Course Code: 1950324 Roll No: MLRS- R19

MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

III B.Tech I Sem Regular End Examination, February 2022

Operations Research
(MECH)

Time: 3 Hours. **Max. Marks: 70**

Note: 1. Question paper consists: Part-A and Part-B.
2. In Part – A, answer all questions which carries 20 marks.
3. In Part – B, answer any one question from each unit.
Each question carries 10 marks and may have a, b as sub questions.

PART- A

(10*2 Marks = 20 Marks)

1.	a)	Distinguish between the Big-M and two-phase simplex methods of solving LPPs	2M	CO1	BL4
	b)	What is a redundant constraint in LPP? Give an example.	2M	CO1	BL2
	c)	What is non-standard transportation problem?	2M	CO2	BL2
	d)	Give the applications of assignment problems.	2M	CO2	BL2
	e)	What do you understand by sequencing?	2M	CO3	BL1
	f)	What is group replacement policy? When do you opt this policy?	2M	CO3	BL1
	g)	Define a game and brief out the salient features in it.	2M	CO4	BL2
	h)	List out the limitations of EOQ.	2M	CO4	BL1
	i)	What do you understand by (M/M/1):(∞/FCFS)?	2M	CO5	BL2
	j)	Define Bellman's principle of optimality and its application to DPP.	2M	CO5	BL1

PART- B

(10*5 Marks = 50 Marks)

2	a)	What are the various phases of operation research problems?	5M	CO1	BL4
	b)	A dietician recommends the minimum daily (quantity) requirement of the vitamins A, B and C for a health conscious customer to be 30, 20 and 16 units, respectively. For the supply of these minimum vitamin requirements, the customer relies on two types of foods X and Y. The food X provides 7, 5, 2 units of the three vitamins per gram, respectively, while the food Y provides 2, 4, 8 units of the same three vitamins per gram of the food, respectively. The food X costs Rs. 30 per gram and the food Y Rs. 20 per gram. The problem is to determine the optimum mix of the foods X and Y which the dietician can recommend so as to maximize food richness and minimize the possible bill to the customer. Formulate the problem as LPP.	5M	CO1	BL4

OR

3 Solve the following LPP using Simplex method and verify your solution using graphical method — 10M CO1 BL4

Maximize $Z=40x_1 + 50x_2$
Subject to $2x_1 + 3x_2 \leq 30$
$8x_1 + 4x_2 \leq 45$
$x_1, x_2 \geq 0$

4 Solve the following transportation problem, i.e., find the IBFS by North West corner rule and OFS by modi method, where the entries are cost coefficients. — 10M CO2 BL4

	To Destination				Availability
		1	2	3	4	
From Origins	1	15	0	20	10	50
	2	12	8	11	20	50
	3	0	16	14	18	100
Requirement		30	40	60	70	200

OR

5 Five workers are available to work with the machines and the respective costs (in Rs.) associated with each worker's machine assignment is given below. A sixth machine is available to replace one of the existing and the associated costs and also given below. — 10M CO2 BL4

a) Determine whether the new machine can be accepted.
b) Determine also optimal assignment and the associated saving cost.

Machines

	M_1	M_2	M_3	M_4	M_5	M_6
W_1	12	3	6	-	5	9
W_2	4	11	-	5	-	8
W_3	8	2	10	9	7	5
W_4	-	7	8	6	12	10
W_5	5	8	9	4	6	-

6 There are six jobs, each of which must go through machines A,B and C. Processing time (in hours) are given in the following table — 10M CO3 BL4

Job	*1*	*2*	*3*	*4*	*5*	*6*
Machine A	12	10	9	14	7	9
Machine B	7	6	6	5	4	4
Machine C	6	5	6	4	2	4

Order of the processing of each job is ACB. Sequence suggested is 5-3-6-2-1-4. Find the total time elapsed for the sequence suggested.

OR

7 A truck - owner finds from his past experience that the maintenance costs are Rs. 200 for the first year and then increase by Rs. 2,000 every year. The cost of truck type *A* is Rs. 9,000. Determine the best age at which to replace the truck. If the optimum replacement is followed what will be the average yearly cost of owning and operating the truck? Truck type *B* costs Rs. 20,000. Annual operating costs are Rs. 400 for the first year and then increase by Rs. — 10M CO3 BL4

800 every year. The truck owner has now the truck type *A* which is one year old. Should it be replaced by *B* type, and if so, when?

8	a)	List out the working rule in purchase inventory model with two price breaks.	5M	CO4	BL1
	b)	Raju and Ravi plays game as follows, they simultaneously and independently write one of the three numbers 1, 2 and 3. If the sum of the numbers written is even, Ravi pays to Raju this sum in rupees. If it is odd, Raju pays the sum to Ravi in rupees. Form the payoff matrix of player Raju and solve the game to find out the value of the game and probabilities of mixed strategies of Raju and Ravi.	5M	CO4	BL4

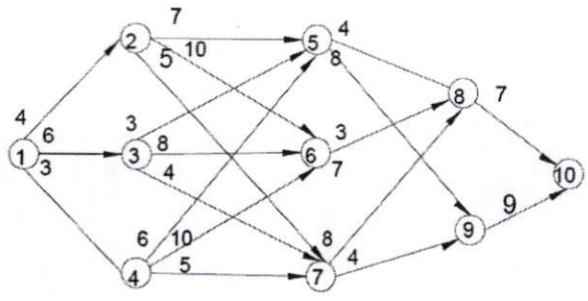
OR

9		In a game of matching coins, player A wins Rs 8 when both the coins show head and Rs 1 when both are tails. B wins Rs 3 when the coins do not match. Given the choice of being matching player A or B which one would you choose and what would be your strategy?	10M	CO4	BL2

10	a)	Explain the negative behaviors of customers in a queuing system	5M	CO5	BL2
	b)	A person repairing radios finds that the time spent on the radio sets has an exponential distribution with mean 20 minutes. If the radios are repaired in the order in which they come in and their arrival is approximately Poisson with an average rate of 15 for 8-hour day, what is the repairman's expected idle time in each day? How many jobs are ahead of the average set just brought in?	5M	CO5	BL4

OR

11		A medical representative located at city 1 has to travel to city 10. He known the distance of alternative routes city 1 to city 10 and has network map based on the distance between the cities as in the following table. Draw the network and find the shortest possible routes. Also, find the shortest routes from any city to city 10.	10M	CO5	BL4



---oo0oo---

EXAMINATION BRANCH

Academic Year	2021 – 2022
Year & Semester	III B.Tech & I Semester
Regulation	R19
Branch	Mechanical
Course Code	1950324
Course Name	Operations Research
Course Faculty's	U. Sudhakar
Course Moderator	U. Sudhakar
Date of Exam	15-02-2022
Reporting Time & Sign	1:30pm & U.S

KEY PAPER

QNO	ANSWER	MARKS
1) a)	**Big – M method**	2M
	1. Big M method is also called as 'penality method'	
	2. method adopted for removing artificial variables from the basis	
	Two – phase method	
	1. given problem is solved in Two-phases.	
	2. based on the solution of the phase-1, phase-2 will be carried out.	
1) b)	**Redundant constraint:-**	
	redundant constraint are those constraint which can be omitted from the system of linear	

QNO	ANSWER	MARKS

constraints without changing the feasible region for the given solution. (1m)

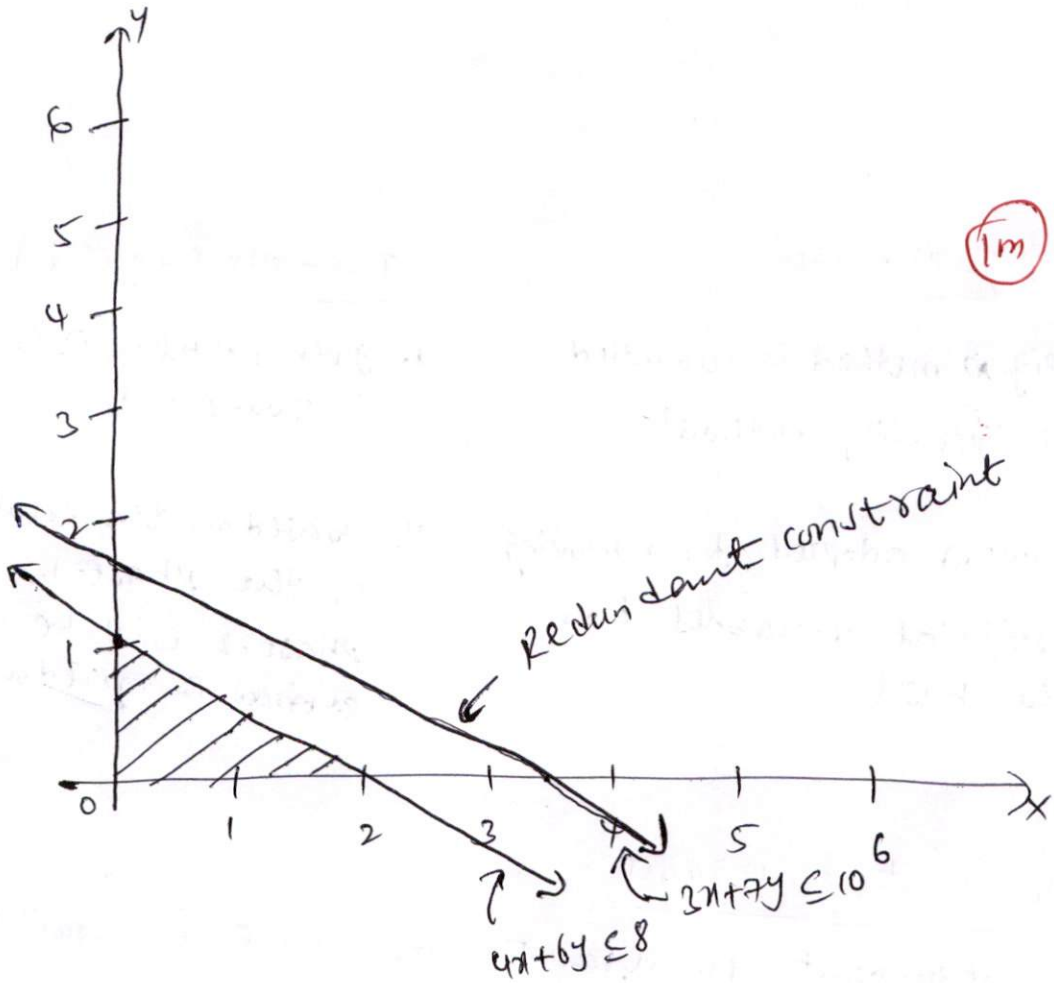
E.g:-

maximize, $z = 3x + 7y$

s/t $3x + 7y \leq 10$

$4x + 6y \leq 8$

$x, y \geq 0$



(1m) (2m)

QNO	ANSWER	MARKS
1) c)	Non-standard transportation problem :- Sum of supply ≠ sum of demand - 1m → supply > demand, create a dummy column → supply < demand, create a dummy row (1m) (2m)	
d)	maximisation case Unbalanced Assignment problem Assignment problem with multiple optimal solutions Restricted (or prohibited) Assignment Travelling salesman problem	2m
e)	Sequencing :- sequencing is a selection of performing operations for the series of jobs on different machines to optimite the total time and the cost. → The following models are used for the sequencing are (i) sequencing n jobs on single machine (ii) sequencing using of Johnson's rule (iii) sequencing using graphical method	2m

QNO	ANSWER	MARKS
11		
f)	group replacement policy is mainly concerned with the items that either work (or) fail completely. (1m) group replacement of items arises when a large number of identical low cost items in a system are increasingly liable to failure with lapse of time (1m)	2m
1		
g)	Game: It is an activity which is played between two or more persons according to the set of rules (1m) → salient features (i) If the no. of participants are 2 then it is called two-person game and if there are n participants it is called n-person game. (ii) Each participants have finite numbers of course of action (1m)	2m
1		
h)	(i) Assumes that demand will be constant through out year. (ii) Assumes that inventory will be restocked in one go each time.	2m

QNO	ANSWER	MARKS

1)

i) $(M/m/1):(\infty/FCFS)$

M → Poisson Arrival

m → Poisson's departure

1 → single server

∞ → no restriction on the queue length i.e customer population is infinite

FCFS → First cum first serve

2m

1)

ii) It states that the optimal policy must be one such that, regardless of how a particular state is reached all later decisions proceeding from that state must be optimal.

1m

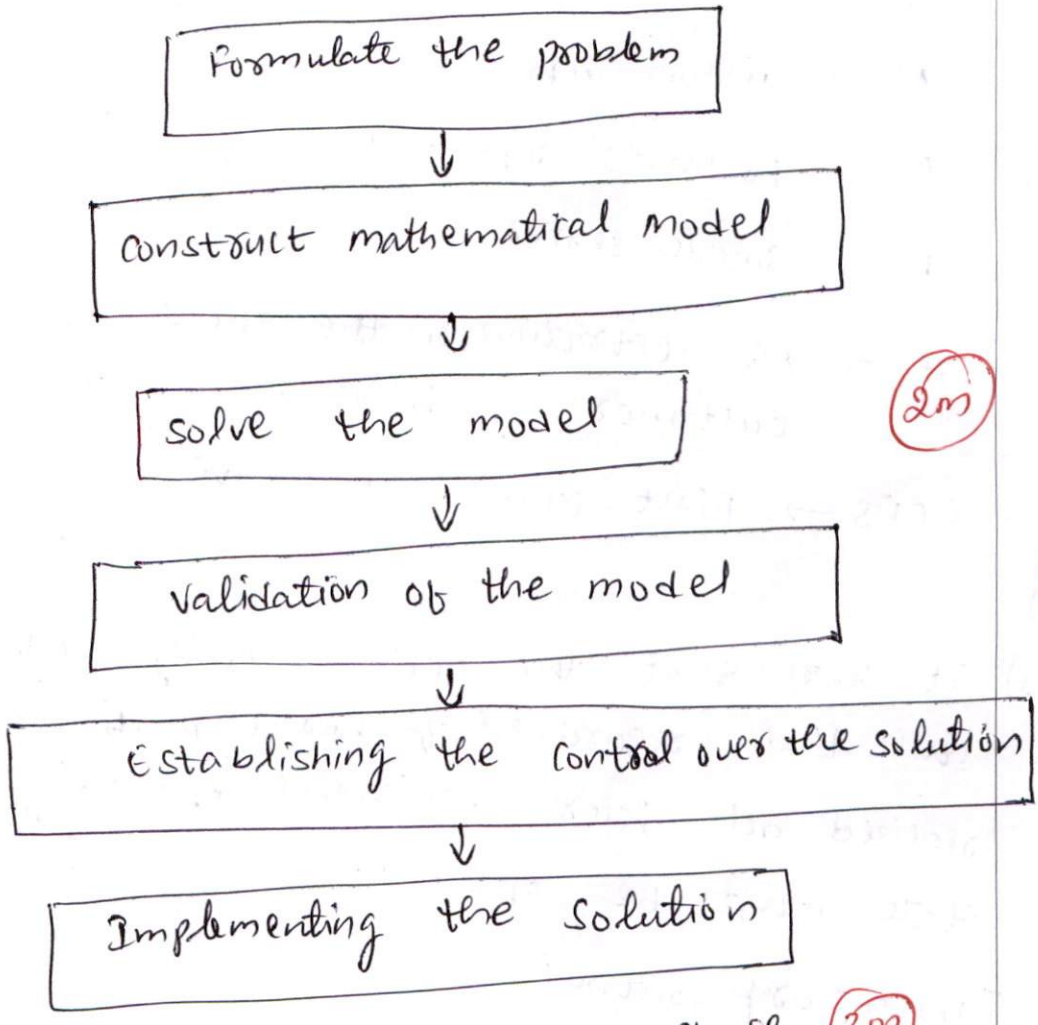
2m

(1) Inventory control
(2) Production
(3) Allocation of Resources
(4) Google maps
(5) Bio informatics

1m

QNO	ANSWER	MARKS

2)
a) Various phases of operations Research:-



2m
5m

→ Explanation of each and every phase (3m)

2)
b) Identification of decision variables – 1m
objective function – 2m
constraints – 1m
decision variables – 1m

5m

QNO	ANSWER	MARKS

3) Maximize $z = 40x_1 + 50x_2$

s/t

$2x_1 + 3x_2 \leq 30$

$8x_1 + 4x_2 \leq 45$

$x_1, x_2 \geq 0$

→ convert inequality constraint into equality constraint by adding slack variable

$2x_1 + 3x_2 + s_1 = 30$ $\quad s_1 \geq 30$

$8x_1 + 4x_2 + s_2 = 45$ $\quad s_2 = 45$

and $x_1, x_2, s_1, s_2 \geq 0$

$\max z = 40x_1 + 50x_2 + 0s_1 + 0s_2$

5M

Form a simplex Table:

		c_j	40	50	0	0	min +ve Ratio
C.B	B.V	x_B	x_1	x_2	s_1	s_2	
0	s_1	30	2	3 (Key)	1	0	30/3 = 10 ←
0	s_2	45	8	4	0	1	45/4 = 11.25
		z_j	0	0	0	0	
		$c_j - z_j$	40	50 ↑	0	0	

QNO	ANSWER	MARKS

→ Find up to $c_j - t_j \leq 0$.

→ validation with graphical method

5m

(4)

		To Destination 1	2	3	4	Availability
From origins	1	15	0	20	10	50
	2	12	8	11	20	50
	3	0	16	14	18	100
Requirement		30	40	60	70	200

→ IBFS by NWCM

	D_1	D_2	D_3	D_4	Availability
1	~~15~~ (30)	~~8~~ (20)	20	10	~~50~~ ~~20~~ 0
2	12	~~8~~ (20)	~~11~~ (30)	20	50 ~~30~~ 0
3	0	16	~~14~~ (30)	~~18~~ (70)	100 ~~70~~ 0
Requirement	~~30~~ 0	~~40~~ ~~20~~ 0	~~60~~ ~~30~~ 0	~~70~~ 0	

5m

$= 15\times30 + 0\times20 + 8\times20 + 11\times30 + 14\times30 + 18\times70$

$=$ Rs. 2620

QNO	ANSWER	MARKS

Modi method:-

Allocation Table

	D_1	D_2	D_3	D_4	Availability
O_1	15	0 (40)	20	10 (10)	50
O_2	12	8	11 (50)	20	50
O_3	0 (30)	16	14 (10)	18 (60)	100
Requirement	20	40	60	70	

5m

Total Transportation cost

$= 0\times40 + 10\times10 + 11\times50 + 0\times30 + 14\times10 + 18\times60$

$= Rs.\ 1870/-$

5)

	m_1	m_2	m_3	m_4	m_5	m_6
W_1	12	3	6	–	5	9
W_2	4	11	–	5	–	8
W_3	8	2	10	9	7	5
W_4	–	7	8	6	12	10
W_5	5	8	9	4	6	–

→ Balance the problem

QNO	ANSWER	MARKS

Row Reduction :-

9	0	3	∞	2	6
0	7	∞	1	∞	4
6	0	8	7	5	3
∞	1	2	0	6	4
4	7	8	3	5	0
0	0	0	0	0	0

Column - Reduction :- In each column there is one zero. so, no need of column reduction.

Make Assignment :-

9	[0]	3	∞	2	6
[0]	7	∞	1	∞	4
6	~~0~~	8	7	5	3
∞	1	2	[0]	6	4
4	7	8	3	5	[0]
~~0~~	~~0~~	[0]	~~0~~	~~0~~	~~0~~

No. of Assignments ≠ No. of rows & columns

QNO	ANSWER	MARKS

Optimality check :-

Final Table

7	~~0~~	1	∞	[0]	4
[0]	9	∞	1	∞	4
4	[0]	6	5	3	1
∞	3	2	[0]	6	4
4	9	8	3	5	[0]
~~0~~	2	[0]	~~0~~	~~0~~	~~0~~

10M

workers	machines	cost
w_1	V	5
w_2	I	4
w_3	II	2
w_4	IV	6
w_5	VI	1
		18

∴ optimal cost of Assignment RS.18

QNO	ANSWER	MARKS

6) Jobs are to proceed in ACB order.

Job	1	2	3	4	5	6
m/c A	12	10	9	14	7	9
m/c C	6	5	6	4	2	4
m/c B	7	6	6	5	4	4

→ conditions

minimum of A ?, maximum of C

7 7, 6 , satisfied

Job	m/c A In	m/c A out	m/c C In	m/c C out	m/c B In	m/c B out
5	0	7	7	9	9	13
3	7	16	16	22	22	28
6	16	25	25	29	29	33
2	25	35	35	40	40	46
1	35	47	47	53	53	60
4	47	61	61	65	65	70

10 m

Total elapsed time = 70 hours

Idle time of m/c A = 9 hours

Idle time of m/c C = 43 hours

Idle time of m/c B = 38 hours

QNO	ANSWER	MARKS

(7)

① year (N)	② Capital cost (C)	③ maintenance cost (R_N)	④ cumulative Running cost (ΣR_N)	⑤ Total cost ②+④	⑥ Average Annual cost ⑤/(1)
1	9000	200	200	9200	9,200
2	9000	2200	2400	11400	5,700
3	9000	4200	6600	15600	5,200
4	9000	6200	12800	21800	5,450

→ The machine 'A' should be replaced at the end of 3rd year.

10m

① year (N)	② Capital cost (C)	③ maintenance cost (R_N)	④ cumulative Running cost (ΣR_N)	⑤ Total cost ②+④	⑥ Average Annual cost ⑤/(1)
1	20,000	400	400	20400	20,400
2	20,000	1200	1600	21600	10,800
3	20,000	2000	3600	23600	7,866.66
4	20,000	2800	6400	26,400	6,600
5	20,000	3600	10,000	30,000	6000
6	20,000	4400	14400	34400	5733.33
7	20,000	5200	15200	35200	5028.57
8	20,000	6000	21200	41200	5150.

QNO	ANSWER	MARKS

→ The machine 'B' should be replaced at the end of 7th year.

→ The truck type 'A' should be replaced with truck type 'B' at the end of 3rd year.

(8)

9) The purchase inventory model with two quantity discounts is expressed as

Range of Quantity	Purchase cost (per unit)
$0 \leq Q < b_1$	C_1
$b_1 \leq Q < b_2$	C_2
$b_2 \leq Q$	C_3

b_1 and b_2 are the quantities which help in ascertaining the price discounts and $C_1 > C_2 > C_3$. The optimum order quantity can be determined with help of following steps,

Step 1:

Compute the optimal order quantity for the lowest price or highest discount (Q_3^*)

$$Q_3^* = \sqrt{\frac{2DC_o}{C_3 \times I}}$$

Q_3^* will be b_2.

QNO	ANSWER	MARKS

step-2:-

(i) If $Q_3^* > b_2$ the order placed is equal to the optimal quantity economic order quantity i-e (Q_3^*)

(ii) If $Q_3^* < b_2$, then proceed to step 3

step-3:-

calculate Q_2^* for price C_2

$$Q_2^* = \sqrt{\frac{2DC_0}{C_2 \times I}}$$

step-4:-

compare Q_2^* with b_1

(a) If $Q_2^* \geq b_1$, then the order placed is equal to the optimal quantity i-e., Q_2^*

(b) If $Q_2^* < b_1$, then proceed to next step.

step-5:-

calculate Q_1^* for price C_1

$$Q_1^* = \sqrt{\frac{2DC_0}{C_1 \times I}}$$

step-6:-

calculate total cost (TC) for Q_1^*, b_1 and b_2

$$TC(Q_1^*) = \frac{D}{Q_1^*} \times C_0 + \frac{Q_1^*}{2} \times C_1 I + DC_1$$

5m

QNO	ANSWER	MARKS

$$TC(b_1) = \frac{D}{b_1} \times C_0 + \frac{b_1}{2} \times C_2 I + DC_2$$

$$TC(b_2) = \frac{D}{b_2} \times C_0 + \frac{b_2}{2} \times C_3 I + DC_3$$

step-7:-

compare $TC(Q_1^*)$, $TC(b_1)$ and $TC(b_2)$.

The least cost is selected and the corresponding order quantity is placed.

8)

b) Payoff matrix Ravi

Raju	1	2	3
1	2	-3	4
2	-3	4	-5
3	4	-5	6

(1m)

→ Saddle point checking and converting to 2×2 matrix (2m)

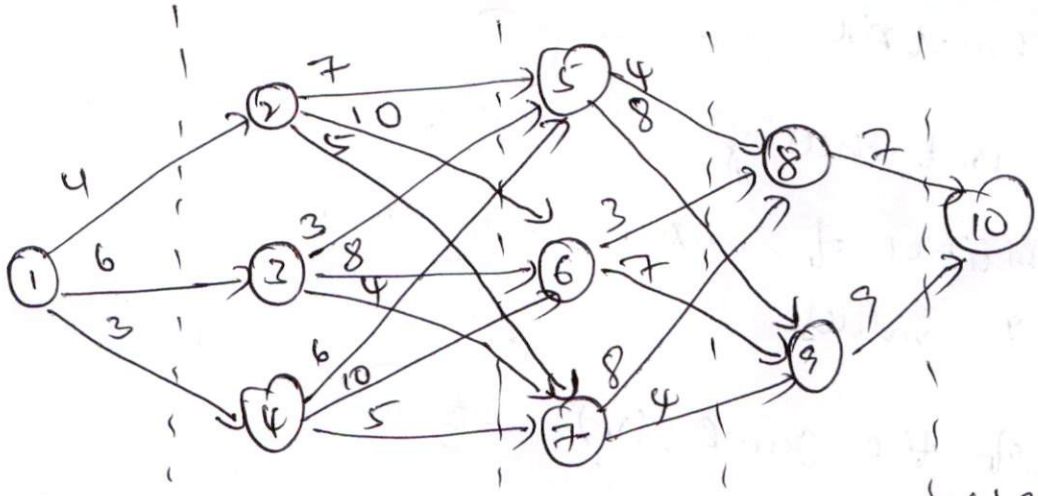
→ Probabilities of mixed strategies ie $P_1 = P_2 = (\quad)$ (1m)

$q_1, q_2, v = (\quad)$ (5m)

→ value of the game, $V = (\quad)$ (1m)

QNO	ANSWER	MARKS
9	Pay-off matrix — 2m Saddle point checking — 2m Probabilities of mixed strategies P_1 & P_2, Values and V_1 & V_2 values — 3m Value of the game, (V) — 3m	10m
10 a	negative behaviour of customers in a queuing system are (i) Balking of queue (ii) Forced balking (iii) Reneging (iv) Jockeying (v) service facility Explanation — 3m	2m 5m
10 b	The given problem is divided into '5' stages with dotted lines as shown in fig.	

QNO	ANSWER	MARKS



Stage 1:- If node '10' is the destination, then no need to travel

Stage 2:- If destination is node '8' or node '9', then the shortest path calculation is shown in table below

Decisions / State variable (S_1)	Destination (i.e., Node 10)		Minimum distance	Optimal decision
	State distance	Cumulative distance		
8	7	7	7	8-10
9	9	9	9	9-10

QNO	ANSWER	MARKS

Stage 3:-

Decisions / State variable (S_i)	Destinations: Node 8 (7)		Node 9 (5)		minimum distance	optimal decision	cumulative optimal decision
	state distance	cumulative distance	state distance	cumulative distance			
5	4	4	8	17	11	5-8	5-8-10
6	3	10	7	16	10	6-8	6-8-10
7	8	15	4	13	13	7-9	7-9-10

Stage 4:-

Decisions / State variable (S_i)	Destinations: Node 5 (11)		Node 6 (10)		Node 7 (13)		min. distance	Optimal stage decision	cumulative optimal decision
	state distance	cu. dist	st. dis.	cu. distance	st. dis	cu. dis			
2	7	18	10	20	5	18	18	2-5 2-7	2-5-8-10 2-7-9-10
3	3	14	8	18	4	17	14	3-5	3-5-8-10
4	6	17	10	20	5	18	17	4-5	4-5-8-10

Stage-5

Decisions / State variable (S_i)	Destinations: Node 2 (18)		Node 3 (14)		Node 4 (17)		min. distance	Optimal stage decision	cu. op. decision
	St. dis.	cu. dis	St. dis	cu. dis	St. dis	cu. dis			
1	4	22	6	20	3	20	20	1-3 1-4	1-3-5-8-10 1-4-5-8-10

QNO	ANSWER	MARKS

sequence(node): $1 \to 3 \to 5 \to 8 \to 10$

or

$1 \to 4 \to 5 \to 8 \to 10$

distance(kms): $6+3+4+7 = 20$

or

$3+6+4+7 = 20$

10m

$\therefore$ shortest path $= 1 \to 3 \to 5 \to 8 \to 10$ (or)

$1 \to 4 \to 5 \to 8 \to 10$

Distance $= 20$ kms