FINAL EXAMINATION

ANSWERS TO PRACTICE TEST PAPER **TERM – JUNE 2026**

PAPER – 16 **SYLLABUS 2022**

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) You are given the following estimates for next year's budgeted sales of a single product produced by SCC Ltd.: Selling Price ₹ 12 per unit, Probability for sales demand are as follows:

Units	Probability
3200	0.50
4000	0.30
5000	0.20

Calculate the value of sales for the Period

A) ₹ 3,800

B) ₹ 45,600

C) ₹ 47,800

D) None of the above

(ii) Surya Ltd., a manufacturing company has a break-even point when sales are ₹ 12,00,000 and fixed costs at that level of sales are ₹ 4,80,000. If the Margin of Safety (MOS) and sales of the company are 40% and 5,00,000 units respectively, what will be the sale price per unit?

A) ₹ 2

B) ₹ 4

C) ₹ 6

D) ₹ 8

(iii) The P/V ratio of a company dealing in Electrical equipment is 50% and the margin of safety is 20%. BEP of the firm at a sales volume of ₹ 50,00,000 will be

A) ₹ 40,00,000

B) ₹ 30,00,000

C) ₹ 35,00,000

D) ₹ 37,00,000

(iv) A company uses traditional standard costing system. The inspection and set-up costs are actually ₹ 1,760 against a budget of ₹ 2,000. ABC system is being implemented and accordingly the number of batches is identified as the cost driver for inspection and set up. The budgeted production is 10,000 units in batches of 1,000 units whereas actually 9,000 units were produced in 11 batches. The cost per batch under ABC system will be

A) ₹ 160

B) ₹ 176

C) ₹ 200
D) ₹ 1760

(v) The following figures are extracted from the books of a company:
Budgeted O/H - ₹ 10,000 (Fixed ₹ 6,000, Variable ₹ 4,000)
Budgeted Hours - 2000
Actual O/H - ₹ 10,400 (Fixed ₹ 6,100, Variable ₹ 4,300)
Actual Hours - 2100
Variable O/H cost variance and Fixed O/H cost variance will be:
A) ₹ 100 (A) and ₹ 200 (A)
B) ₹ 100 (F) and ₹ 200 (F)
C) ₹ 100 (A) and ₹ 200 (F)
D) ₹ 200 (A) and ₹ 100 (F)

(vi) A firm is required to procure three items I, II & III from three vendors V1 , V2 & V3 respectively. The quoted prices in Rupees are given in the table below. The management policy clearly states that each item should be procured from only one vendor and each vendor should supply only one item. The minimum total cost of procurement is –

Items	Vendors		
	V1	V2	V3
I	110	120	130
II	115	140	140
III	125	145	165

A) ₹ 365
B) ₹ 340
C) ₹ 370
D) ₹ 385

(vii) The value of the game of

		Player B	
		B1	B2
Player A	A1	4	6
	A2	-10	10

is ___
Fill in the above.
A) 4
B) 3
C) 2
D) 1

(viii) RSP Ltd. manufactures a product whose time for the first unit is 1000 hours. It experience a learning curve of 80%, What will be the total time taken in hours for unit 5 to 8?

A) 1564 hours
B) 1634 hours
C) 1460 hours
D) 1536 hours

(ix) Which of the following statement is correct?

A) Functioning of ETL Tool is same as that of ELT Tool.
B) For Data Analytics the purpose of ETL Tool is same as that of ELT Tool.
C) Both (A) and (B)
D) None of the above

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

A) Procurement
B) Human Resource Development
C) Service
D) Technology Development

(xi) An increase in the selling price per unit will cause

A) A decrease in the number of units required to breakeven.
B) An increase in the contribution margin ratio.
C) An increase in the margin of safety.
D) All of the Above

(xii) Kanban Japanese System under JIT approach ensures that:

A) Continuous supply of inventory or product
B) Minimum & maximum level of stock to be maintained
C) Inventory valuation
D) All of the above

(xiii) Standard cost and budgeted cost are

A) Interrelated but not interdependent.
B) Interdependent but not interrelated.
C) Interrelated and interdependent.
D) None of the Above.

(xiv) Which of the following is not a term normally used in value analysis?

A) Resale value
B) Use value
C) Esteem value
D) Cost value

(xv) SKC Ltd., a manufacturer of components for ABC, has the capacity to produce 4 Lakh units. The market demand is sensitive to the sale price, and the company could sell 1 Lakh units at a price of ₹ 5,000 each. The demand thereafter would double for each 500 per unit fall in the selling price. If the company expects a minimum margin of 25%, what would be the Target Cost per unit for the company to sell at full capacity utilisation?

A) ₹ 1,000
B) ₹ 2,000
C) ₹ 2,500
D) ₹ 3,000

Answers:

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)
B	B	A	C	C	D	A	D	B	C	D	A	A	A	D

SECTION – B

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

[5 x 14 = 70]

2. Dixon Ltd., a cement manufacturing company, produces '30 grade' cement for which the company has an assured market. The output for 2025 has been budgeted at 1,80,000 units at 90% capacity utilization. The cost sheet based on output (per unit) is as follows:

Particulars	₹
Selling Price	130
Direct Material	30
Component "EX"	9.40
Direct Wages @ ₹7 per hour	28
Factory Overheads (50% fixed)	24
Selling and distribution Overheads (75% variable)	16
Administrative Overheads (Fixed)	5

The factory overheads are applied on the basis of direct labour hours.

To utilize the idle capacity and to improve the profitability of the company, the following proposal was put up before the Board of Directors for consideration:
An order has been received from abroad for 6,000 units of product '30 grade' cement at ₹ 175 per unit.
The cost data are:
Direct material ₹ 56 per unit,
Direct labour 10 hours per unit,
Selling and distribution overheads applicable to this product order is ₹ 14 per unit and
Variable factory overheads are chargeable on the basis of direct labour hours.
The company at present manufactures component 'EX' one unit of which is required for each unit of product '30 grade 'cement. The cost details for 15000 units of component 'EX' are as follows:

Particulars	₹
Direct Material	**30,000**
Direct Labour	**52,500**
Variable Overheads	**25,500**
Fixed Overheads	**33,000**
Total	**1,41,000**

The component "EX" however is available for purchase at the market at ₹ 7.90 per unit.

Required:

(i) Prepare a statement showing profitability of the company as envisaged in the Budget.

(ii) Evaluate the export order and state whether it is acceptable or not.

(iii) Prepare an appraisal of proposal to manufacture component "EX" and state whether component "EX" should be manufactured in the factory or purchased from the market. Assume that no alternative use of spare capacity is available.

[14]

Answer:

Segregation of Variable Costs and Fixed Costs:

		Cost/per unit (₹)	Variable Cost (₹/ unit)	Fixed Cost (₹)
Direct Material		30.00	30.00	-
Component EX		9.40	7.20	3,96,000
Direct Wages		28.00	28.00	-
Factory Overhead	50% fixed	24.00	12.00	21,60,000
Selling & Distribution Overhead	75% variable	16.00	12.00	7,20,000
Administration Overhead	Fixed	5.00	0.00	9,00,000
Total		112.40	89.20	41,76,000

(i) Statement showing Profitability as envisaged in the Budget:

Units sold	1,80,000
	Amount (₹)
Selling Price per unit	130.00
Less: Variable cost per unit	89.20
Contribution per unit	40.80
Total Contribution	73,44,000
Less: Fixed Cost	41,76,000
Profit	31,68,000

(ii) Evaluation of Export Order:

	₹ per Unit	₹ per Unit
Direct material	56	
Direct labour	70	
Variable factory overhead	30	
Selling and distribution overheads	14	
Total variable cost		170
Selling price (export)		175
Contribution		5
Total units		6000
Additional contribution from export order (6,000 units × ₹ 5)		₹ 30,000

Verification of availability of Capacity to fulfill the export order:

Total labour Hours on Product 50 grade	7,20,000
Total labour Hours on component EX	90,000
Total hours utilized at 90% capacity	8,10,000
Total Hours at 100% capacity	9,00,000
Balance Hours available	90,000
Hours required for export order	60,000

Decision: Since export order gives an additional contribution of ₹30,000 and availability of capacity also exists to fulfill the export order, the same is acceptable.

(iii) Appraisal of Make or Buy Decision:

(Per 15000 units)	Make (₹)	Buy (₹)
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

Decision: If the company makes the component, the out-of-pocket cost is ₹ 7.20 per unit whereas if the component is bought, the out-of-pocket cost is ₹ 7.90. Since no alternative use of spare capacity is available, it is profitable to make.

3. (a) A Company with two manufacturing divisions is organised on profit centre basis. Division 'A' is the only source for the supply of a component that is used in Division B in the manufacture of a product KLIM. One such part is used in each unit of the product KLIM. As the demand for the product is not steady, Division B can obtain orders for increased quantities only by spending more on sales promotion and by reducing the selling prices. The Manager of Division B has accordingly prepared the following forecast of sales quantities and selling prices

Sales units per day	Average Selling price per unit of KLIM (₹)
1,000	5.25
2,000	3.98
3,000	3.30
4,000	2.78
5,000	2.40
6,000	2.01

The manufacturing cost of KLIM in Division B is ₹3,750 for first 1,000 units and ₹750 per 1,000 units in excess of 1,000 units. Division A incurs a total cost of ₹1,500 per day for an output to 1,000 components and the total costs will increase by ₹900 per day for every additional 1,000 components manufactured. The Manager of Division A states that the operating results of his Division will be optimised if the transfer price of the component is set at ₹1.20 per unit and he has accordingly set the aforesaid transfer price for his supplies of the component to Division A.

You are required to:

(1) Prepare a schedule showing the profit at each level of output for Division A and Division B.

(2) Calculate the profit of the company as a whole at the output level which

(i) Division A's net profit is maximum.

(ii) Division B's net profit is maximum.

[7]

(b) T Ltd. produces and sells a product. The company expects the following revenues and costs in 2024:
Revenues (400 sets sold @ ₹600 per product) = ₹2,40,000
Variable costs = ₹ 1,60,000
Fixed costs = ₹ 50,000
Calculate the amount of sales T Ltd. must has to earn a target net income of ₹63,000 if they have a tax rate of 30%?

[7]

Answer:

(a) Profit at each level of output

(1) Statement showing profit of Division A

Sale per day (units)	Sale value Units × ₹ 1.20 (₹)	Cost (₹)	Profit/(loss) (₹)

1,000	1,200	1,500	(300)
2,000	2,400	2,400	-
3,000	3,600	3,300	300
4,000	4,800	4,200	600
5,000	6,000	5,100	900
6,000	7,200	6,000	1,200

(2) Statement showing profit of division B

No of units	Selling Price per Unit	Sales	Transfer Price	Other Manufacturing Cost	Total Cost	Profit / (Loss)
	₹	₹	₹	₹	₹	₹
1	2	3	4	5	6	7
		(1 × 2)			(4 + 5)	(3 – 6)
1,000	5.25	5,250	1,200	3,750	4,950	300
2,000	3.98	7,960	2,400	4,500	6,900	1,060
3,000	3.30	9,900	3,600	5,250	8,850	1,050
4,000	2.78	11,120	4,800	6,000	10,800	320
5,000	2.40	12,000	6,000	6,750	12,750	(750)
6,000	2.01	12,060	7,200	7,500	14,700	(2640)

(i) Profit of the company at the output level where division A's net profit is maximum

Profit of Division A is maximum, i.e. ₹1,200/- at the output level of 6,000 units

At the level of 6,000 units:

Profit of Division A = ₹1,200

Profit of Division B = (-) ₹2,640

Profit of the Company = (-) ₹1,440

(ii) Profit of the company at the output level where division B's net profit is maximum

Profit of Division B is maximum, i.e. ₹ 1,060 at the output level of 2,000 units

At the level of 2,000 units:

Profit of Division A = ₹ Nil

Profit of Division B = ₹1,060

Profit of the Company = ₹1,060

(b)

Sales = ₹2,40,000

Variable Costs = ₹1,60,000

Current Contribution = (2,40,000 – 1,60,000) = ₹80,000

Contribution of Sales Ratio = (80,000 ÷ 2,40,000) = 1/3

Target Net Income (Net Profit) = ₹63,000

Tax Rate = 30%

Profit Before Tax = {(Net Profit ÷ (1-Tax Rate)}

= {63,000 ÷ (1-30%)} = ₹90,000

Fixed Costs + ₹50,000

Target Contribution = (PBT + FC)

= 90,000 + 50,000

= ₹1,40,000

Target Sales = (Target Contribution ÷ C/S Ratio)

= (₹1,40,000 ÷ 1/3)

= ₹4,20,000

4. (a) A company produces four products, viz. A, B, C and D. The data relating to production activity are as under

Product	Quantity of production	Material cost/ ₹. per unit	Direct labour hours/unit	Machine hours/ unit	Direct Labour cost/₹ per unit
A	4,500	12	2	1.50	8
B	13,640	15	2	0.75	9
C	2,340	25	5	2.50	27
D	18,350	21	4	4.00	25

Production overheads are as under:	₹
(i) Overheads applicable to machine-oriented activity:	1,65,900
(ii) Overheads relating to ordering materials	8,760
(iii) Set up costs	21,400
(iv) Administration overheads for spare parts	44,690
(v) Material handling costs	25,545

The following further information has been compiled:

Product	No. of set up	No. of materials orders	No. of times materials handled	No. of spare parts
A	3	3	6	6
B	18	12	30	15
C	5	3	9	3
D	24	12	36	12
Total	50	30	81	36

Select a suitable cost driver for each item of overhead expense and calculate the cost per unit of cost driver.

[7]

(b) Value Analysis enables people to contribute towards value addition by continuous focus on product design and services". - In this context, discuss the phases of Value Analysis.

[7]

Answer:

Computation of Cost Driver Rates

(i) Overheads relating to Machinery oriented activity Cost

Driver: Machine Hour Rate

Machine Oriented Overheads = ₹1,65,900

Total Machine hours = (4500 x 1.5) + (13640 x 0.75) + (2340 x 2.5) + (18350 x 4)

= 6750 + 10230 + 5850 + 73400

= 96230

Cost Driver Rate = 1,65,900 /96,230

= ₹ 1.724 per hour

(ii) Overheads relating to ordering materials Material

Ordering Overheads = ₹ 8,760

Cost driver: No. of Material orders

Cost Driver Rate = 8,760/30 = ₹ 292 per order

(iii) Set up costs

Set Up Overheads = ₹21,400 Cost

driver: No. of set ups

Cost Driver Rate = (21,400/50) = ₹ 428 per set up

(iv) Administrative Overheads for spare parts

Administrative Overheads = 44,690

Cost driver: No. of spare parts

Cost Driver Rate = (44690/36) = ₹1241.39 per spare part

(v) Material Handling costs

Material Handling Overheads = 25,545

Cost driver: No. of times materials are handled

Cost Driver Rate = (25545/81) = ₹ 315.37 per material handling

(b) The Phases of Value Analysis are summarized as follows:

1. Origination: The phase of origination starts with the identification of a project to undertake value analysis. After selecting the project, a project team consisting of experts from various fields and departments is constituted.

2. Information: The second phase is that of collecting relevant information. In this phase, the relevant facts relating to specifications, drawings, methods, materials, etc. are collected. Costs are, also, ascertained for each of the elements that are being studied.

3. Functional Analysis: Then follows the important phase of functional analysis. After familiarisation with the relevant facts & figures, a functional analysis is carried out to determine the functions and uses of the product and its components. The cost and importance of each function are identified. A value index is computed on the basis of cost benefit ratio for each of the functions

4. Innovation: This is the creative phase concerned with the generation of new alternatives to replace or remove the existing ones. The objective is to produce ideas and to formulate alternative means and methods for accomplishing the essential functions and improving the value of the element under consideration.

5. Evaluation: During the stage of evaluation, each and every alternative is analysed and the most promising alternatives are selected. These alternatives are further examined for economic and technical feasibility. The alternatives finally selected must be capable of performing the desired functions satisfactorily.

6. Choice: In this phase, the decision makers choose the best of alternatives. The programs and action plans are then developed to implement the chosen alternative.

7. Implementation: The chosen alternative is put to the actual use with the help of the programs and action plans. The progress of implementation is continuously monitored and followed up to ensure that the desired results are achieved.

5. (a) BBK Ltd. manufactures MKY by mixing three raw materials. For every batch of 100Kg. of MKY, 125 Kg. of raw materials are used. In April 2024, 60 batches were prepared to produce an output of 5,600 Kg. of MKY. The standard and actual particulars for April 2025 are as under

Raw Material	Standard		Actual		Quantity Of Raw Material Purchased Per kg
	Mix %	Price Per Kg	Mix %	Price Per Kg	
A	50	20	60	21	5,000
B	30	10	20	8	2,000
C	20	5	20	6	1,200

Calculate relevant material variances. **[7]**

(b)

Item	Budget	Actual
No. of working Days	20	22
Output per Man hour	1.0 Units	0.9 Units
Overhead Cost	₹ 1,60,000	₹ 1,68,000
Man- Hours Per Day	8,000	8,400

Calculate Overhead Variances. **[7]**

Answer:

(a) Standard Production = (60 batches x 100 units per batch) = 6,000 units
Standard Raw Material for 6,000 units = (60 batches x 125 kg) = 7,500 kg
Standard Loss = (7,500 - 6,000) = 1,500 kg
Actual Production = 5,600 units

Standard Mix for 60 batches (i.e., 6,000 units)

Raw Material	Mix %	Quantity (kg)	Price (₹)	Value (₹)
A	50	3,750	20	75,000
B	30	2,250	10	22,500
C	20	1,500	5	7,500
Total		7,500		1,05,000
Standard Loss @25 kg per Batch		60 x 25 = 1,500		
Production		6,000		1,05,000

Standard Mix for Actual Production of 5,600 units

Raw Material	Mix (%)	Quantity (kg)	Standard Price (₹)	Value (₹)
A	50	3,500	20	70,000
B	30	2,100	10	21,000
C	20	1,400	5	7,000
Total		7,000		98,000

Actual Mix for 5,600 units

Raw Material	Mix (%)	Quantity (kg)	Standard Price (₹)	Actual price (₹)	Standard Value(₹)	Actual Value(₹)
A	60	4,500	20	21	90,000	94,500
B	20	1,500	10	8	15,000	12,000
C	20	1,500	5	6	7,500	9,000
Total		7,500			1,12,500	1,15,500
Actual Loss = 7,500 — 5600		1,900				
Production		5,600			1,12,500	1,15,500

Note: Purchased quantity is 8,200 kg; but consumed quantity is only 7,500 kg.

Material Cost Variance = Standard Cost — Actual Cost

= 98,000 — 1,15,500 = ₹ 17,500 (A)

Material Price Variance = AQ (SP-AP) = (1,12,500 - 1,15,500) = ₹ 3,000 (A)

Material Yield Variance = Standard Price of Standard Mix for Actual Production

— Standard Price of Standard Mix for Standard Production

= (98,000 — 1,05,000) = ₹ 7,000 (A)

Material Mix Variance = Standard Price of Standard Mix for Standard Production — Standard Price of Actual Mix for Actual Production

= (1,05,000 — 1,12,500) = ₹ 7,500 (A)

(b) Step 1: Computations

SR = Budgeted FOH ÷ Budgeted Hours

= 1,60,000 ÷ (20 working days × 8,000 man hours)

= 1,60,000 ÷ 1,60,000

= 1

RBH = (22 working days × 8,000 man hours) = 1,76,000

AH = (22 working days × 8,400 man hours) = 1,84,800

AQ = 1,84,800 × 0.9 = 1,66,320

SH = (AQ ÷ Units per hour) = (1,66,320 ÷ 1 unit per hour) = 1,66,320

(1) SRSH	(2) SRAH	(3) SRRBH	(4) SRBH	(5) ARAH
1 × 1,66,320	1 × 1,84,800	1 × 1,76,000		
₹ 1,66,320	₹ 1,84,800	₹ 1,76,000	₹ 1,60,000	₹ 1,68,000

SRSH = Standard Cost of Standard Fixed Overheads = ₹ 1,66,320

SRAH = Standard Cost of Actual Fixed Overheads (or) Fixed Overheads absorbed or recovered

= ₹ 1,84,800

SRRBH = Revised budgeted Fixed overheads = ₹ 1,76,000

SRBH = Budgeted Fixed overheads = ₹ 1,60,000

ARAH = Actual Fixed Overheads = ₹ 1,68,000

Step2: Computations

FOH Efficiency Variance = (SRSH – SRAH) = (1,66,320 – 1,84,800) = ₹ 18,480(A)

FOH Capacity Variance = (SRAH – SRRBH) = (1,84,800 – 1,76,000) = ₹ 8,800(F)

FOH Calendar Variance = (SRRBH – SRBH) = (1,76,000 – 1,60,000) = ₹ 16,000(F)

FOH Volume Variance = (SRSH – SRBH) = (1,66,320 – 1,60,000) = ₹ 6,320(F)

FOH Budget Variance = (SRBH – ARAH) = (1,60,000 – 1,68,000) = ₹ 8,000(A)

FOH Cost Variance = (SRSH – ARAH) = (1,66,320 – 1,68,000) = ₹ 1,680(A)

6.(a) Sri Lanka, the third largest tea producing country has a production share of 9% of the international market and one of the world's leading exporters with a share of 19% of the global demand. Thus, tea industry is crucial to enhance their economic competitiveness in the world market. The nature of the highly competitive global market has made scientific and reasonable production management increasingly important for tea companies to differentiate themselves from competitors. In order to enhance their competitive position, Sri Lankan tea manufacturers are giving serious thought to use

optimization techniques like Linear Programming to find their best product mix to achieve maximization of profit. Dulwan Tea Company, established in 1974 is one of the leading tea exporters of the country. They use their own leaves which grow in their tea plantations. More than 2500 varieties of flavoured and non-flavoured tea products are produced and globally exported by the company. This brand is available in more than 90 countries in the world including UK, Poland, Canada, South Africa, Australia and New Zealand. Therefore, how to optimize the production process yielding maximum profit is a critical and challenging task in front of the decision makers of Dulwan. After lot of deliberations among themselves, the management of Dulwan has decided to hire a Cost and Management consultant.

Accordingly, they hired Mr. Kuppuswamy, a resident of Jafina, Sri Lanka and a well-known consultant of the island. In his first visit to the company the management explained to him the requirements and Mr. Kuppuswamy technically phrased the objective of the work as follows.

- To formulate a mathematical model that would suggest a viable product mix to ensure maximum profit of the company as well as evaluating performance of the proposed product mix.
- To highlight the peculiarities of using linear programming technique at a single operating procedure and prove that despite the obstacles, the application of the technique in determining the product mix enables Dulwan Tea Company to be more profitable than the otherwise.

Thereafter a team is formed from the existing employees of the company and under the guidance of Mr. Kuppuswamy they started working to formulate the problem as a Linear Programming model. Since the company is dealing with huge varieties of tea product, everybody could realize that solving such LPP manually is impossible. So it is decided to purchase a suitable software for the purpose and Mr. Kuppuswamy is requested to get at least three quotes from renowned global software companies. When the process is on, all of a sudden new opportunities open and the company decided to bid for supplying few of its very premium quality tea to the European market. But the management was not very sure as to which quality of tea they should try to sell so that the objective of profit maximization is fulfilled. Once again Mr. Kuppuswamy was approached and this time he decided to find the best product mix by solving the problem manually (as variety of very premium quality tea was not much and the decision regarding which software to purchase not finalized).

During solution of the problem manually, at one stage the following Simplex Table is obtained

C_B	Product Mix	Quantity	X_1	X_2	X_3	S_1	S_2	S_3	A_1
2	X_1	4	1	2	1/2	0	0	1/4	0
0	S_2	12	0	0	-1	0	1	-1/2	0
0	S_1	12	0	6	0	1	0	1	-1
	C_j		2	4	1	0	0	0	-M
	Z_j	8	2	4	1	0	0	1/2	0
	$C_j - Z_j$		0	0	0	0	0	-1/2	-M

Answer the following questions, with proper explanation, related to the Simplex Table above.

i) How many varieties of very Premium quality tea are considered in the problem?

ii) Is the solution given in the table above Optimal?

iii) What is the Objective Function?

iv) Is there any alternate solution to the problem?

v) Is the solution feasible?

vi) What is the optimum product mix and the maximum profit.

vii) If any alternate solution is possible then find it.

[7]

(b) A salesman has to visit five cities A, B, C, D and E. The inter-city distances in kilometre are tabulated below. Note the distance between two cities need not be same both ways.

From/To	A	B	C	D	E
A	-	12	24	25	15
B	6	-	16	18	7
C	10	11	-	18	12
D	14	17	22	-	16
E	12	13	23	25	-

If the salesman starts from city A and has to come back to city A, by applying the principles of Assignment, which route would you advise him to take so that the total distance travelled by him is minimised?

[7]

Answer:

(a)

i. From the table it is clear that there are three decision variables x_1, x_2 and x_3
So, 3 varieties of very Premium quality tea are considered.

ii. The given table has either zero or negative entries in the Index Row or $(C_j - Z_j)$ Row. Also, this is a problem of maximization. So, the criteria of optimality is satisfied here. hence the solution is optimal

iii. C_j row represents the contribution per unit of different variables. Thus, from the table, respective contributions of the Decision variables x_1, x_2 and x_3 are 2, 4 and 1.
So the Objective Function is $Z = 2x_1 + 4x_2 + x_3$

iv. In the Optimal Table only decision variable x_1 is present in the Basis. Thus the other two decision variables x_2 and x_3 are non-basic variables and corresponding to both the entries in the Index Row or $(C_j - Z_j)$ Row are zero. This indicates the presence of multiple optimum solutions. Hence there exists alternate solution to the problem.

v. As no Artificial Variable is present as Basic Variable in the final table, infeasibility of the solution is not applicable. Hence the solution is feasible.

vi. Optimum product mix is as follows –
Quantity of Type 1 quality premium tea to be produced = x_1 = 4 quantity units and no units for the other two varieties of tea and.
Maximum profit = 8 money units

vii. From the answer given in (v) above, we can say that two alternate solutions are possible- either that will contain x_2 or x_3 So a new solution is find as below by arbitrarily choosing the column of x_2 as the Key Column.

Table -1 showing Optimal Solution

C_B	Product Mix	Quantity	X_1	X_2	X_3	S_1	S_2	S_3	A_1	Ratio	
2	X_1	4	1	2*	1/2	0	0	1/4	0	4/2 = 2	Key Row
0	S_2	12	0	0	-1	0	1	-1/2	0	12/0 = 0	
0	S_1	12	0	6	0	1	0	1	-1	12/6 = 2	
	C_j		2	4	1	0	0	0	-M		
	Z_j	8	2	4	1	0	0	1/2	0		
	$C_j - Z_j$		0	0	0	0	0	-1/2	-M		
				Key Coloumn							

Minimum Ratio column has two tied ratios corresponding to two basic variables x_1 and s_1. We arbitrarily choose the row corresponding to x_1 as the Key Row. So the key element is 2 and the cell for that is shaded as shown. Hence in the next table x_2 enters and x_1 departs.

Table 2 showing Alternative Solution

C_B	Product Mix	Quantity	X_1	X_2	X_3	S_1	S_2	S_3	A_1
4	X_2	2	1/2	1	1/4	0	0	1/8	0
0	S_2	12	0	0	-1	0	1	-1/2	0
0	S_1	0	-3	0	-3/2	1	0	1/4	-1
	C_j		2	4	1	0	0	0	-M
	Z_j	8	2	4	1	0	0	1/2	0
	$C_j - Z_j$		0	0	0	0	0	-1/2	-M

As all the entries in Index Row or ($C_j - Z_j$) Row are zero or negative, the solution is optimal. Here also the maximum value of Objective Function is 8 money units and the optimum product mix is –
Quantity of Type 2 quality premium tea to be produced = x_2 = 2 quantity units and no units for the other two varieties

(b) Reduced matrix after Row subtraction operation:

From/To	A	B	C	D	E
A	-	0	12	13	3
B	0	-	10	12	1

C	0	1	-	8	2
D	0	3	8	-	2
E	0	1	11	13	-

Reduced matrix after Column subtraction operation:

Table-2

From / To	A	B	C	D	E
A	-	0	4	5	2
B	0	-	2	4	0
C	0	1	-	0	1
D	0	3	0	-	1
E	0	1	3	5	-

Here minimum number of straight lines to cover all the zeroes = 5 = order of the matrix. So, the solution is optimal. Now, assignments done by following standard rules of Hungarian method is as follows:

From / To	A	B	C	D	E
A	-	[0]	4	5	2
B	0	-	2	4	[0]
C	0	1	-	[0]	1
D	0	3	[0]	-	1
E	[0]	1	3	5	-

As per the solution above, the salesman will travel from A to B, B to E, then E to A. This is not meeting the requirement of travelling through all the cities and finally returning to the starting point. Hence the solution is unacceptable.

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From / To	A	B	C	D	E
A	-	[0]	4	5	2
B	0	-	[2]	4	0
C	0	1	-	[0]	1
D	0	3	0	-	[1]
E	[0]	1	3	5	-

The solution is A → B → C → D →E → A.
The distance travelled will be = 12+16+18+16+12 = 74 km.
There can be another schedule also: A → B → E → C → D → A.
Based on this, distance will be = 12+7+23+18+14 = 74 km

7. (a) Joy Givers and Milan Toys are the two toy manufacturers who always compete with each other to increase their respective market shares. For both the companies the Marketing team, work with close coordination with the Design team and always come out with attractive toys which are normally in great demand. To meet the demand, they have various strategic options like working for 8 hours a day, 12 hours a day, 16 hours a day, 24 hours a day, subcontracting etc. which will ultimately increase the market share. Joy Givers have decided not to go for all the above-mentioned options and set up the following payoff matrix in which the percentage increase in market share is given against different strategies of Milan Toys

Strategies of	Milan Toys			
Joy Givers	Working 8 hrs/day	Working 12 hrs/day	Working 16 hrs/day	Subcontracting
Working 12 hrs/day	8	10	9	14
Working 16 hrs/day	10	11	8	12
Subcontracting	13	12	14	13

Use Principle of Dominance to find the Optimal Strategies of the two manufacturers and calculate the value of the Game.

[7]

(b) An engineering firm is tendering for a contract to supply a steel fabrication with target duration of 46 days. The tasks have been analysed as follows:

Activity	Duration (Days)
1-2	10
1-3	12
1-4	10
2-4	9
2-5	13
3-6	17
4-6	12
5-6	14

The firm is awarded the contract and starts work with all activities on their earliest start times but after work on the 15th day there is a fire which destroys all the work-in-progress on task 2-4, 2-5 and 3-6. Fortunately, no other completed tasks are affected but it is estimated that task 5-6 will now need 20 days. The project manager feels that due to fire there will be variability in the task times and has made some uncertainty estimates which are shown as task standard deviation in days:

Activity	Standard Deviation (Days)
2-4	0.82
2-5	1.33
5-6	0.47
4-6	2.17
3-6	1.33

i. Prepare a PERT network as originally envisaged.

ii. Assess the new expected project duration and identify the critical path through the remaining activities after the fire.

iii. Evaluate the probability of the project being completed on time after the fire. [Given area between Z = 0 and Z = -1.42 is 0.4222] **[7]**

Answer:

(a)

Joy Givers is the Maximising player with strategies represented along the rows and Milan Toys is the Minimising Player with strategies represented along the columns. For ease of representation we consider the respective strategies of Joy Givers as J_1, J_2 & J_3 and those of Milan Toys as M_1 , M_2 & M_3 .

Strategies of	Milan Toys			
Joy Givers	M_1	M_2	M_3	M_4
J_1	8	10	9	14
J_2	10	11	8	12
J_3	13	12	14	13

All the elements of 4th Column are either greater than or equal to the corresponding elements of the 1st Column. So 4th Column's strategy (M_4) is dominated by the 1st Column's strategy (M_1). Hence M_4 is ignored. The new matrix is given below

Strategies of	Milan Toys		
Joy Givers	M_1	M_2	M_3
J_1	8	10	9
J_2	10	11	8
J_3	13	12	14

All the elements of 1st Row are less than the corresponding elements of the 3rd Row. Thus, strategy of 1st Row i.e. J_1 is dominated by the strategy of the 3rd Row i.e. J_3 and ignored. The reduced matrix becomes

Strategies	Milan Toys		
Joy Givers	M_1	M_2	M_3
J_2	10	11	8
J_3	13	12	14

Apparently first two rules of dominance cannot be applied to either of the rows or columns of the above matrix, but if the average of the elements of the strategies M_2 and M_3 be taken then we get a matrix shown below.

Strategies	Milan Toys	
Joy Givers	M_1	M_2
J_2	10	(11+8)/2=9.5
J_3	13	(12+14)/2=13

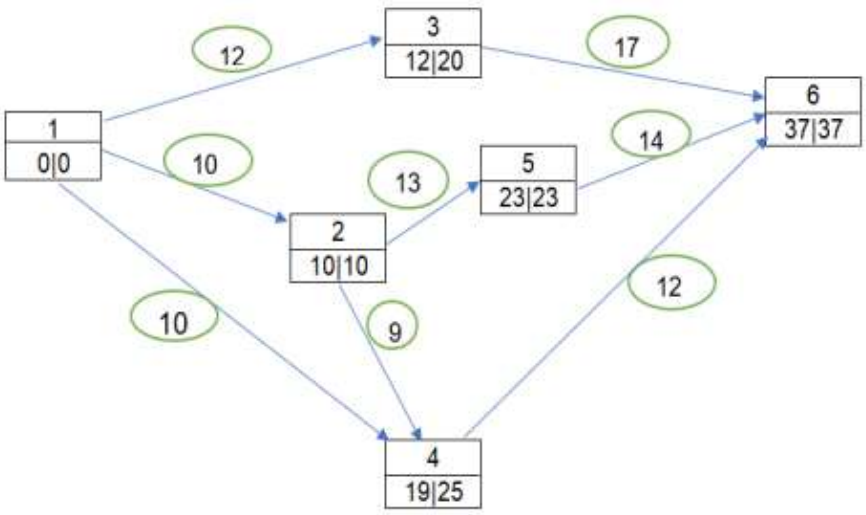
So the elements of the strategy M1 are either more or equal to the average of the corresponding elements of M2 and M3 . Hence M1 is dominated by M2 and M3 . Thus, M1 is deleted and the reduced matrix is as below

Strategies of	Milan Toys		Row Minimum
Joy Givers	M_2	M_3	
J_2	11	8	8
J_3	12*	14	12 = Minimax
Column Maximum	12 = Minimax	14	

So Maximin value = 12 = Minimax value. Hence there exists a Saddle Point at the junction J_3 M_2 Thus, optimal strategy of Joy Giver is J_3 that is "Working 24 hours /day" and that for Milan Toys is M_2 that is "Working 12 hours/day". Value of the Game = 12 (which means a 12% increase in market share for Joy Givers)

(b)

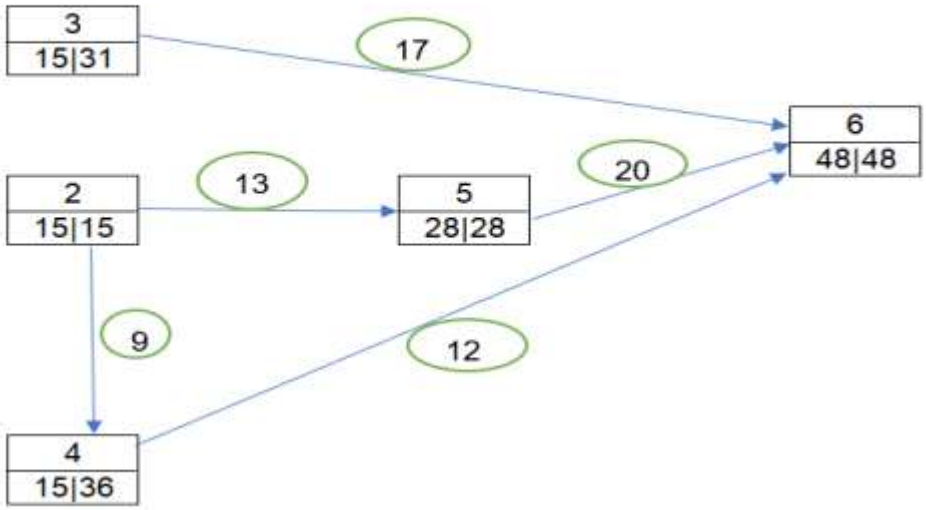
Network Diagram before Fire



Activities 1-2, 1-3 and 1-4 had already been completed before the fire. After fire, 15 days are over and 31 days (46 days-15 days) remain with the following outstanding activities:

Activity	Duration (Days)
1-2	10
1-3	12
1-4	10
2-4	9
2-5	13
3-6	17
4-6	12
5-6	14

Network Diagram after Fire



(ii). New Expected Project Duration is 48 days and Revised Critical Path after fire is 2-5-6.

(iii). Standard Deviation of the Project = 1.41

Using Z value, we have Z = -1.42

Using area under standard normal curve, the probability of achieving 46 days is = 8%

8. (a) The demand (rides per day) of Roller Coaster Ride in an Entertainment Park in one of the metro cities is given by the equation q = - 450p + 41500, where p = Price per ride in ₹. Calculate the price that maximizes total revenue.

[7]

(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.

	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:

(a) Total Revenue is algebraically expressed as a function of price as follows

R(p) = Price per ride × Demand Or, R(p) = p × q

Or, R(p) = p (- 450p + 41500)

Or, R(p) = 41500p – 450p2

Differentiating both sides with respect to 'p' we get

$\frac{d}{dp}$ [R(p)] = 41500 – 900p ..... (i)

As per the necessary condition of optimization, $\frac{d}{dp}$ [R(p)] = 0 d^2 p^2

Or, 41500 – 900p = 0 Or, p = 46.11

To ascertain whether the value of p obtained corresponds to a maxima, we have to take help of sufficient condition written above.

Again, differentiating both sides of (i) with respect to 'p' we get, $\frac{d2}{p2}$ [R(p)] = - 900 < 0

So, there exist a Maxima at p = 46.11

Thus, the price to be charged to maximize the Total Revenue is ₹ 46.11/-

(b) 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

	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

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

Seasonal Index for any Quarter = (Arithmetic Mean of that Quarter / Grand Average) x 100