PAPER – 16 : STRATEGIC COST MANAGEMENT

SUGGESTED ANSWERS

SECTION-A

1.

(i) (B)

(ii) (B)

(iii) (B)

(iv) (B)

(v) (D)

(vi) (A)

(vii) (C)

(viii) (D)

(ix) (C)

(x) (A)

(xi) (C)

(xii) (A)

(xiii) (A)

(xiv) (D)

(xv) (C)

SECTION– B

2.

(i) The relevant cost of producing the new product is the variable cost plus the lost contribution from selling the processing time to another manufacturer. It is given that, the main product will absorb 3 days per week.

Calculation of Variable Overhead rates

	Dept. 4	**Dept. 5**
Normal Hrs. per annum (0.9 x 40 hr x 50 wks.)	1,800 hrs	1,800 hrs
Fixed O.H. rate/hr. (₹)	20 (36,000/1,800)	28 (50,400/1800)
Total O.H. rate/hr. (given) (₹)	40	40
Thus, Variable OH rate /hr. (₹)	20	12

The variable costs per hour are:

Department 4: Power Cost ₹ 40 + Variable Cost ₹ 20 = ₹ 60

Department 5: Power Cost ₹ 60 + Variable Cost ₹ 12 = ₹ 72

Note: It is given that Labour Costs are fixed

If the new product is not developed, Department 4 shall sell unused processing time at ₹ 70 per hour. It is not profitable for Department 5 to sell processing time at ₹ 70 per hour because its variable costs itself is ₹72 per hour.

Therefore, the relevant cost per processing hour is:

Department 4: ₹70 (₹ 60 variable cost + ₹10 lost contribution for not selling processing time)

Department 5: ₹72.

Calculation of Relevant cost for producing the new product

Direct Material (Given)	10.00
Department 4, Variable Operating Cost (0.75 hr. x ₹ 70)	52.50
Department 5, Variable Operating Cost (0.333 hr. x ₹72)	24.00
Relevant Cost	86.50

Alternative Presentation:

(i) The relevant cost of producing the new product is the variable cost plus the lost contribution from selling the processing time to another manufacturer. It is given that, the main product will absorb 3 days per week.

Calculation of Variable Overhead rates

	Dept. 4	Dept. 5
Normal Hrs. per annum (0.9 x 40 hr x 50 wks.)	1,800 hrs	1,800 hrs
Fixed O.H. rate/hr. (₹)	20 (36,000/1,800)	28 (50,400/1800)
Total O.H. rate/hr. (given) (₹)	40	40
Thus variable OH rate /hr. (₹)	20	12

Calculation of Relevant cost for producing the new product

Direct Material (Given)	10.00
Power Cost- Department 4 (0.75 hr. x ₹40) Department 5 (0.333 hr. x ₹60)	30.00 20.00
Variable Overhead - Department 4 (0.75 hr. x ₹20) Department 5 (0.333 hr. x ₹12)	15.00 4.00
Opportunity Costs for not selling processing time* (0.75 hr. X ₹10)	7.50
Relevant Cost	86.50

Note: Labour Costs are fixed (given)

* If the new product is not developed, Department 4 shall sell unused processing time at ₹ 70 per hour.

Therefore, opportunity costs for not selling the processing time is ₹ 70 - ₹60 = ₹10

It is not profitable for Department 5 to sell processing time at ₹ 70 per hour because its variable costs itself is ₹ 72 per hour.

(ii) Additional Contribution for various selling price / demand levels

	₹	₹	₹
Selling Price (Given)	100	110	120
Restricted Demand (Units)	1067	1000	500
Relevant cost (₹)	86.50	86.50	86.50
Contribution (₹)	13.50	23.50	33.50
Total Contribution (₹)	14,404.50	23,500	16,750

Decision: Hence selling 1,000 units @ ₹ 110 per unit will achieve optimum contribution

Note:

Maximum units that can be produced in Dept 4 & Dept 5 in 800 hrs are:

Department 4 (800 Hrs. / 0.75 hr.) = 1,067 units

Department 5 (800 Hrs. / 0.333 hr.) = 2,400 units

Restriction exists in Dept 4 only.

(iii) Computation of Spare time for production of 1,000 units p.a.

	Department 4	Department 5
Time required per unit (Hours)	$\frac{3}{4}$	$\frac{1}{3}$
Total time for producing 1,000 units (Hours)	750	334
Time available (Hours)	800	800
Spare time (Hours)	50	466
Spare time per week (Hours)	1	9.32

Conclusion:
Therefore Department 4 can sell 1 hr. per week at ₹ 70 per hour. It is not profitable to sell spare capacity of 9.32 hrs. / week at the existing rate of ₹ 70 per hour, because its relevant cost is ₹ 72 per hour.

(iv) Weekly gain from this programme

Selling price	₹110
Variable Cost	
Direct Materials	10
Department 4 variable operating cost 0.75 x 60	45
Department 5 variable operating cost 0.333 x 72	24
Total Variable Cost	79
Contribution / unit	31
Weekly sales (1,000 ÷50)	20 units
Additional contribution / week	₹620
Plus contribution of selling 1 hr. (selling price – variable cost = 70 – 60)	10
Total contribution	630
Without the new product, the weekly contribution 16 hours x ₹ 10 per hr.	160
Additional gain for introducing the new product	470

3. (a):

(i) Statement Showing Profitability of Division – A (under different levels)

Sales per day (units)	Rate ₹	Total Value ₹	Total Cost	Profit / (Loss) ₹
1,000	12.00	12,000	15,000	(3,000)
2,000	12.00	24,000	24,000	--
3,000	12.00	36,000	33,000	3,000
4,000	12.00	48,000	42,000	6,000
5,000	12.00	60,000	51,000	9,000
6,000	12.00	72,000	60,000	12,000

Statement Showing Profitability of Division -B (Under different Levels):

No of Units	Selling Price	Sale Value	Transfer Price ₹	Other Mfg. Cost ₹	Total	PROFIT / LOSS
1,000	52.50	52,500	12,000	37,500	49,500	3,000
2,000	39.80	79,600	24,000	45,000	69,000	10,600
3,000	33.00	99,000	36,000	52,500	88,500	10,500
4,000	27.80	1,11,200	48,000	60,000	1,08,000	3,200
5,000	24.00	1,20,000	60,000	67,500	1,27,500	(7,500)
6,000	20.10	1,20,600	72,000	75,000	1,47,000	(26,400)

(ii) (a) PROFITABILITY OF THE COMPANY AT THE OUTPUT LEVEL WHERE DIVISION A'S NET PROFIT IS MAXIMUM:

	₹
PROFIT OF DIVISION A AT 6,000 UNITS	12,000
PROFIT OF DIVISION B AT 6,000 UNITS	(26,400)
PROFIT / LOSS	(14,400)

(b) PROFITABILITY OF THE COMPANY AT THE OUTPUT LEVEL WHERE DIVISION B'S NET PROFIT IS MAXIMUM:

	₹
PROFIT OF DIVISION B AT 2,000 UNITS	10,600
PROFIT OF DIVISION A AT 2,000 UNITS	--
PROFIT / (LOSS)	10,600

(iii) When the Company is not organised on Profit Centre Basis:

Profit at Different Levels of Output

Units	Division – A ₹	Division – B ₹	Total Profit /Loss ₹
1,000	(3,000)	3,000	Nil
2,000	--	10,600	10,600
3,000	3,000	10,500	13,500
4,000	6,000	3,200	9,200
5,000	9,000	(7,500)	1,500
6,000	12,000	(26,400)	(14,400)

Profit Maximisation Output:

Best Output Level for maximization of profit is 3,000 units.

3. (b):

(i) Statement showing Meu's Life Cycle Cost (1,25,000 units):

Particulars	Amount (₹)
Research & Development Cost	32,50,000
Manufacturing Costs (₹175 X 1,25,000 + ₹12,75,000 X3)	2,57,00,000
Marketing Costs [(₹74 +₹16) x 1,25,000 +₹6,72,000 X3]	1,32,66,000
Administration Cost (₹6,60,000 X 3)	19,80,000
Warranty (1,25,000 units/ 50units X 4 parts X ₹30)	3,00,000
Total Cost	4,44,96,000

Commission on sales = 4% of ₹400 = ₹16;
Marketing cost excluding commission = ₹ 90 - ₹ 16 = ₹ 74

(ii) Statement showing Meu's Revised Life Cycle Cost (1,40,000 units):

Revised Sales units = 1,25,000 X 1.12 = 1,40,000
Revised Selling Price per unit = ₹400 X 95% = ₹380
Fixed Manufacturing cost = ₹12,75,000 + ₹1,20,000 = ₹13,95,000

Particulars	Amount (₹)
Research & Development Cost	32,50,000
Manufacturing Costs (₹175 X 1,40,000 + ₹13,95,000 X3)	2,86,85,000
Marketing Costs [(₹74 +₹380 X 4%) x 1,40,000 +₹6,72,000 X 3]	1,45,04,000
Administration Cost (₹6,60,000 X 3)	19,80,000
Warranty (1,40,000 units/ 50units X 4 parts X ₹30)	3,36,000
Total Cost	4,87,55,000

(iii) Decision:

Statement Showing Meu's Life Time Profit:

Particulars	Amount (₹) 1,25,000 units	Amount (₹) 1,40,000 units
Sales	5,00,00,000 (1,25,000 X ₹400)	5,32,00,000 (1,40,000 X ₹380)
Less: Total Cost	4,44,96,000	4,87,55,000
Profit	55,04,000	44,45,000

Reducing the price by 5% will decrease profit by ₹ 10,59,000 (i.e. 19.24%). Therefore, the company should not go for price reduction.

4. (a):

(i) Total Factory Cost (TFC)

[20,000 x (12 + 20) + 30,000 x (10 + 15) + 4,50,000]

= 13,90,000 + 4,50,000 = ₹ 18,40,000

(ii) Cost per factory hour:

18,40,000 ÷ 2,30,000 = ₹ 8

(iii) Return per bottleneck hour for both products:

Product S:

$$\frac{110-50}{5}=\frac{60}{5}= ₹\ 12$$

Product T:

$$\frac{120-76}{4}=\frac{44}{4}= ₹\ 11$$

(iv) Throughput Accounting (TA) Ratio for both Products: $\frac{\text{Return per hr.}}{\text{Cost per hr}}$

Product S:

$$\frac{₹12}{₹8} = 1.5$$

Product T:

$$\frac{11}{8}= 1.375$$

(v) Throughput cost per month:

(20,000 x 5 + 30,000 x 4) = 2,20,000 hours

2,20,000 x ₹ 8 = ₹ 17,60,000

(vi) Efficiency Ratio:

(Throughput Cost ÷ Actual TFC) x 100

= (₹. 17,60,000 ÷ ₹ 18,40,000) x 100

= 0.9565 i.e. 95.65 %

4. (b):

The principles and practices of Lean Accounting are appended in the following table:

SL.	Principles	Practices
1.	Lean & Simple Business Accounting	Continuously eliminates waste from the transactions, processes, reports, and other accounting methods.
2.	Accounting process that supports lean transformation	Management Control & Continuous improvement. Cost Management Customer & supplier value and Cost Management.
3.	Clear & Timely Communication of information	Financial reporting Visual reporting of financial & non-financial performance measurements. Decision making
4.	Planning from a lean perspective	Planning & Budgeting. Impact of lean improvement. Capital planning Invest in people
5.	Strengthen internal accounting control	Internal control based on Lean Operational Controls. Inventory Valuation.

5.(a):

(i) **Material Mix Variance** = Standard Price per unit X (Revised Standard Quantity–Actual Quantity)

Material	Calculation	Variance (₹)
P	24 X (55* – 40)	360 (F)
R	30 X (55 *– 70)	450 (A)
TOTAL		90 (A)

*RSQ has been calculated by the following formula: Total Actual Quantity/ Total Standard Quantity X Individual Standard Quantity.

Material P: (50/100 X 110) = 55
Material R: (50/100 X 110) = 55

(ii) **Material Usage Variance** = Standard Price per unit X (Standard Quantity - Actual Quantity)

Material	Calculation	Variance (₹)
P	24 (50 – 40)	240 (F)

Calculation of Standard Input of Material R:

Material Usage Variance = Standard Price per unit X (Standard Quantity - Actual Quantity)
We have, 30 (a – 70) = 600 (A), where a is the Standard Input of Material R.
30a = 2,100 – 600 = 1,500
Or, a = 1,500 / 30 = 50

(iii) **Material Price Variance** = Actual Quantity X (Standard Price per unit - Actual Price per unit)

Material	Calculation	Variance (₹)
P	40 (24 – 30)	240 (A)
R	70 (30 – 40)	700 (A)
TOTAL		940 (A)

(iv) **Material Cost Variance** = Standard Price per unit X Standard Quantity – Actual Price per unit X Actual Quantity

Material	Calculation	Variance (₹)
P	24 X 50 – 30 X 40	NIL
R	30 X 50 – 40 X 70	1,300 (A)
TOTAL		1,300 (A)

<u>Alternative:</u>

Let SQ for Material R = Q units

Material Usage Variance for R:

= (SQ x SP) – (AQ x SP)

600 (A) = (SQ x 30) – (70 x 30)

600 (A) = 30 SQ – 2,100

30 SQ = 2,100 – 600

$SQ = \frac{1500}{30} = 50$ units

Variance Computation Chart:

Materials	**(1) SQ x SP**	**(2) RSQ x SP**	**(3) AQ x SP**	**(4) AQ x AP**
P	50 x 24 = 1,200	55 x 24 = 1,320	40 x 24 = 960	40 x 30 = 1,200
R	50 x 30 = 1,500	55 x 30 = 1,650	70 x 30 = 2,100	70 x 40 = 2,800
	2,700	2,970	3,060	4,000

Material wise Break-up of Variances:

	Particulars	**Product P**	**Product R**	**Total**
I.	Mix Variance [(2) – (3)]	360 (Fav.)	450 (Adv.)	90 (Adv.)
II.	Usage Variance [(1) – (3)]	240 (Fav.)	600 (Adv.)	360 (Adv.)
III.	Price Variance [(3) – (4)]	240 (Adv.)	700 (Adv.)	940 (Adv.)
IV.	Total Material Cost Variance [(1) – (4)]	0	1300 (Adv.)	1300 (Adv.)

5. (b):

(i) Overheads Expenditure Variance

= Overheads Cost Variance (–) Overheads Volume Variance

= ₹2,800(A)– ₹2,000(A)

= ₹800(A)

(ii) Actual incurred overheads

Overheads Expenditure Variance = Budgeted Overheads (–) Actual Overheads

₹ 800(A) = ₹12,000 (–) Actual Overheads

Therefore, Actual Overheads = ₹12,800

(iii) Actual hours for actual production

= Actual Overhead/ Actual Overhead Recovery Rate

= ₹ 12800/8= 1,600 Hrs.

(iv) Overheads Capacity Variance

Budgeted Overheads for Actual Hours (–) Budgeted Overheads

= ₹ 5 × 1,600 hrs. – ₹ 12,000

= ₹ 8,000 – ₹ 12,000

= ₹ 4,000 (A)

(v) Overheads efficiency variance

= Absorbed Overheads (–) Budgeted Overheads for Actual Hours

= ₹10,000 – ₹ 5 × 1,600 hours

= ₹ 2,000 (F)

(vi) Standard hours for actual production

= Absorbed Overhead/ Standard rate per hour

= ₹10,000/₹5

= 2,000 hrs

(vii) Calculation of Standard Rate/Hour

Overhead Cost Variance = Absorbed Overheads (–) Actual Overheads

₹2,800 (A) = Absorbed Overheads (–) ₹12,800

Absorbed Overheads = ₹10,000

Standard Rate per Hour = Budgeted Overhead/Budgeted Hours

= ₹12,000/2,400 hrs

= ₹ 5 /hr

6. (a):

(i) Contribution made by product Alfa = 1000 – [200+160+60+380] = ₹ 200

Contribution made by product Beta = 900 – [200+80+120+350] = ₹ 150

Direct Material per unit of product Alfa = 200/50=4 kgs	Direct Material per unit of product Beta = 200/50=4 kgs
Direct Labour hour per unit of product Alfa = 160/40 =4 hrs	Direct Labour hour per unit of product Beta = 80/40=2 hrs
Painting hour per unit of product Alfa = 60/60 =1 hr	Painting hour per unit of product Beta = 120/60=2 hrs

Let the decision variables x1 and x2 denote the number of units of product Alfa and product Beta to be produced respectively.

The appropriate mathematical formulation of the given problem as LP model is:

Maximize (contribution) Z =200 x1 + 150 x2

Subject to the constraints

4x1 + 4 x2 ≤ 960 (Raw material constraint)

4x1 + 2 x2 ≤ 800 (Direct Labour hour constraint)

x1+ 2 x2 ≤ 400 (Painting hour constraint)

x1 ≥ 0, x2 ≥ 0 (Non negativity constraint)

(ii) DUAL problem is expressed as follows:

Minimize Zy =960 y1 + 800 y2+ 400 y3

Subject to the constraints

4y1 + 4y2+y3 ≥ 200

4y1 + 2y2+2y3 ≥ 150

y1, y2, y3 ≥ 0

6. (b):

(i) There are 5 rows and 4 columns, hence a dummy column is to be inserted. Further, assigning C1 → R1 and C5 → R2, we have the cost table:

	Cost of Repairs (₹in Lakhs)			
Contractors	**Road**	**R3**	**R4**	**Dummy**
	C2	40	39	0
	C3	42	38	0
	C4	36	36	0

As there is ZERO in each row, we go straight to the column reduction:

	Cost of Repairs (₹in Lakhs)			
Contractors	**Road**	**R3**	**R4**	**Dummy**
	C2	4	3	0
	C3	6	2	0
	C4	0	0	0

The minimum number of lines to cover all zeroes is 2, which is less than 3, the order of the matrix. Hence, optimum solution has not been reached and the solution needs to be improved.

To improve the solution, the minimum uncovered element (i.e. 2) is deducted from all the uncovered elements and added with the covered elements at the junction. The new matrix will be as under:

	Cost of Repairs (₹in Lakhs)			
Contractors	**Road**	**R3**	**R4**	**Dummy**
	C2	2	1	0
	C3	4	0	0
	C4	0	0	2

The minimum number of lines to cover all zeroes is 3, which is equal to the order of the matrix, hence optimum solution has been reached. The assignment is made below:

	Cost of Repairs (₹in Lakhs)			
Contractors	**Road**	**R3**	**R4**	**Dummy**
	C2	2	1	[0]
	C3	4	[0]	0
	C4	[0]	0	2

The optimal assignment is:

Contractor	**Road**	**Cost (₹ in lakhs)**
C1	**R1**	**18**
C2	**No assignment**	**X**
C3	**R4**	**38**
C4	**R3**	**36**
C5	**R2**	**30**
Total		**122**

Hence, total minimum cost of the repair project is ₹122 lakhs.

(ii) Minimum Discount for eliminated contractor:

The eliminated contractor is C2, as they were not assigned any road in the optimal plan.
To "merit a contract" C2 must offer a price lower than the current winning bids for the roads they are most competitive in (R3 or R4)

Current cost for R4: 38 lakhs (assigned to C3)

C2 's current bid for R4: ₹ 39 lakhs.

Required discount: C2 must at least match the current assignment: ₹ (39 - 38) = ₹1 lakh.

C2 must offer a minimum Discount of ₹1 lakh to equal C3 from R4.

OR: The minimum discount of ₹ 4 lakhs (40- 36) must offer by C2 to get/ equal C4 from R3

7. (a)

Random No. coding for Arrival:

No. of laptops	Probability	Cumulative Probability	Random Number
8	0.10	0.10	00 - 09
9	0.25	0.35	10 - 34
10	0.20	0.55	35 -54
11	0.15	0.70	55 - 69
12	0.18	0.88	70 - 87
13	0.12	1.00	88 - 99

Random No. coding for Service:

No. of laptops	Probability	Cumulative Probability	Random Number
8	0.15	0.15	00 – 14
9	0.20	0.35	15 - 34
10	0.25	0.60	35 -59
11	0.16	0.76	60 - 75
12	0.14	0.90	76 – 89
13	0.10	1.00	90 - 99

Simulation Sheet:

Let us simulate the arrival and service of laptops for the next seven days using the given random numbers:

Day	R No. of Arrival	No. of laptops arrived	Opening Job	R No. of Service	No. of Laptops serviced*	Closing Job
1	69	11	1	52	10	2
2	45	10	2	36	10	2
3	46	10	2	62	11	1
4	10	9	1	49	10	0
5	82	12	0	68	11	1
6	16	9	1	77	12	0
7	35	10	0	55	10	0

* This represents the service capacity of service centre.

Average No. of laptops held for more than one day = Total Closing Jobs/ No. of days = 6 laptops / 7 days = 0.86 laptops per day.

7. (b):

Calculation of price per unit for 1st order of 60 units:

Learning will be applicable only in Dept. B

Cumulative output becomes 100 units + 60 units = 160 units i.e. 1.6 times.

From the table, learning rate is 86.1% for 1.6 times.

Therefore, total hours for 160 units = 160 X 40 X 0.861 = 5,510.40 hrs

Hours for 60 units = Hrs for 160 units – Hrs for 100 units

= 5,510.40 – 4,000 = 1,510.40 Hrs

Therefore, hours per unit = 1,510.40 / 60 = 25.17

Calculation of Selling Price per unit:

Particulars	Calculation	Amount (₹)
Direct Materials		500.00
Direct Labour Dept. A: 20 hrs @ ₹10 Dept. B: 25.17 hrs @ ₹15	 200.00 377.55	 577.55
Variable Overhead	20% of ₹577.55	115.51
Fixed Overhead Dept. A: 20 hrs @ ₹8 Dept. B: 25.17 hrs @ ₹5	 160.00 125.85	 285.85
Total Cost		1478.91
Profit		369.73
Selling Price per unit		1848.64

Calculation of price per unit for 2nd order of 40 units:

Cumulative output becomes 100 units + 60 units + 40 units = 200 units i.e. 2 times.
From the table, learning rate is 80% for 2 times.
Therefore, total hours for 200 units = 200 X 40 X 0.80 = 6,400 hrs
Hours for 40 units = Hrs for 200 units – Hrs for 160 units
= 6,400 - 5,510.40 = 889.60 Hrs
Therefore, hours per unit = 889.60 / 40 = 22.24

Calculation of Selling Price per unit:

Particulars	Calculation	Amount (₹)
Direct Materials		500.00
Direct Labour Dept. A: 20 hrs @ ₹10 Dept. B: 22.24 hrs @ ₹15	 200.00 333.60	 533.60
Variable Overhead	20% of ₹533.60	106.72
Fixed Overhead Dept. A: 20 hrs @ ₹8 Dept. B: 22.24 hrs @ ₹5	 160.00 111.20	 271.20
Total Cost		1411.52
Profit		352.88
Selling Price per unit		1764.40

8. (a):

(i) Total cost $C(x) = x^3 + 60x^2 + 8x$

Total Revenue $R(x) = (3x^2 - 3x + 656)\ x$

$= 3x^3 - 3x^2 + 656x$

Profit $(P) = (3x^3 - 3x^2 + 656x) - (x^3 + 60x^2 + 8x)$

$= 3x^3 - x^3 - 3x^2 - 60x^2 + 656x - 8x)$

$= 2x^3 - 63x^2 + 648x$

For maximization of profit,

$\frac{dp}{dx} = 0 \text{ and } \frac{d^2p}{dx^2} = Negative < 0$

Derivative w.r. to x

$\frac{dp}{dx} = \frac{d}{dx}\left(2x^3 - 63x^2 + 648x\right)$

$\therefore\ 6x^2 - 126x + 648 = 0$

$Or,\ x^2 - 21x + 108 = 0$

$Or,\ x(x-9) - 12(x-9) = 0$

$(x-12)(x-9) = 0$

$i.e.\ x = 12 \text{ or } 9$

Again,

$\frac{d^2p}{dx^2} = 12x - 126,\ at\ x = 9$

$\frac{d^2p}{dx^2} = 108 - 126 = -18 < 0$ **(Negative)**

Therefore, P is **maximum at x = 9**

At $x = 12,\ \frac{d^2p}{dx^2} = 144 - 126 = 18 > 0$ **(Positive)**

P is minimum at x = 12

Hence, the SUTON Ltd., should sell 9 items to make Maximum profit

ALTERNATIVE SOLUTION:

For maximization of Profit, Marginal Revenue = Marginal Cost

Marginal Revenue (MR) = d/dx (Total Revenue) = d/dx ($3X^3 - 3X^2 + 656X$) = $9X^2 - 6X + 656$

Marginal Cost (MC) = d/dx ($X^3 + 60X^2 + 8X$) = $3X^2 + 120X + 8$

We have MR = MC,

$9X^2 - 6X + 656 = 3X^2 + 120X + 8$

$Or,\ x^2 - 21x + 108 = 0$

$Or,\ x(x-9) - 12(x-9) = 0$

$(x-12)(x-9) = 0$

$i.e.\ x = 12 \text{ or } 9$

Again,

$\frac{d^2p}{dx^2} = 12x - 126,\ at\ x = 9$

$\frac{d^2p}{dx^2} = 108 - 126 = -18 < 0$ **(Negative)**

Therefore, P is **maximum at x = 9**

At $x = 12,\ \frac{d^2p}{dx^2} = 144 - 126 = 18 > 0$ **(Positive)**

P is minimum at x = 12

Hence, the SUTON Ltd., should sell 9 items to make Maximum profit

(ii) Profit $(P) = 2x^3 - 63x^2 + 648x$

$= 2(9)^3 - 63(9)^2 + 648(9)\ at\ x = 9$

$= 7290 - 63 \times 81 = 2187\ (Rs)$

The maximum profit SUTON Ltd., can earn from the product is ₹ 2187.

8. (b):

Fit a Linear Trend Equation

First, we tabulate the monthly production data (Y) for the 36 months (n = 36) covering 2022, 2023 and 2024. We assign X is the time variable (X = 1 for Jan. 2022, X = 36 for Dec. 2024).

Month	2022	2023	2024
Jan	15	23	25
Feb	16	22	25
Mar	18	28	35
Apr	18	27	36
May	23	31	36
Jun	23	28	30
Jul	20	22	30
Aug	28	28	34
Sep	29	32	38
Oct	33	37	47
Nov	33	34	41
Dec	38	44	53
Total	294	356	430

Totals:

$\Sigma Y = 1080$

$n = 36$

Mean Y = 1080 / 36 = 30

Compute Trend Equation (Least Squares)

Given:

$\Sigma X = 666$

$\Sigma X^2 = 16206$

$\Sigma XY = 22377$

$$b = \frac{n\Sigma XY - (\Sigma X)(\Sigma Y)}{n\Sigma X^2 - (\Sigma X)^2}$$

$$b = \frac{36(22377) - 666(1080)}{36(16206) - 666^2}$$

$$b = \frac{805572 - 719280}{583416 - 443556}$$

$$b = \frac{86292}{139860} = 0.617$$

$$a = \bar{Y} - b\bar{X}$$

$$a = 30 - 0.617(666/36) = 18.58$$

Trend Equation

$$\boxed{Y = 18.58 + 0.617X}$$

Calculate Trend Values (T) and Ratios (A/T × 100)

Example calculations

January

- Jan 2022 (X=1):
  T = 18.58 + 0.617(1) = 19.197
  Ratio = 15 / 19.197 × 100 = 78.14

- Jan 2023 (X=13):
  T = 18.58 + 0.617 (13) = 26.601
  Ratio = 23 / 26.601 × 100 = 86.46
- Jan 2024 (X=25):
  T = 34.005
  Ratio = 25 / 34.005 × 100 = 73.52

Average (Jan):
$(78.14 + 86.46 + 73.52)/3 = 79.37$

Repeating for all months we have:

MONTH	Avg Ratio (2022)	Avg Ratio (2023)	Avg Ratio (2024)	Average Ratio
JAN	78.14	86.46	73.52	79.37
FEB	80.75	80.83	72.21	77.93
MAR	88.10	100.59	99.32	96.00
APR	85.52	94.90	100.40	93.61
MAY	106.16	106.64	98.70	103.83
JUNE	103.22	94.35	80.88	92.82
JULY	87.34	72.57	79.56	79.82
AUG	119.07	90.54	88.72	99.44
SEPT	120.17	101.47	97.58	106.41
OCT	133.33	115.07	118.81	122.40
NOV	130.09	103.75	102.05	111.96
DEC	146.24	131.78	129.93	135.98
TOTAL				1199.57

Final Seasonal Index:
The sum of the average ratios is 1199.57. Since the sum of Seasonal ratios for 12 months should be exactly 1200, a minor correction factor (1200/11199.57 = 1.00036) is applied.

Month	Seasonal Index	Month	Seasonal Index
JAN	79.40	JULY	79.85
FEB	77.96	AUG	99.48
MAR	96.03	SEPT	106.45
APR	93.64	OCT	122.44
MAY	103.87	NOV	112.00
JUNE	92.85	DEC	136.03

[Calculation of final seasonal index has been made by multiplying correction factor with each calculated seasonal index]

Conclusion:
The production of Turmeric Powder peaks significantly in DECEMBER (136.03) and reaches its lowest point in FEBRUARY (77.96).

ALTERNATIVE SOLUTION (if calculation is made up to 3 decimal places)
Method:
Trend Ratio Method (Multiplicative Model)
Fit a Linear Trend Equation $y = a + b\chi$

Table 1: Monthly Data and Calculations of Ratio

Month	χ	Production (Y)	χ^2	χy	Trend T = 18.59 + 0.617 χ	Ratio (Y/T) x 100
Jan – 22	1	15	1	15	19.207	78.10
Feb – 22	2	16	4	32	19.824	80.71
Mar – 22	3	18	9	54	20.441	88.06
Apr – 22	4	18	16	72	21.058	85.48
May – 22	5	23	25	115	21.675	106.11
Jun – 22	6	23	36	138	22.292	103.18
Jul – 22	7	20	49	140	22.909	87.30
Aug – 22	8	28	64	224	23.526	119.02
Sep – 22	9	29	81	261	24.143	120.12
Oct – 22	10	33	100	330	24.760	133.28
Nov – 22	11	33	121	363	25.377	130.04
Dec – 22	12	38	144	456	25.994	146.19
Jan – 23	13	23	169	299	26.611	86.43
Feb – 23	14	22	196	308	27.228	80.80
Mar – 23	15	28	225	420	27.845	100.56
Apr – 23	16	27	256	432	28.462	94.86
May – 23	17	31	289	527	29.079	106.61
Jun – 23	18	28	324	504	29.696	94.29
Jul – 23	19	22	361	418	30.313	72.58
Aug – 23	20	28	400	560	30.930	90.53
Sep – 23	21	32	441	672	31.547	101.44
Oct – 23	22	37	484	814	32.164	115.04
Nov – 23	23	34	529	782	32.781	103.72
Dec – 23	24	44	576	1056	33.398	131.74
Jan – 24	25	25	625	625	34.015	73.50
Feb – 24	26	25	676	650	34.632	72.19
Mar – 24	27	35	729	945	35.249	99.29
Apr – 24	28	36	784	1008	35.866	100.37
May – 24	29	36	841	1044	36.483	98.68
Jun – 24	30	30	900	900	37.100	80.86
Jul – 24	31	30	961	930	37.717	79.54
Aug – 24	32	34	1024	1088	38.334	88.69
Sep – 24	33	38	1089	1254	38.951	97.56
Oct – 24	34	47	1156	1598	39.568	118.78
Nov – 24	35	41	1225	1435	40.185	102.03
Dec – 24	36	53	1296	1908	40.802	129.90
TOTAL	$\sum X = 666$	$\sum X = 1080$	$\sum X^2 = 16206$	$\sum XY = 22377$		

Calculation of Slope (b):

Formula $b^2 = \left[n\sum XY - \left(\sum X\right)\left(\sum Y\right)\right] / \left[n\sum X^2 - \left(\sum X\right)^2\right]$

Substitution $b = \left[\left(36 \text{ x } 22377\right) - \left(666 \text{ x } 1080\right)\right] / \left[36 \text{ x } 16206 - \left(666\right)^2\right]$

Calculation $b = \left(805572 - 719280\right) \div \left(583416 - 443556\right)$

Result $b = \left(86292 \div 139860\right) = 0.6170$

Calculation of Intercept (a):

Formula $a = \left(\sum Y / n\right) - b \left(\sum X / n\right)$

Substitution $a = \left(1080 / 36\right) - 0.6170 \left(666 / 36\right)$

Calculation $a = 30 - 11.41 = 18.59$

Trend Equation: $Y = 18.59 + 0.617 \chi$

Average of Ratios and Final Indices

The ratios for each specific month across the three years are averaged to find the Seasonal Index.

Correction Factor and Adjusted Seasonal Indices

Correction Factor = 1200 / 1199.19 = 1.00068

Adjusted Seasonal Index (Adjusted SI) = Raw Seasonal Index x 1.00068

Month	2022 Ratio	2023 Ratio	2024 Ratio	Raw SI (Average)	Adjusted SI
Jan	78.10	86.43	73.50	79.34	79.39
Feb	80.71	80.80	72.19	77.90	77.95
Mar	88.06	100.56	99.29	95.97	96.03
Apr	85.48	94.86	100.37	93.57	93.64
May	106.11	106.61	98.68	103.80	103.87
Jun	103.18	94.29	80.86	92.78	92.84
Jul	87.30	72.58	79.54	79.81	79.87
Aug	119.02	90.53	88.69	99.41	99.48
Sep	120.12	101.44	97.56	106.37	106.44
Oct	133.28	115.04	118.78	122.37	122.45
Nov	130.04	103.72	102.03	111.93	112.01
Dec	146.19	131.74	129.90	135.94	136.03
Total	1277.59	1178.60	1141.39	1199.19	1200.00

Conclusion: The production of Turmeric Powder peaks significantly in DECEMBER (136.03) and reaches its lowest point in FEBRUARY (77.95).