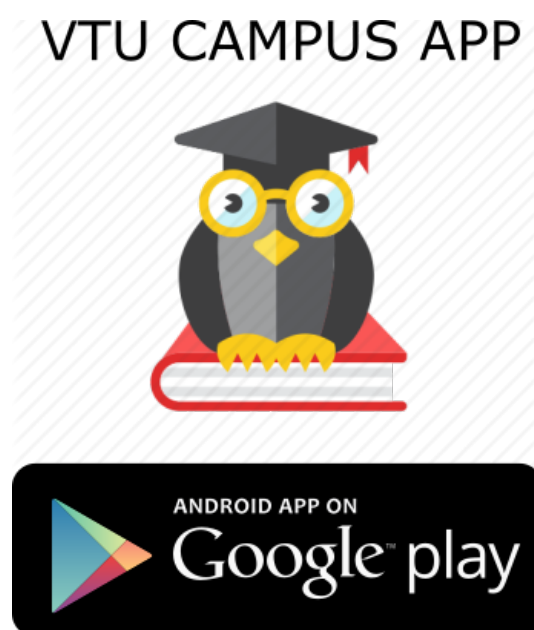


Operations Research VTU Question Paper Set 2017



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10EE661

Sixth Semester B.E. Degree Examination, June/July 2016
Operation Research

Time: 3 hrs.

Max. Marks:100

**Note: 1. Answer any FIVE full questions, selecting
atleast TWO questions from each part.
2. Normal distribution table is permitted.**

PART – A

- 1
 - a. Define Operation Research. List the applications of LPP. (05 Marks)
 - b. Using Graphical method find, $Z_{\max} = 3x_1 + 4x_2$
 Subject to $5x_1 + 4x_2 \leq 200$
 $3x_1 + 5x_2 \leq 150$
 $8x_1 + 4x_2 \geq 80$
 $5x_1 + 4x_2 \geq 100$
 and $x_1, x_2 \geq 0$. (08 Marks)
 - c. Solve the following LPP by Simplex method
 $Z_{\min} = x_1 - 3x_2 - 2x_3$
 Subject to $3x_1 - x_2 + 2x_3 \leq 7$
 $-2x_1 + 4x_2 \leq 12$
 $-4x_1 + 3x_2 + 8x_3 \leq 10$. (07 Marks)
- 2
 - a. Explain degeneracy in LPP and also explain the procedure to resolve degeneracy. (08 Marks)
 - b. Write the dual for the following LPP
 $Z_{\max} = 3x_1 + 5x_2 + 7x_3$
 Subject to the constraints $x_1 + x_2 + 3x_3 \leq 10$
 $4x_1 - x_2 + 2x_3 \geq 15$
 $x_1, x_2 \geq 0$
 x_3 is unrestricted variable. (12 Marks)
- 3
 - a. Solve the LPP by dual Simplex method.
 $\text{Max } Z = -3x_1 - 2x_2$
 Subject to $x_1 + x_2 \geq 1$
 $x_1 + x_2 \leq 7$
 $x_1 + 2x_2 \geq 10$
 $x_2 \leq 3$; $x_1, x_3 \geq 0$. (10 Marks)
 - b. Solve the LPP by using revised Simplex method.
 $\text{Max. } Z = x_1 + x_2 + 3x_3$
 Subject to constraints $3x_1 + 2x_2 + x_3 \leq 3$
 $2x_1 + x_2 + 2x_3 \leq 2$
 $x_1, x_2, x_3 \geq 0$. (10 Marks)



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- 4 a. A company has 5 tasks and 5 persons to perform the same. The matrix shows the returns (profit) in hundreds of Rupees, for assigning jobs to the persons. Assign 5 tasks to 5 persons to maximize the total returns. (08 Marks)

		PERSONS				
		P ₁	P ₂	P ₃	P ₄	P ₅
TASK	J ₁	5	11	10	12	4
	J ₂	2	4	6	3	5
	J ₃	3	12	5	14	6
	J ₄	6	14	4	11	7
	J ₅	7	9	8	12	5

- b. Solve the traveling salesman problem given by the following data : $C_{12} = 20$; $C_{13} = 4$; $C_{14} = 10$; $C_{23} = 5$; $C_{34} = 6$; $C_{25} = 10$; $C_{35} = 6$; $C_{45} = 20$, where $C_{ij} = C_{ji}$. There is no route between i and j , if the value of C_{ij} is not shown. (12 Marks)

PART - B

- 5 a. List the difference between transportation and assignment problems. (06 Marks)
- b. A product is produced by 4 factories A, B, C and D. The unit production costs in them are Rs 2, Rs 3, Rs 1 and Rs 5 respectively. Their production capacities are factory A = 50 units and B = 70 units, C = 30 units and D = 50 units. These factories supply the product to 4 stores, demands of which are 25, 35, 105 and 20 units respectively. Unit transport cost in rupees from each factory to each store is given in the table.

		1	2	3	4
Factory	A	2	4	6	11
	B	10	8	7	5
	C	13	3	9	12
	D	4	6	8	3

Determine the extent of deliveries from each of the factories to each of the stores so that the total production and transportation cost is minimum. (14 Marks)

- 6 a. Define Optimal strategy. Using dominance concept, obtain the optimal strategies for both the players and determine the value of game. The pay off matrix for player A is given (12 Marks)

	I	II	III	IV
I	3	2	4	0
II	3	4	2	4
III	4	2	4	0
IV	0	4	0	8

- b. Use graphical method to solve the following sequencing problem, also calculate the total time required to complete both the jobs. (08 Marks)

JOB 1	Sequencing order and time	A	B	C	D	E
		2	3	4	6	2
JOB 2	Sequencing order and time	C	A	D	E	B
		4	5	3	2	6

- 7 a. The following table shows the jobs of a network along with their time estimation in days.

JOB	1-2	1-3	1-4	2-5	3-5	4-6	5-6
T _o	1	1	2	1	2	2	3
T _m	1	4	2	1	5	5	6
t _p	7	7	8	1	14	8	15

- i) Draw the project network.
 - ii) Compute the expected duration and variance, also critical path.
 - iii) Calculate standard deviation.
 - iv) What is the probability of completion of project :
 - a) 4 days earlier than expected.
 - b) Not more than 4 days later than expected.
- b. Determine the optimum project duration (days) and cost (Rs) for the following data :

(12 Marks)

Activities	Normal		Crash	
	Time	Cost	Time	Cost
1-2	8	100	6	200
1-3	4	150	2	350
2-4	2	50	1	90
2-5	10	100	5	400
3-4	5	100	1	200
4-5	3	80	1	100

Indirect cost is Rs 70 per day.

(08 Marks)

- 8 a. Explain Economic life of an equipment by illustrating chart. (08 Marks)
- b. Below table gives the operation cost, maintenance cost and salvage value at the end of every year of a machine whose purchase value is Rs 12,000. Find the economic life of the machine assuming.
- i) The interest rate is 0%.
 - ii) The interest rate as 15%.

(12 Marks)

End of year (n)	Operation cost at the end of year (Rs)	Maintenance cost at the end of year (Rs)	Salvage value at the end of year (Rs)
1	2000	2500	8000
2	3000	3000	7000
3	4000	3500	6000
4	5000	4000	5000
5	6000	4500	4000
6	7000	5000	3000
7	8000	5500	2000
8	9000	6000	1000



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10EE661

Sixth Semester B.E. Degree Examination, Dec.2015/Jan.2016

Operations Research

Time: 3 hrs.

Max. Marks: 100

Note: Answer FIVE full questions, selecting at least TWO questions from each part.

PART – A

- 1 a. What is operations Research? Explain linear programming problems. (04 Marks)
- b. The owner of metro sports wishes to determine how many advertisements to place in the selected three monthly magazines A, B and C. His objective is to advertise in such a way that total exposure to principal buyers of expensive sports goods is maximized. Percentages of readers for each magazine are known. Exposure in any particular magazine is the number of advertisements placed multiplied by the number of principal buyers. The following data is available.

	Magazine		
	A	B	C
Readers	1 lakh	0.6 Lakh	0.4 Lakh
Principal buyers	20%	15%	8%
cost per advertisement (RS)	8000/-	6000/-	5000/-

The budgeted amount is at most Rs 1 lakh for advertisements. The owner has already decided that magazine A should have no more than 15 advertisements and that B and C each have at least 50 advertisements. Formulate an LP model for this problem. (06 Marks)

- c. Solve the LPP :

$$\text{Max } Z = 3x_1 + 2x_2$$

$$\text{Subject to : } 4x_1 + 3x_2 \leq 12$$

$$x_1 + x_2 \leq 8$$

$$x_2 - 4x_1 \geq -8 \text{ and } x_1, x_2 \geq 0.$$

(10 Marks)

- 2 a. Solve the following LPP graphically and comment on the result.

$$\text{Maximize } Z = x_1 + x_2$$

$$\text{Subject to : } x_1 + x_2 \leq 1$$

$$-3x_1 + x_2 \geq 3$$

$$x_1 \geq 0, \text{ and } x_2 \geq 0,$$

(06 Marks)

- b. Use Big M method to solve the following LPP.

$$\text{Minimize } Z = 5x_1 + 3x_2$$

$$\text{Subject to constraints } 2x_1 + 4x_2 \leq 12$$

$$2x_1 + 2x_2 = 10$$

$$5x_1 + 2x_2 \geq 10 \text{ and } x_1, x_2 \geq 0.$$

(14 Marks)

- 3 a. Write the Dual of the following primal problem.

$$\text{Maximize } Z = 2x_1 + 3x_2$$

$$\text{Subject to } 5x_1 + 2x_2 \leq 40$$

$$6x_1 + 12x_2 \leq 80 \text{ where } x_1 \text{ and } x_2 \text{ are unrestricted in sign.}$$

(06 Marks)

- b. Use Revised simplex method to solve the following LPP.

$$\text{Maximize } Z = x_1 + x_2$$

$$\text{Subject to } 2x_1 + 5x_2 \leq 6$$

$$x_1 + x_2 \geq 2 \text{ and}$$

$$x_1 \geq 0, \text{ and } x_2 \geq 0,$$

(07 Marks)

- c. Solve the given LPP using dual simplex method.

$$\text{Minimize } Z = 2x_1 + 4x_2$$

$$\text{Subject to constraints } 2x_1 + x_2 \geq 4$$

$$x_1 + 2x_2 \geq 3$$

$$2x_1 + 2x_2 \leq 12$$

$$x_1, x_2 \geq 0.$$

(07 Marks)

- 4 a. Alpha construction company has five crews. The skills of the crews differ from one another. The company has five different projects on hand. The times (in days) taken by different crews to complete different projects are summarized in Table Q4(a). Find the best assignment of the crews to different project such that the total time taken to complete all the projects is minimized

Table Q4 (a)

Crew

	Project				
	A	B	C	D	E
1	20	30	25	15	35
2	25	10	40	12	28
3	15	18	22	32	24
4	29	8	34	10	40
5	35	23	17	26	45

Project execution time in days

(10 Marks)

- b. A machine operator processes five types of items on his machine each week and must choose a sequence for them. The set up cost per change depends on the items presently on the machine and set up to be made, according to the following table

To items

From items

	A	B	C	D	E
A	∞	4	7	3	4
B	4	∞	6	3	4
C	7	6	∞	7	5
D	3	3	7	∞	7
E	4	4	5	7	∞

If he processes each type of them only once in each week, how should he sequence the items on his machine in order to minimize the total set up cost?

(10 Marks)



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PART – B

- 5 a. What is degeneracy in transportation problems? How to resolve it? (04 Marks)
 b. Obtain the initial basic feasible solution to the given transportation problem using Vogel's Approximation method. (06 Marks)

Table Q 5 (b)

D \ S	D ₁	D ₂	D ₃	D ₄	Supply
S ₁	2	2	2	1	3
S ₂	10	8	5	4	7
S ₃	7	6	6	3	5
Demand	4	3	4	4	15

- c. A company has three plants A, B and C, 3 ware houses X, Y and Z. The number of units available at the plants is 60, 70, 80 and the demand at X, Y, Z is 50, 80, 80 respectively. The unit cost of transportation is given in the following table.

	X	Y	Z
A	8	7	3
B	3	8	9
C	11	3	5

Find the optimum allocation, so that the total transportation cost is minimum. (10 Marks)

- 6 a. Define pure strategy, mixed strategy and Two – person zero sum game. (06 Marks)
 b. Solve the game whose pay off matrix is given by

	Player B		
Player A	3	2	4
	0	-4	2
	2	-1	5

Comment on the result.

(06 Marks)

- c. In a game of matching coins with two players A and B, suppose A wins one unit of value when there are two heads, wins nothing when there are two tails and losses $\frac{1}{2}$ unit of value when there are one head and one tail. Determine the pay off matrix, the best strategies for each player and the value of the game to player A. (08 Marks)

- a. A project consists of a series of tasks A, B, ..., H, I with the following relationships, W < X, Y means X and Y can not start until W is completed. X, Y < W means, W can not start until both X and Y are completed. With this notation, construct the network diagram having the following constraints: A < D, E; B, D < F; C < G; B < H; F, G < I. Find the critical path and minimum time of completion of project, when the time of completion of each task is given as below. Also find the float for each activity.

Task	A	B	C	D	E	F	G	H	I
Time Days	23	8	20	16	24	18	19	4	10

(08 Marks)

- b. A project is composed of different activities whose time estimates are listed in the following table.

Activity	Estimated Duration		
	Optimistic to	Most likely tm	Pessimistic Tp
1 – 2	1	2	9
2 – 3	1	4	7
2 – 4	2	4	12
3 – 4	0	0	0
3 – 5	2	3	4
4 – 5	4	6	8
4 – 6	3	5	7
5 – 6	1	3	5
5 – 7	5	7	15
3 – 7	6	8	16
6 – 7	3	4	5

- Draw the project network
- Find the expected duration and variance of each activity
- Determine the expected project completion time
- What is the probability of completing the project in 25 days?

(Given that for standard normal $Z = 1.08$, area under the standard normal curve from extreme left $Z = -\infty$ to Z is 0.8599)

(12 Marks)

- 8 a. A truck owner finds from his past records that the maintenance costs per year of a truck, whose purchase price is Rs. 8000, are as given in table Q8(a). Determine the time at which it is profitable to replace the truck.

Year	1	2	3	4	5	6	7	8
Maintenance Cost	1000	1300	1700	2200	2900	3800	4800	6000
Resale price	4000	2000	1200	600	500	400	400	400

(08 Marks)

- b. The following mortality rates have been observed for a certain type of light bulbs.

Week	1	2	3	4	5
Percent failure of the end of week	10	25	45	75	100

There are 1000 bulbs in use and it costs Rs. 2 to replace an individual bulb, which has burnt out. If all the bulbs were replaced simultaneously, it would cost 50 paise per bulb. It is proposed to replace all bulbs at fixed intervals, whether or not they have burnt out and to continue replacing burnt out bulbs as they fail. Determine the optimum interval at which all the bulbs should be replaced.

(12 Marks)



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Sixth Semester B.E. Degree Examination, June/July 2015

Operation Research

Time: 3 hrs.

Max. Marks:100

Note: Answer FIVE full questions, selecting at least TWO questions from each part.

PART – A

- 1 a. Solve the given LPP, using graphical method.
 Maximize $z = 3x_1 + 5x_2$
 Subject to $x_1 + 2x_2 \leq 2000$
 $x_1 + x_2 \leq 1500$
 $x_2 \leq 600$
 $x_1, x_2 \geq 0$ (06 Marks)
- b. A firm manufactures two types of products P_1 and P_2 and sells them at a profit of Rs 2 on product P_1 and Rs 3 on product P_2 . Each product is processed on two machines M_1 and M_2 product p_1 requires one minute of processing time on M_1 and two minutes of processing time on M_2 . Product P_2 requires one minute on M_1 and one minute on M_2 . Machine M_1 is available for not more than 6 hours 40 minutes while machine M_2 is available for 10 hours during any day. Formulate the problem as a LPP. (04 Marks)
- c. Use two phase simplex method to
 Minimize $z = x_1 + x_2 + x_3$
 Subject to $x_1 - 3x_2 + 4x_3 = 5$
 $x_1 - 2x_2 \leq 3$
 $2x_2 + x_3 \geq 4$
 $x_1, x_2, x_3 \geq 0$ (10 Marks)
- 2 a. Solve using simplex method
 Maximize $z = 3x_1 + 9x_2$
 Subject to $x_1 + 4x_2 \leq 8$
 $x_1 + 2x_2 \leq 4$
 $x_1, x_2 \geq 0$ (10 Marks)
- b. Solve using Big M method and read the solution for dual from primal optimal solution
 Maximize $z = 5x_1 + 12x_2 + 4x_3$
 Subject to $x_1 + 2x_2 + x_3 \geq 5$
 $2x_1 - x_2 + 3x_3 = 2$
 $x_1, x_2, x_3 \geq 0$ (10 Marks)
- 3 a. Define dual problem. find the dual of the following LP problem.
 Maximize $z = 2x_1 + 3x_2 + x_3$
 Subject to $4x_1 + 3x_2 + x_3 = 6$
 $x_1 + 2x_2 + 5x_3 = 4$
 $x_1, x_2, x_3 \geq 0$ (06 Marks)

- b. Define (i) Feasible solution (ii) Optimal solution in a linear programming problem.

(04 Marks)

- c. Solve using simplex method.

$$\text{Maximize } z = 3x_1 + 2x_2 + 5x_3$$

$$\text{Subject to } x_1 + 2x_2 + x_3 \leq 430$$

$$3x_1 + 2x_3 \leq 460$$

$$x_1 + 4x_2 \leq 420$$

$$x_1, x_2, x_3 \geq 0$$

(10 Marks)

- 4 a. Five employees are available to do five different jobs. From the past records the time in hrs that each employee takes to do each job is known and given in the table below. How should the jobs be allotted one per person so as to minimize the total man hours? (10 Marks)

		Employees				
		I	II	III	IV	V
Jobs	A	2	9	2	7	1
	B	6	8	7	6	1
	C	4	6	5	3	1
	D	4	2	7	3	1
	E	5	3	9	5	1

- b. Solve the travelling sales man problem given by the following data:

$$C_{12} = 20, C_{13} = 4, C_{14} = 20, C_{23} = 5, C_{34} = 6,$$

$$C_{25} = 10, C_{35} = 6, C_{45} = 10 \quad \text{where } C_{ij} = C_{ji}$$

And there is no route between cities i and j if the value of C_{ij} is not given.

(10 Marks)

PART – B

- 5 a. Obtain an initial basic feasible solution for the following transportation problem using
i) North – west corner rule ii) Vogels Approximation method

		1	2	3	4	5	Supply
A	A	2	11	10	3	7	4
	B	1	4	7	2	1	8
	C	3	9	4	8	12	9
	Demand	3	3	4	5	6	

(10 Marks)

- b. Find the optimum solution for the transportation problem using MODI method.

		W ₁	W ₂	W ₃	W ₄	Factory capacity
Ware house requirement	F ₁	19	30	50	10	7
	F ₂	70	30	40	60	9
	F ₃	40	8	70	20	18
	Ware house requirement	5	8	7	14	

(10 Marks)

- 6 a. Solve the following game graphically and find the value of the game

		Player b			
		b ₁	b ₂	b ₃	b ₄
Player a	a ₁	8	5	-7	9
	a ₂	-6	6	4	-2

(10 Marks)

- b. Determine the best sequencing of 6 jobs on 4 machines from the given table of processing time. The sequence of operation to be considered is $M_1 \rightarrow M_2 \rightarrow M_3 \rightarrow M_4$

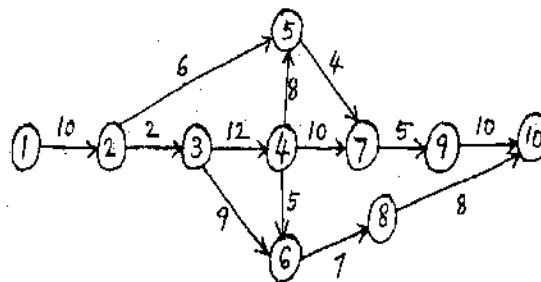
Jobs	Processing Time on Machines			
	M_1	M_2	M_3	M_4
A	6	5	3	4
B	7	2	5	5
C	9	6	3	3
D	8	5	5	4
E	8	3	4	3
F	9	5	5	4

(10 Marks)

- 7 a. Obtain the critical path and project duration for the following PERT network

(10 Marks)

Fig. Q7 (a)



- b. Explain the following terms in PERT/CPM

- Earliest time
- Latest time
- Total activity slack
- Event slack
- Critical path

(10 Marks)

- 8 a. In a plant we have 105 machines operating. The average preventive maintenance cost for a machine has been worked out to be Rs 35. The breakdown cost is Rs 500 and the breakdown history of the machines is given below. Decide an appropriate maintenance policy?

Month of the year	1	2	3	4	5	6	7	8	9	10	11	12
Break down Frequency	2	3	4	5	5	6	9	12	12	14	15	15

(10 Marks)

- b. We have the lots of 1000 bulbs, supplied to shop cost of individual replacement is Rs 10 and the bulk replacement cost is Rs 2.50 per bulb. The failure pattern noticed is as follows :

Period in months	1	2	3	4	5
Failure rate %	0.10	0.15	0.25	0.30	0.20

Work out the optimum replacement policy.

(10 Marks)

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Sixth Semester B.E. Degree Examination, June / July 2014
Operations Research

Time: 3 hrs.

Max. Marks: 100

Note: 1. Answer FIVE full questions, selecting at least TWO questions from each part.
2. Use of Quantitative / Statistical / Normal distribution Tables permitted.

PART – A

- 1 a. Explain the following with respect to simplex method:
 - i) Dealing with unrestricted variables. (06 Marks)
 - ii) Degeneracy and how it can be resolved.
- b. Explain the formulation of dual when primal problem contains constraints with,
 - i) Equal sign. (04 Marks)
 - ii) Unrestricted variable.
- c. Solve the following linear programming problem using Charne's penalty method:

Maximize $z = -2x_1 - x_2$
 Subjected to, $3x_1 + x_2 = 3$
 $4x_1 + 3x_2 \geq 6$
 $x_1 + 2x_2 \leq 4$
 $x_1, x_2 \geq 0$ (10 Marks)
- 2 a. A farmer has 100 acre land. He can sell all tomatoes and radishes he can raise. The price he can obtain is Rs.1.0 per kg for tomatoes and Rs.2.0 per kg for radishes. The average yield per acre is 2000 kgs of tomatoes and 1000 kgs of radishes. Fertilizer is available at Rs.0.5 per kg and the amount required per acre is 100 kgs for tomatoes and 50 kgs for radishes. Labour required for sowing, cultivating and harvesting per acre is 5 man days for tomatoes and 6 man days for radishes. A total of 400 man days of labour are available at Rs.20 per man day. Formulate this problem as linear programming problem to maximize the farmers total profit. Also solve the problem using graphical method. (10 Marks)
- b. Using two phase simplex method solve the following linear programming problem:

Maximize $z = 3x_1 - x_2$
 Subjected to, $2x_1 + x_2 \geq 2$
 $x_1 + x_2 \leq 2$
 $x_2 \leq 4$
 $x_1, x_2 \geq 0$ (10 Marks)
- 3 a. Solve the LPP given below using revised simplex method.

Maximize $z = 6x_1 - 2x_2 + 3x_3$
 Subjected to, $2x_1 - x_2 + 2x_3 \leq 2$
 $x_1 + 4x_3 \leq 4$
 $x_1, x_2, x_3 \geq 0$ (15 Marks)
- b. Explain in brief, the essence of parametric programming in operations research. (05 Marks)



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- 4 a. Indian cricket team has five very good batsmen with five batting positions needs to be assigned. Following table gives batting averages of each of these batsmen in all five batting positions. How should the batting position be allocated so as to minimize match losing percentage? (10 Marks)

Batting Positions \ Batsman	I	II	III	IV	V
SACHIN	59.49	61.52	56.97	18.55	50.43
KOHLI	60.62	58.23	40.37	32.28	49.40
PUJARA	34.50	50.89	51.85	48.10	43.54
DHONI	45.54	58.05	54.12	36.41	44.83
SEHWAG	31.42	49.43	51.09	59.57	43.57

- b. Solve the traveling salesman problem, given the cost matrix as shown below: (10 Marks)

	To City			
	A	B	C	D
From City A	-	46	16	40
B	41	-	50	40
C	82	32	-	60
D	40	40	36	-

PART – B

- 5 a. Karnataka power corporation has three electric power plants that supply the needs of five cities. Each power plant can supply the following numbers of kWh of electricity:

Sharavathi plant : 8 million units

Raichur plant : 12 million units

Varahi plant : 14 million units

The peak power demands of these five cities are as follows (in kWh):

Bangalore : 4 million units

Mysore : 4 million units

Mangalore : 6 million units

Tumkur : 8 million units

Davanagere : 8 million units

The cost of sending 1 million kWh of electricity from different plants to each city is given in table below. To minimize the cost of meeting each city's peak power demand, formulate a balanced transportation problem. Obtain initial basic feasible solution by VAM method and optimal solution by MODI method. (14 Marks)

	Bangalore	Mysore	Mangalore	Tumkur	Davanagere
Sharavathi plant	4	2	3	2	6
Raichur plant	5	4	5	2	1
Varahi plant	6	5	4	7	3

- b. i) List out the differences between transportation and assignment problem.
ii) Write any three differences between a balanced and an unbalanced transportation problem. (06 Marks)

- 6 a. What is a game strategy? Explain in brief, pure strategy and mixed strategy as applicable to game theory. (05 Marks)

- b. Write any three properties of a competitive game. (03 Marks)

- c. Define the following with respect to game theory:

i) Pay off matrix.

ii) Game of choice. (02 Marks)

- 6 d. Two players Prakruthi and Sudheeksha play a game in which each has three coins: a 5 paise, a 10 paise and 20 paise. Each selects a coin without the knowledge of the other's choice. If the sum of the coins is an odd amount Prakruthi wins Sudheeksha's coins. If the sum is even Sudheeksha wins Prakruthi's coins.
- Develop a pay off matrix with respect to player Prakruthi.
 - Find the optimal strategies for the players. What is the value of the game?

(10 Marks)

- 7 a. A project consists of a series of tasks labelled A, B,H, I with the following relationships.[w < x, y means x and y cannot start until w is completed) with this notation, construct the network diagram having the following constraints:
A < D, E; B, D < F; C < G; B < H; F, G < I

Find also the minimum time of completion of the project when the time (in days) of completion of each task is as follows:

Task:	A	B	C	D	E	F	G	H	I
Time:	23	8	20	16	24	18	19	4	10

Further determine

- Earliest start time [ES]
- Earliest Finish time [EF]
- Latest start time [LS]
- Latest finish time [LF]
- Total Float time [TF]

(08 Marks)

- b. A small project is composed of seven activities whose time estimates are listed in table below:

Activity		1 – 2	1 – 3	1 – 4	2 – 5	3 – 5	4 – 6	5 – 6
Estimated Duration in Weeks	Optimistic	1	1	2	1	2	2	3
	Most likely	1	4	2	1	5	5	6
	Pessimistic	7	7	8	1	14	8	15

- Draw the project network.
- Find the expected duration and variance of each activity.
- Calculate early and late occurrence times for each event, what is the expected project length?
- Calculate the variance and standard deviation of project length? What is the probability that the project will be completed?
 - at least 4 weeks earlier than expected?
 - Not more than 4 weeks earlier than expected.
- If the project due date is 19 weeks, what is the probability of meeting the due date.

(12 Marks)

- 8 a. The data on running costs per year and resale price of equipment A whose purchase price is 2 lakhs are as follows:

Year	1	2	3	4	5	6	7
Running costs in Lakhs	0.30	0.38	0.46	0.58	0.72	0.90	1.10
Resale value in Lakhs	1	0.50	0.25	0.12	0.08	0.08	0.08

- What is the optimum period of replacement?
- When equipment A is two years old, equipment B which is new model for the same usage is available. The optimum period for replacement is 4 years with an average cost of Rs.72000. Should equipment A be changed with equipment B? If so, when?

(12 Marks)

- b. Why do we need to replace machines? List out different replacement strategies. Also explain in brief, various types of failures which are responsible for replacement of machines.

(08 Marks)

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