.90 0.15 13.35
4	Contribution	(2-3)	9.85
5	Fixed Costs	(5.20+0.65)	5.85
6	Profit	(4-5)	4.00

Suggestion: Alternative (C) with the highest profit of ₹4.00 lakhs works out to be the best.

3. (a) Division A is a profit centre which produces three products X, Y and Z. Each product has an external market. The details are as follows:

	X	Y	Z
External market price per unit (₹)	**48**	**46**	**40**
Variable cost of production in division A (₹)	**33**	**24**	**28**
Labour hours required per unit in division A	**3**	**4**	**2**

Product Y can be transferred to Division B, but the maximum quantity that might be required for transfer is 300 units of Y.

	X	Y	Z
The maximum external sales are:	**800 Units**	**500 Units**	**300 Units**

Instead of receiving transfers of Product Y from Division A, Division B could buy similar product in the open market at a slightly cheaper price of ₹ 45 per unit.

Compute the transfer price for each unit, for 300 units of Y, if the total labour hours available in Division A are?
(a) 3800 hours
(b) 5600 hours. **[7]**

Answer:

Computation of contribution per labour hour from external sales:

	X	Y	Z
Market price (₹)	48	46	40
Variable cost (₹)	33	24	28
Contribution (₹)	15	22	12
Labour hours required	3	4	2
Contribution per labour hour (₹)	5	5.50	6
Ranking	III	II	I

(a) Computation of transfer price when the capacity is 3800 hours:

Allocation of Hours if the capacity is 3800 labour hours

	X	Y	Z
External Sales (Units)	800	500	300
Labour hours required per Unit	3	4	2
Hours needed for External Sales	2400	2000	600
Allocation of Hours if the capacity is 3800 hours as per ranking	1200 (Bal. fig.)	2000	2400

The existing capacity is not sufficient, even, to produce the units to meet the external sales. In order to transfer 300 units of Y, 1200 hours are required in which division A has to give up the production of X [since lowest ranking] to the extent of 1200 hours (1200 hours ÷ 3 labour p.a. =400 units).
Transfer price for 300 units of Y will, therefore, work out to
Variable Cost of Y (₹ 24) + [{(Contribution loss for X (₹ 5 × 1200 hours = 6,000)} ÷300] = 24 + 20 = ₹ 44

(b) Computation of transfer price when the capacity is 5600 labour hours:
Allocation of Hours if the capacity is 5600 hours

	X	Y	Z
External Sales (Units)	800	500	300
Labour hours required per Unit	3	4	2
Hours needed for External Sales	2400	2000	600
Balance of hours (Surplus)		600	

Labour Hours needed for 300 units of Y = 300 × 4		= 1200
Surplus Labour Hours Available	= 5600 – 5000	= 600
Short fall in Labour Hours	= 1200 – 600	= 600

The short fall 600 hours may have to be diverted from X resulting in a contribution loss of ₹3,000 (600 × ₹5)

Transfer price for 300 units of Y will, therefore, work out to

Variable Cost of Y (₹24) + [{Contribution loss for X (₹5 × 600 hours = 3,000)} ÷ 300] = ₹24 + ₹10 = ₹34

(b) A company has estimated the unit variable cost of a Product to be ₹ 10, and the selling price is ₹ 15 per unit. Budgeted sales for the year are 20,000 units. Estimated fixed costs are as follows:

Fixed Cost p.a.(₹)	50,000	60,000	70,000	80,000	90,000
Probability	0.1	0.3	0.3	0.2	0.1

Assess the probability that the company will equal or exceed its target profit of ₹ 25,000 for the year? [7]

Answer:
The different outcomes for fixed cost are mutually exclusive events. If fixed costs are ₹ 50,000 for example, they can't be anything else as well.

Budgeted sales = 20,000 units
Budgeted Contribution per Unit = 15 - 10 = ₹ 5

Budgeted total contribution (20,000 × ₹5)	1,00,000
Target profit	25,000
Maximum fixed costs if target is to be achieved	75,000

Higher Profit would mean lower FC, other things remaining constant.
So, Pb that Co. will equal or Exceed its target profit of ₹ 25,000 = Pb that FC will be ₹ 75,000 or less.
The probability that fixed costs will be ₹ 75,000 or less is:
= P (50,000 or 60,000 or 70,000)
= P (50,000) + P (60,000) + P (70,000)
= 0.1 + 0.3 + 0.3
= 0.7 or 70%

4. (a) T Ltd, produces a product which passes through two processes - cutting and finishing. The following information is provided:

[7]

	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.

Answer:

Cutting process capacity = 50,000hours ÷ 5 = 10,000 units
Finishing process capacity = 60,000hours ÷ 12 = 5,000 units
Throughput contribution per unit = (Selling Price – Material Cost)
= (₹ 1,000 – ₹ 400) = ₹ 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 = (Throughput contribution - Subcontracting charges)
=(₹ 600 – ₹ 400) = ₹ 200
Throughput Contribution for 5,000 units = (5000 × 200) = ₹ 10,00,000
Throughput Contribution for 7,000 units = (7000 × 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 unis 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) Discuss the significance of lean accounting. **[7]**

Answer:
Lean accounting is the application of lean principles to the accounting and associated functions within the enterprise. Lean Accounting facilitates the changes that are required to a company's accounting, control, measurement, and management processes to support lean manufacturing and lean thinking. Lean Accounting enables identification and elimination of non-value adding waste in the accounting and reporting processes; Improves visual reporting on product lines; and realigns accounting activities to a consulting role rather than a transaction role. Lean accounting empowers the finance and accounting functions to partner with the evolving lean enterprise. When the finance department revamps its processes in line with the lean methods, the time savings and communication gains are substantial. The

purpose of lean accounting is to tell us about the flow through the Value Stream; to tell us about the capacity for extra work in the Value stream; and to tell us about the incremental costs of alternative decisions and actions. Lean accounting provides a stage that enables the accounting team to move from a transaction focus to a new high value role of consulting within other areas of the company. Enterprises using Lean accounting have better information for decision-making, have simple and timely reports that are clearly understood by everyone in the company, they understand the true financial impact of lean changes; they focus the business around the value created for the customers, and accounting actively drives the lean transformation. This helps the company to grow, to add more value for the customers, and to increase cash flow and value for the stock-holders and owners. Lean accounting ensures the right people have the right information at the right time to make the right decision in the areas of pricing, production, procuring, inventory management, performance measuring, etc.

5. Compute the missing data indicated by the Question marks from the following: [14]

	Product 'R'	Product 'S'
Sales quantity		
Std.(units)	?	400
Actual (Units)	500	?
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.

Answer:

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 × 12) - 12 r] = 1200 or 6000 - 12r = 1200
r = ₹ 400

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

Given, Sales Mix Variance = (AQSP – RSQSP) = ₹ 450(F)
(6000 + 15s – 6750 -13.5s) = 450 -750 +1.5 s = 450
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)

6. (a) The past data of demand per week (in '00 kgs.) of a confectionery item is given below –

Demand/Week	**0**	**5**	**10**	**15**	**20**	**25**
Frequency	**2**	**11**	**8**	**21**	**5**	**3**

Using the sequence of random numbers – 35, 52, 13, 90, 23, 73, 34, 57, 35, 83, 94, 56, 67, 66 generate the demand for the next 10 weeks. Also determine the average demand per week

[7]

Answer:

Table showing Random Number Range for Demand

Demand/ week	Frequency (f)	Probability (p = f / ∑f)	Cumulative Probability	Range
0	2	.04	.04	00-03
5	11	.22	.26	04-25
10	8	.16	.42	26-41
15	21	.42	.84	42-83
20	5	.10	.94	84-93
25	3	.06	1.00	94-99
Total	∑f = 50	1.00		

Table showing Simulated values for the next ten weeks

Week	Random No.	Demand in '00 Kgs.
1	35	10
2	52	15
3	13	5
4	90	20
5	23	5
6	73	15
7	34	10
8	57	15
9	35	10
10	83	15

Explanatory Note on the method of obtaining simulated demed :
35 is the first one of the given Random Nos. So it is used for Week 1. Also 35 lies within the Range 26-41 of the previous table. Again 10 is the demand / week for the range 26-41. Hence demand for week 1 is 10. Similarly, the demands for the other weeks are simulated.

Average demand per week = Total demand / No. of weeks = 120/10 = 12 ('00) Kgs.

(b) 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. [7]

Answer:
(i) Let x1 and x2 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 = x1 + x2 Subject to the Constraints
0.12x1 + 0.04x2 ≥ 600 (Constraint on the income from Dividend)
0.10x1 + 0.40x2 ≥ 1000 (Constraint on the income from Growth)
x1, x2 ≥ 0 (Non-negativity Constraint)
This is the formulated Primal Problem

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

		PRIMAL (Minimization problem)			
DUAL (Maximization problem)	Decision Variables	x1	x2	Relation	RHS of Constraint
	y1	0.12	0.04	≥	600
	Y2	0.10	0.04	≥	1000

	Relation	≤	≤	-	-
	RHS of Constraint	1	1	-	-

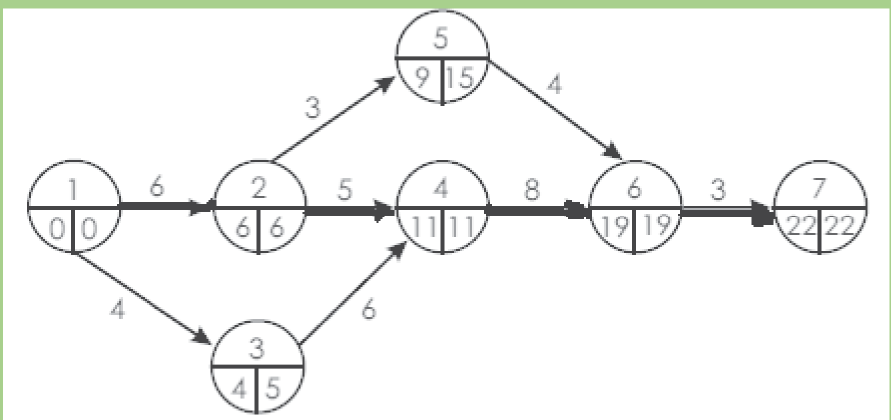
The Dual is given as –
To Maximize Z* = 600y1 + 1000y2
Subject to the Constraints
$0.12y1 + 0.10y2 \leq 1$
$0.04y1 + 0.40y2 \leq 1$
$y1, y2 \geq 0$

7. (a) The following table gives data on normal time & cost as well as crash time & cost for a project.
You need to draw the Network diagram and identify the Critical Path.
Also compute the Normal duration of the project and the corresponding Total Cost associated with it.
Crash the relevant activities systematically and determine the optimum completion time of the project. Also determine the corresponding cost when it is given that the Indirect Cost is ₹100 per day. **[7]**

Activity	Normal		Crash	
	Time (days)	Cost (₹)	Time (days)	Cost (₹)
1—2	6	600	4	1,000
1—3	4	600	2	2,000
2—4	5	500	3	1,500
2—5	3	450	1	650
3—4	6	900	4	2,000
4—6	8	800	4	3,000
5—6	4	400	2	1,000
6—7	3	450	2	800

Answer:

The network for normal activity times indicates project duration of 22 days with critical path 1-2-4-6-7. It is shown below:

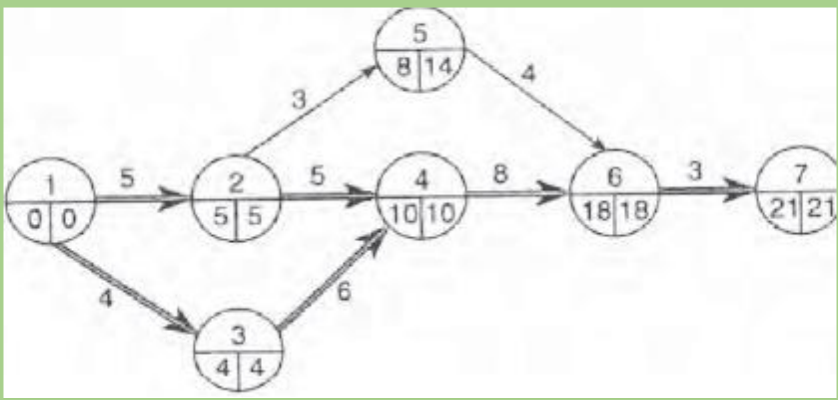


Total Cost associated with it is given as (Normal Direct Cost + Indirect Cost for 22 Days @ ₹ 100 per Day)
Normal Direct Cost = (600 + 600 + 500 + 450 + 900 + 800 + 400 + 450) = ₹ 4700
Indirect Cost = 22 × 100 = ₹ 2200
Required Total Cost = 4700 + 2200 = ₹ 6900

1st Stage of Crashing
Cost slope of each of the Critical Activities of the Network diagram is calculated and ranked as below.

Critical Activity	Cost Slope =	Rank as per ascending order of Cost Slope
1-2	(1000 – 600)/ (6 – 4) = ₹ 200 per day	1
2-4	(1500 – 500)/ (5 – 3) = ₹ 500 per day	3
4-6	(3000 – 800)/ (8 – 4) = ₹ 550 per day	4
6-7	(800 – 450)/ (3 – 2) = ₹ 350 per day	2

As Cost Slope of Activity 1 – 2 is minimum, crashing is to be started from this Activity. Maintaining criticality of the existing Critical Path, Activity 1 – 2 is crashed by 1 Day.



New Network Diagram is shown above. It is having Duration of 21 Days and the associated Total Cost is given as TC = Normal Direct Cost + Indirect Cost (for 21 Days @ ₹ 100 per Day) + Cost of Crashing Activity 1-2 by 1 Day
= 4700 + 21 × 100 + 1 × 200 = ₹ 7000
It is seen that other activities too have become Critical. Now there are two Critical Paths given by 1 – 2 – 4 – 6– 7 as well as 1 – 3 – 4 – 6 – 7

2nd Stage of Crashing
Cost Slopes of each of the new Critical Activities are calculated as below.
Cost Slope of Activity 1 – 3 = (2000 – 600)/ (4 – 2) = ₹ 700 per Day & that of 3 – 4 = (2000 – 900)/ (6-4) = ₹ 550/- per Day.

As there are more than one Critical Path, parallel Crashing is necessary for some of the activities to maintain criticality of the existing Critical Paths. Various options of Crashing and their corresponding Cost Slopes are shown below.

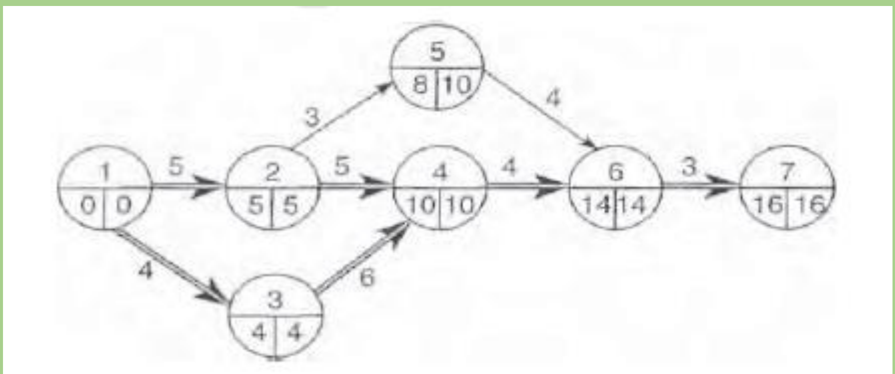
Options	Possible Crash (Days)	Cost Slope (₹/ Day)	Rank
Activities (1 - 2) & (1 - 3)	1*	200 + 700 = 900	4
Activities (1 - 2) & (3 - 4)	1*	200 + 550 = 750	3
Activities (2 - 4) & (1 - 3)	2	500 + 700 = 1200	6
Activities (2 - 4) & (3 - 4)	2	500 + 550 = 1050	5
Activity (4 – 6)	4	550	2
Activity (6 – 7)	1	350	1

* Though as per the supplied data activities (1-3) & (3-4) can be crashed by 2 days each, but (1 – 2) cannot be crashed more than 1 Day after 1st stage of Crashing.

From the above ranking Crashing of (6-7) by 1 Day is suggested. Due to this project duration will be 20 Days and associated Total Cost = Normal Direct Cost + Indirect Cost for 20 Days @ ₹ 100 per Day+ Crashing Cost of Activity (1 – 2) by 1 Day @ ₹ 200 per Day + Crashing Cost of Activity (6 – 7) by 1 Day @ ₹ 350 per Day = 4900+ 20 × 100 + 1 × 200 + 1 × 350 = ₹ 7450

3rd Stage of Crashing

After 2nd Stage of Crashing, no new Critical Path emerged. So the options remain same as in the 2nd Stage with the exception of Activity (6 – 7) which is totally crashed in the 2nd Stage.
From the above list of Ranking, Activity (4 – 6) is having lowest Cost Slope. Thus it is crashed by 4 days now.
New Network having project duration of 16 Days is shown below.

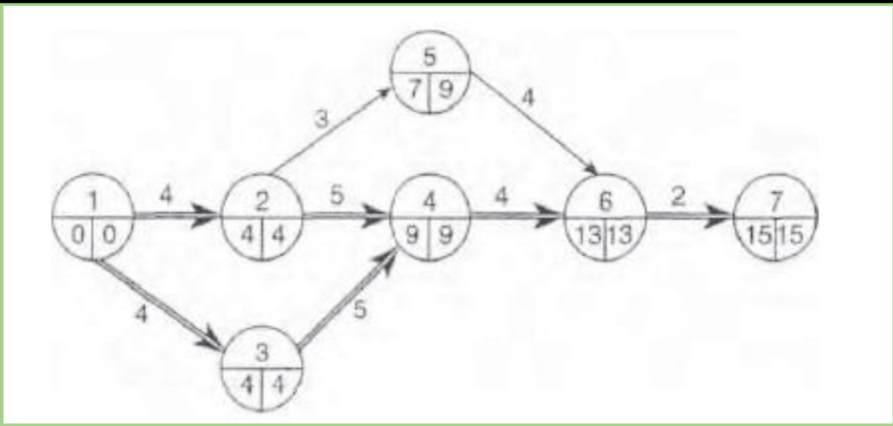


Total Cost of the Project = Normal Direct Cost + Indirect Cost (for 16 Days @ ₹ 100/ Day) + Crashing Cost [for Activity (1 – 2) by 1 Day @ ₹ 200/ Day + for Activity (6 – 7) by 1 Day @ ₹ 350/ Day + for Activity (4 – 6) by 4 Days @ ₹ 550/ Day] = 4900 + 1600 + 200 + 350 + 550 × 4 = ₹ 9250

4th Stage of Crashing

After 3rd Stage of Crashing, no new Critical Path emerged. So the options remain same as in the 2nd Stage with the exception of Activities (6 – 7) and (4 – 6) which are fully crashed in the 2nd and 3rd Stages.

From the above list of Ranking, Activity (1 – 2) and (3 – 4) together is having lowest Cost Slope. Thus both are crashed by 1 day now. New Network having project duration of 15 Days is shown below.

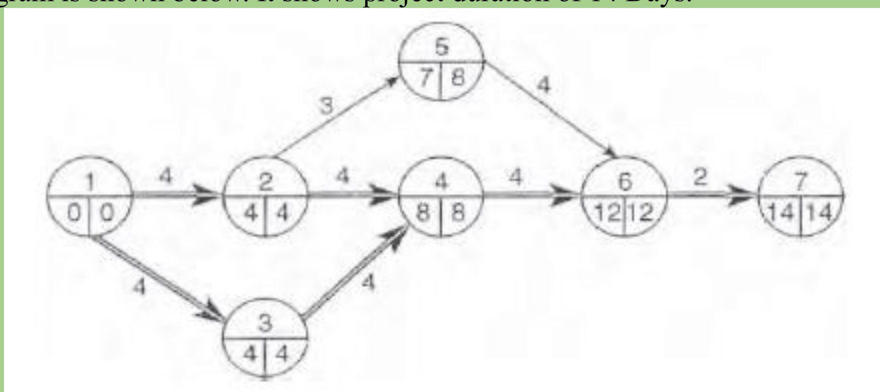


Total Cost of the Project
= Normal Direct Cost + Indirect Cost (for 15 Days @ ₹ 100/ Day) + Crashing Cost [for Activity (1 – 2) by 1 Day @ ₹ 200/ Day + for Activity (6 – 7) by 1 Day @ ₹ 350/ Day + for Activity (4 – 6) by 4 Days @ ₹ 550 per Day + for Activities (1 – 2) & (3 – 4) together by 1 Day @ ₹ 750/Day]
= 4900 + 1500 + 200 + 350 + 550 × 4 + 750 = ₹ 9900

5th Stage of Crashing
Though after 4th Stage of Crashing no new Critical Paths emerged, but the Activity (1 – 2) has been crashed fully. Thus the options remaining are as follows.

Options	Possible Crash (Days)	Cost Slope (₹/ Day)	Rank
Activities (2 - 4) & (1 - 3)	2	500+700=1200	2
Activities (2 - 4) & (3 - 4)	1*	500+550=1050	1

* Though Activity (2 - 4) can be crashed by 2 Days but after 4th Stage, (3 – 4) has only 1 Day of Crashing left.
As Cost Slope of Activities (2 – 4) & (3 – 4) taken together is least, both are crashed by 1 Day and the new Network diagram is shown below. It shows project duration of 14 Days.

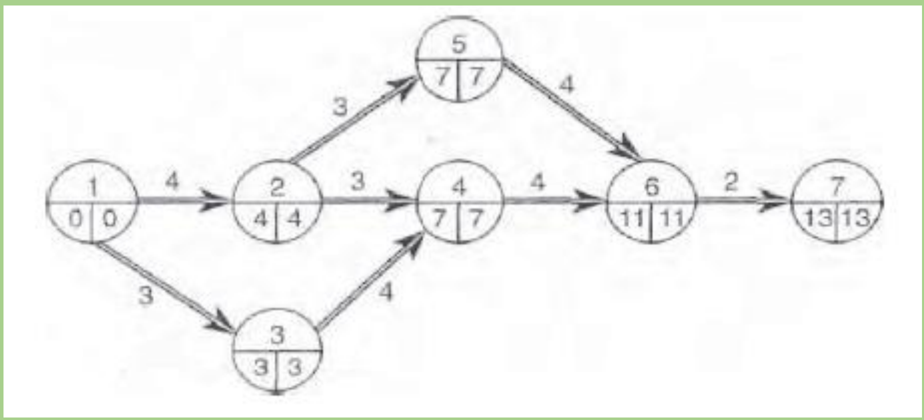


Total Cost of the Project
= Normal Direct Cost + Indirect Cost (for 14 Days @ ₹ 100/ Day) + Crashing Cost [for Activity (1 – 2) by 1 Day @ ₹ 200/ Day + for Activity (6 – 7) by 1 Day @ ₹ 350/ Day + for Activity (4 – 6) by 4 Days @ ₹ 550/ Day +

for Activities (1 – 2) & (3 – 4) together by 1 Day @ ₹ 750/Day + for Activities (2 – 4) & (3 – 4) together by 1 Day@ ₹ 1050/ Day]
= 4900 + 1400 + 200 + 350 + 550 X 4 + 750 + 1050 = ₹ 10850

6th Stage of Crashing

After 5th Stage of Crashing no new Critical Paths emerged. So the available option as per the table above is to crash (2 – 4) and (1 – 3) together and they can be crashed by 1 Day because after 5th Stage only 1 Day of crashing is available for Activity (2 – 4). The new Network diagram having project duration of 13 Days is shown below.



Total Cost of the Project
= Normal Direct Cost + Indirect Cost (for 13 Days @ ₹ 100/ Day) + Crashing Cost [for Activity (1 – 2) by 1 Day @ ₹ 200/ Day + for Activity (6 – 7) by 1 Day @ ₹ 350/ Day + for Activity (4 – 6) by 4 Days @ ₹ 550 per Day + for Activities (1 – 2) & (3 – 4) together by 1 Day @ ₹ 750/Day + for Activities (2 – 4) & (3 – 4) together by 1 Day @ ₹ 1050/ Day + for Activities + for Activities (2 – 4) & (1 – 3) by 1 Day @ ₹ 1200/ Day]
= 4900 + 1300 + 200 + 350 + 550 X 4 + 750 + 1050 + 1200 = ₹ 11950
From the diagram it is clear that all the paths of the Network are Critical. Also activities of the path 1 – 2 – 4 – 6- 7 are each fully crashed. Thus no further crashing of the Network is possible.

It is noticed that the Total Cost of the Project kept on increasing all along. This has happened due to the fact that the rate of decrease of Indirect Cost is much lower than the rate of increase of Direct Cost for Crashing. Hence optimum duration of the project cannot be obtained and rather minimum possible duration is obtained and that value is 13 Days. Associated Total Cost of project is ₹ 11950.

(b) A firm received an order to make and supply eight units of standard product which involves intricate labour operations. The first unit was made in 10 hours. It is understood that this type of operation is subject to an 80% learning rate. The workers are getting wages at the rate of ₹12 per hour.

(i) What is the total time and labour cost required to execute the above order

(ii) If a repeat order of 24 units is also received from the same customer, calculate the labour cost necessary for the second order.

[7]

Answer:

80% Learning Curve results are given below:

Production (Units)	Cumulative Average Time (hours)	Total Time (hours)
1	10	10
2	8	16
4	6.4	25.6
8	5.12	40.96
16	4.096	65.54
32	3.2768	104.86

Labour time required for first eight units = 40.96 hours
Labour cost required for 8 units = 40.96 hours × ₹ 12/hr = ₹ 491.52
Labour time for 32 units = 104.86 hours
Labour time for first eight units = 40.96 hours Labour time required for 2nd order of 24 units
= 104.86 – 40.96 = 63.90 hours

Labour cost for the 2nd order of 24 units = 63.90 hours × ₹12/hr = ₹ 766.80

8. (a) Solve the Game using Dominance Principle

$$\begin{array}{cc} & \textbf{Player B} \\ \textbf{Player A} & \begin{pmatrix} 15 & 2 & 3 \\ 6 & 5 & 7 \\ -7 & 4 & 0 \end{pmatrix} \end{array}$$

[7]

Answer:

Let the given Game is played by the Players A and B with A (the maximising player) having strategies A1, A2 and A3 represented along the rows and B (the minimising player) having strategies B1, B2 and B3 represented along the columns. So the given Payoff Matrix can be written as follows –

Strategies of B

Strategies of A	B1	B2	B3
A1	**15**	**2**	**3**
A2	**6**	**5**	**7**
A3	**-7**	**4**	**0**

All the elements of Row A3 are less than the corresponding elements of Row A2. So A3 is dominated by A2. Hence, It is ignored and deleted. The new matrix is given below.

Strategies of B

Strategies of A	B1	B2	B3
A1	15	2	3
A2	6	5	7

Here all the elements of B3 are more than the corresponding elements of B2. Hence B3 is dominated by B2 and ignored to get the new matrix below.

Strategies of B

Strategies of A	B1	B2	B3
A1	15	2	2
A2	6	5	5
Column Max	15	5	

Maximum among the Row minimums = 5 = Maximin value and Minimum among the Column maximums = 5
= Minimax value. As, Maximin and Minimax values are equal, there exists a Saddle Point. It occurs at the cell A2B2.
Hence optimal strategies of A and B are respectively A2 and B2. Also value of the Game = 5

[NOTE – This is a problem of Pure Strategy and could have been solved without the use of Dominance Rules, but the question has specifically asked for the usage of Dominance Rules. So the same is used.]

(b) Calculate the Seasonal Indices for the following quarterly data in certain units. Appropriate method for finding the Indices has to be decided by you with due explanation.

Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
2020	39	21	52	81
2021	45	23	63	76
2022	44	26	69	75
2023	53	23	64	84

[7]

Answer:

The values in any quarter do not reveal any definite tendency to change. Thus there is no appreciable trend in the given dataset. So it is decided to use Method of Simple Average (Quarterly) to find out the Seasonal Indices. Also a Multiplicative Model is assumed for the data.

Calculations for Seasonal Index

Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total
2020	39	21	52	81	-
2021	45	23	63	76	-
2022	44	26	69	75	-
2023	53	23	64	84	-
Total	181	93	248	316	838
Arithmetic Mean	45.25	23.25	62	79	209.5
Seasonal Index	86.4	44.4	118.4	150.8	400

Calculations

Arithmetic Mean for any Quarter = Total for that quarter /4, Grand Average = Total of the Arithmetic Means /4

Seasonal Index for any Quarter = (Arithmetic Mean of that Quarter / Grand Average) x100