

1. OPERATION RESEARCH

1. Explain definition & scope of operation research.
2. State the phases of Operation Research.

2. LINEAR PROGRAMMING PROBLEM

1. A factory uses three machines to produce two machine parts. The following table represents the machining time for each part and other related information. Find the number of parts to be manufactured per week to maximize the profit. Comment -on the obtained solution.

Machine	Time for machining(min.)		Max. time available/week
	Part 1	Part 2	
Lathe	12	6	3000
Milling	4	10	2000
Grinding	2	3	900
Profit/Unit(Rs.)	40	100	

2. Solve following LPP by simplex method only & comments on your special observations if any.
Max. $Z = 2x_1 + x_2$ S/t: $4x_1 + 3x_2 \leq 12$, $4x_1 + x_2 \leq 8$, $4x_1 - x_2 \leq 8$, $x_1, x_2 \geq 0$.
3. Write the dual of

i) Maximize $Z = 3x_1 + 2x_2$

Subject to $x_1 + x_2 \geq 1$

$x_1 + x_2 \leq 7$

$x_1 + 2x_2 \leq 10$

$x_2 \leq 3$

$x_1, x_2 \geq 0$

ii) Maximize $Z = 5x_1 - 6x_2 + 4x_3$

Subject to $3x_1 + 4x_2 + 6x_3 \geq 9$

$x_1 + 3x_2 + 2x_3 \geq 5$

$-7x_1 + 2x_2 + x_3 \geq -10$

$x_1 - 2x_2 + 4x_3 \geq 4$

$x_1, x_2, x_3 \geq 0$

4. Solve by simplex: Max. $Z = 100x_1 + 50x_2 + 50x_3$, Subject to $4x_1 + 3x_2 + 2x_3 \leq 1000$,
 $3x_1 + 8x_2 + x_3 \leq 800$, $4x_1 + 2x_2 + x_3 \leq 600$, $x_1, x_2, x_3 \geq 0$
5. What are the advantages and limitations of graphical method in solving LPP? Obtain the solution graphically for the following LPP : Maximize $Z = 3x_1 + 4x_2$ Subject to $5x_1 + 4x_2 \leq 200$, $3x_1 + 5x_2 \leq 150$, $5x_1 + 4x_2 \geq 100$, $8x_1 + 4x_2 \geq 80$, $x_1, x_2 \geq 0$
6. What do you mean by linear programming? Define following terms: linear function, objective function, decision variable, constraints, feasible solution, and optimal solution.
7. Using Simplex method of LP technique, solve the following problem. Also comment on the "type of solution". Maximize $Z = 5x_1 + 4x_2$, Subject to $x_1 - 2x_2 \leq 1$, $x_1 + 2x_2 \geq 3$, $x_1, x_2 \geq 0$.
8. Solve the following LPP : Minimize $z = -3x_1 + x_2 - 2x_3$ Subject to
 $x_1 + 3x_2 + x_3 \leq 5$, $2x_1 - x_2 + x_3 \geq 2$, $4x_1 + 3x_2 - 2x_3 = 5$, $x_1, x_2, x_3 \geq 0$.
9. An Industry produces two products P and Q, which possess the total production capacity of 9 tonnes per day. P and Q require the same production capacity. The firm has a permanent contract to supply at least 2 tonnes of P and at least 3 tonnes of Q per day to another industry. Each tonne of P requires 20 machine hours production time and each tonne of Q requires 50 machine hours production time. The daily maximum possible no. of machine hours is 360. All the firm's output can be sold, and the profit made is Rs. 80 per tonne of P and Rs. 120 per tonne of Q. Graphically, determine the maximum profit and the product mix for this profit.

3. TRANSPORTATION AND ASSIGNMENT

1. The transportation costs incurred to the four factories (P, Q, R & S) and their capacities are as shown in table. The production costs to them are Rs. 2, 3, 1 and 5 respectively. Whereas, demands of market A, B, C, D are 25, 35, 105, 20 respectively. Propose the deliveries from each of factories to each market so the total production and transportation cost is the minimum. Use VAM and MODI methods.

	A	B	C	D	Capacity
P	2	4	6	11	50
Q	10	8	7	5	70
R	13	3	9	12	30
S	4	6	8	13	50

2. Company has factories A1, A2 & A3 which supply to warehouses at W1, W2 & W3. Weekly factory capacities are 240, 200 & 130 units respectively. Weekly warehouses requirements are 190, 150 & 110 units respectively. Unit transportation in costs Rs. as follows: - Find I.B.S. BY VAM method & Optimum solution BY MODI method.

	W1	W2	W3	Sup
A1	16	20	12	240
A2	14	8	18	200
A3	26	24	16	130
Dem	190	150	110	

3. A company has 3 plants P, Q and R as well as 3 warehouses A, B and C. The products are transported from the plants to the warehouses which are located at varying distances from the plants. On account of these varying distances, the transportation costs (per unit) from plants to warehouses as given below. Find out the minimum transportation costs.

		Warehouses			
		A	B	C	Supply
Plants	P	12	8	18	400
	Q	20	10	16	350
	R	24	14	12	150
Demand		500	200	300	

4. Consider the transportation problem shown in table below. Find the initial basic feasible solution using Northwest corner method and Least cost cell method.

		1	2	3	4	5	SUPPLY
PLANT	1	20	4	32	28	20	3000
	2	12	36	24	26	32	5000
	3	16	8	28	24	20	8250
	4	28	44	40	16	36	3750
DEMAND		3500	4000	2500	1500	4000	

5. A Manufacturer wants to ship 8 loads of his product as shown in following matrix. The matrix gives the mileage from origins, O to the destinations, D. The shipping cost is Rs. 10 per load per mile. What will be the optimal schedule and optimal cost? Use Vogel's approximation method to find initial basis feasible solution and MODI method to obtain optimal solution.

	D1	D2	D3	Supply
O1	50	30	220	1
O2	90	45	170	3
O3	250	200	50	4
Demand	4	2	2	

6. The following is the cost matrix of assigning the 4 operators to 4 jobs. Each operator is assigned only one job so as to minimize the total cost of jobs. What will be the total minimum job cost?

Opertors	Job			
	J1	J2	J3	J4
O1	2	10	9	7
O2	15	4	14	8
O3	13	14	16	11
O4	4	15	13	9

7. Discuss Travelling Salesman problem in brief. The matrix below shows the cost in rupees of processing 3 jobs X, Y and Z on machines A, B and C. If all jobs can be processed on all machines, assign the jobs to the machines and find the minimum total cost of processing.

Job	Machine		
	A	B	C
X	35	25	32
Y	41	30	29
Z	45	34	27

8. Solve the following assignment problem by minimization method.

	P	Q	R	S	T
M1	12	5	9	18	11
M2	13	7	6	12	14
M3	3	2	3	4	5
M4	18	9	12	16	15
M5	12	6	14	19	10

9. The captain of cricket team has to allot 5 middle batting positions to 5 batsmen. The average runs scored by each batsman at these positions are as follows:

	I	II	III	IV	V
A	40	40	35	25	50
B	42	30	16	25	27
C	50	48	40	60	50
D	20	19	20	18	25
E	58	60	59	55	53

Using assignment model, determine the assignment of batsmen to positions which would give maximum runs in favour of team.

10. Company wants to find out the minimum time require to complete four tasks by available four workers with him so that he can take another from the order party. Following table gives the time in hours for each workers for each job

	A	B	C	D
1	24	10	21	11
2	14	22	10	15
3	15	17	20	19
4	11	19	14	13

4. QUEUING THEORY

1. Explain the terms w.r.t. queuing theory i) Balking ii) Reneging iii) Jockeying
2. At a reservation counter, 20 customers arrive on average every 10 minutes. The clerk can serve 22 customers in 10 minutes. Find i) average number of customers in the system ,ii) average queue length and iii) average time a customer waits before being served. State assumption made for the probability distribution.
3. Automobile arrives at a petrol pump having one petrol unit in Poisson fashion with an average of 10 units per hour. The service time is distributed exponentially with a mean of 3 min. Find following: - a.) Average number of unit in system, b.) Average waiting time for customer in queue, c.) Probability that number of units in system is 2, d.) Probability that waiting time exceeds 30 min.
4. A copy maker has 1 copy making machine and he operates as the order comes. The order arrival is poison distribution having interval time of 0.5 min. The average time to serve a copy is distributed with mean of 0.3 min. Determine the following: (1) Utilization factor of the machine (2) Idle time for machine in a day having working hours of 10 hours (3) No of persons waiting in the system (4) No of persons waiting in the queue (5) Average waiting time in the queue.
5. Customers arrive at a one window drive according to the poisons distribution with the mean of 10 minutes and service time per customer is exponential with mean of 6 minutes. The space in front of the window can accommodate only three vehicles including the serviced one. Other vehicles have to wait outside the space. Calculate
 - Probability that an arriving customer can drive directly to the space in front of the window
 - Probability that an arriving customer will have to wait outside the directed space
 - How long an arriving customer is expected to wait before getting the service?

5. INVENTORY CONTROL

1. Following is the data collected by the company for one of the item having annual demand of 1000 units: Interest on the capital locked for inventory = 15%, pilferage of inventory=5% of total inventory cost, other holding cost= 20% of inventory cost, order processing cost/order= Rs 150, order follow up cost/order= Rs 125, inspection and other procurement cost/order= Rs 125. If the cost per item is Rs 10 and discount offered is 10% for minimum order quantity of 500 items, Should the order be placed without discount for EOQ or with discount for quantity of 500 items? What will be saving by selected option?
2. Explain the following terms in connection with inventory management. (1) Re-order point (2) Safety stock (3) Lead time (4) Economic lot size (5) Carrying cost
3. A purchase manager has decided to place an order for a minimum quantity of 500 units of a particular item of inventory in order to get discount of 10%. Past records reveal that 8 orders (each of 200 units) were placed last year. Given ordering cost = Rs. 500 per year, Inventory carrying cost = 40% of inventory value and price of item = Rs. 400 per unit. What is the effect of this decision on company?
4. The production department for a company requires 3,600 Kg of raw material for manufacturing a particular item per year. It has been estimated that the cost of placing an order is Rs. 36 and the cost of carrying inventory is 25 per cent of the investment in the inventories .The price is Rs. 10 per Kg. The purchase manager wishes to determine an ordering policy for raw material. Calculate (1) The optimal lot size (2) The optimal order cycle time (3) The minimum yearly variable inventory cost (4) The minimum yearly total inventory cost

5. Inventory control manager of a firm has collected the following data on one item
 - Minimum total cost per annum = Rs. 16000, Inventory holding cost per unit per year = Rs. 4, No of order per year = 10, Price per unit = Rs. 25. Calculate annual demand of the item, procurement cost per order, inventory carrying cost as a percentage of average inventory investment and economic order quantity (EOQ).
6. The following information is provided for an item: Annual usage = 1200, Ordering cost = Rs 60 per order, Carrying costs 10%, Unit cost of item = Rs 10, and lead time 10 days. Find (i) EOQ (ii) Number of order per years (iii) Average usage if there are 300 working days per year (iv) Safety stock if highest usage rate is 70 units per day (v) R. O. L (vi) Average inventory (vii) Inventory carrying cost per year.

6. REPLACEMENT THEORY

1. From the following survival table, calculate the probability of staff resignation in each year.

Year	0	1	2	3	4	5	6	7	8	9	10
No. of original staff in service at end of year	1000	940	820	580	400	280	190	130	70	30	0

2. There are 1000 bulbs installed in a complex. It cost Rs 3/bulb for individual replacement and Rs 0.7/bulb if replaced in group. It has been decided to go for the group replacement of the bulbs (policy being replacing all bulbs at decided period as well as individual replacement of bulbs failing in this period). The table below gives the mortality rate for the bulb at the end of each month. Find the best interval period for group replacement.

End of month	1	2	3	4	5	6
Cumulative probability of failure to date	0.09	0.25	0.49	0.85	0.97	1.00

3. A person is planning to purchase a car. A new car is costing rupees 3 lacs. The resale value of the car at the end of the year is 85 % of the previous year. Maintenance & repair cost during the first year are rupees 10000 and they increase by 15 % every year. The minimum resale value of the car can be rupees 75000. When should the car be replaced to minimize average annual cost?
4. What is the need for Replacement of any machine? A machine was purchased with initial investment of Rs 40000. The following data is available. What will be the expected life as per optimum replacement policy and the average annual cost during this period?

Year	1	2	3	4	5	6
Operating & maintenance cost per year in Rs.	1400	1450	1510	1600	1720	1900
Salvage value in Rs.	35000	34000	32500	30500	28000	25000

5. A firm is considering replacement of a machine whose cost price is Rs.12200 & the scrap value Rs.200. The running costs are found from experience to be as follows. When should the machine be replaced?

Year	1	2	3	4	5	6	7	8
Running cost (Rs.)	200	600	700	1000	1200	1800	2500	4000

6. As new automobile vehicle costs of Rs. 10000 & it can be sold at the end of any year with selling price as shown below. The operating and maintenance cost are given year wise in following table. Find when the automobile vehicle needs to be replaced because of wear & tear.

	Expenditure (in rupees)	
Year	Selling price	Operating & maintenance cost
1	7000	1000
2	5000	1600
3	3000	1800
4	2000	2500
5	1000	3000
6	500	3500

7. GAME THEORY

1. Determine the solution of game for the pay-off matrix given below

		PLAYER B		
		I	II	III
PLAYER A	I	-3	-1	7
	II	4	1	-2

2. The following is the payoff matrix between player X and player Y. Find the optimal strategies and the value of the game. Use rule of dominance in calculations.

		PLAYER Y			
		A	B	C	D
PLAYER X	I	0.25	0.2	0.14	0.3
	II	0.27	0.16	0.12	0.14
	III	0.35	0.08	0.15	0.19
	IV	-0.02	0.08	0.13	0

3. Solve the following game whose payoff matrix is given below.

		Player B	
		I	II
Player A	I	1	8
	II	6	2

4. Reduce following matrix by rule of dominance

		PLAYER			
		B1	B2	B3	B4
PLAYER	A1	6	4	8	0
	A2	6	8	4	8
	A3	8	4	8	0
	A4	0	8	0	16

5. Two companies are thinking on selecting the advertising media. There are three medias available along with the pay of as shown in the pay of matrix. Value is in gain sales in (1000 rupees) suggest optimal strategy for the marketing and find out the value of the game.

		TV	Radio	Internet
PLAYER A	TV	150	200	-400
	Radio	0	75	-100
	Internet	450	100	250

6. Solve the below game theory problem with the concept of dominance method

		Player B			
		I	II	III	IV
Player A	I	3	5	4	2
	II	5	6	2	4
	III	2	1	4	0
	IV	3	3	5	2

8. PROJECT MANAGEMENT

1. Draw a network for following project;

Activity	A	B	C	E	F	G	H	I	J	K
Predecessor	-	-	-	A	A, B	B, C	C	E, F	G, H	H

2. Consider following given data and based on that find out critical path for the given project.

Activity	1-2	1-3	2-4	3-4	3-5	3-6	4-6	5-6
Time(Days)	6	9	3	4	8	12	7	1

3. Tasks A to I constitutes a project in which the precedence relationships are A < D; A < E; B < F; D < F; C < G; C < H, F < I; G < I. Time in day for each task is as follows:

Task	A	B	C	D	E	F	G	H	I
Time	8	10	8	10	16	17	18	14	9

Draw the network of project and find out total float of each activity and identify critical path.

4. A Project is represented by the Network shown below & has the following data. Determine:
 (1) Expected Time & Variance (2) Earliest & Latest times to reach each event (3) The critical path. Time given in below table is in weeks.

Task	A	B	C	D	E	F	G	H	I
	1-2	1-3	1-4	2-5	2-6	3-6	4-7	5-7	6-7
Optimistic time	5	18	26	16	15	6	7	7	3
Pessimistic time	10	22	40	20	25	12	12	9	5
Most likely time	8	20	33	18	20	9	10	8	4

5. Activities A to H of a new project having relationships & timings shown in table below.

Activity	Duration (Days)			Relationship between activities
	t_o	t_m	t_p	
A	2	2	8	A < C, D B < E C < F D < F E, F < H
B	2	5	8	
C	3	6	15	
D	2	5	14	
E	1	1	7	
F	2	2	8	
G	2	2	8	
H	2	5	14	

- (1) Draw the network. (2) Find the critical path and expected time of completion of the project.
 (3) What will be the standard deviation of the project completion duration? (4) What will be the probability of completing the project in expected time of completion?
6. Following table shows jobs, normal and crash time, normal and crash cost of a project.
 Indirect cost for the project is 300 Rs. /day.

Jobs (i-j)	Normal time (days)	Normal cost (Rs)	Crash time (Days)	Crash cost (Rs)
1-2	6	1400	4	1900
1-3	8	2000	5	2800
2-3	4	1100	2	1500
2-4	3	800	2	1400
3-4	--	--	--	--
2-5	6	900	3	1600
4-6	10	2500	6	3500
5-6	3	500	2	800

- (i) Draw the network and find the critical path. (ii) What is normal duration and cost of project.
 (iii) Find optimal cost and duration.

9. DECISION THEORY

1. The research department of a manufacturing company wants to launch 3 types of products. The marketing manager has to decide one of the product to be launched under the following estimated payoffs for various levels of sales:

Type of product	Estimated values of sales (units)		
	15000	10000	5000
A	30	10	10
B	40	15	5
C	55	20	3

What will be the marketing manager's decision if Maximin and Minimax Criteria are applied?

2. Following are the records of demand of an item for the past one month.

Demand	100	110	120	130	140
Probability	0.05	0.25	0.4	0.26	0.04

a). Calculate the expected demand. b). The item cost price of an item is Rs. 25 and selling price is Rs. 30. If at the end of the day any surplus has to be disposed of at Rs. 20 per item.

What is optimum output?

3. A manufacturing industry is considering three course of action as subcontracting, start overtime at the existing facility or construct new facility for the future considering low, medium and high demand. Probabilities of each course of action for low, medium and high demand is as shown in table with expected pay off in (in 1000 Rs). Draw decision tree for the same and determine the most preferred decision and its corresponding expected value.

Event	Subcontracting		Overtime		New facility	
	probability	expected payoff	probability	expected payoff	probability	expected payoff
Low demand	0.25	45	0.25	50	0.25	-200
Medium demand	0.35	60	0.35	75	0.35	40
High demand	0.4	65	0.4	100	0.4	200

4. A businessman has two independent investments A & B available to him, but he lacks the capital to undertake both of them simultaneously. He can choose to take A first and then stop, or if A successful, then take B or vice versa. The probability of success of A is 0.7, while for B is 0.4. Both investments require an initial capital outlay of Rs. 2000 and both return nothing if the venture is unsuccessful. Successful completion of A will return Rs. 3000 (over cost) and successful completion of B will return Rs. 5000 (over cost). Draw the decision tree and determine the best strategy.