PESIT Bangalore South Campus

10CS661: OPERATIONS RESEARCH

Faculty: Mrs.Sangeetha.R **No. Of Hours Specified: 52**

Objective: This course aims to introduce students to use quantitive methods and techniques for effective Decisions–making; model formulation and applications that are used in solving business decision problems.

Class #	Chapter Title/ Reference Literature	Topic to be covered	% of Portions covered	
			Reference Chapter	Cumulative
1	UNIT - 1 INTRODUCTION, LINEAR PROGRAMMING – 1	Introduction: The origin, nature and impact of OR	11.5%	11.5%
2		Defining the problem and gathering data **Formulating a mathematical model**		
3		Deriving solutions from the model **Testing the model;**		
4		Preparing to apply the model Implementation		
5		**Introduction to Linear Programming**		
6		Prototype example, The linear programming (LP) model		
7	UNIT - 2 : LP – 2, SIMPLEX METHOD - 1	Assumptions of LP	13.46%	24.96%
8		Additional examples		
9		The essence of the simplex method		
10		Setting up the simplex method		
11		Algebra of the simplex method		
12-13		The simplex method in tabular form Tie breaking in the simplex method.		
14	UNIT - 3 : SIMPLEX METHOD - 2	Adapting to other model forms	11.5%	36.46%
15		Post optimality analysis		
16		Computer implementation		
17		Computer implementation(contd..)		
18		Foundation of the simplex method		
19		Foundation of the simplex method(contd..)		
20	UNIT - 4 : SIMPLEX METHOD - 2, DUALITY THEORY	The revised simplex method	13.46%	49.92%
21		A fundamental insight		
22		The essence of duality theory		
23		Economic interpretation of duality		
24		Primal dual relationship		
25		Adapting to other primal forms		
26		Adapting to other primal forms(contd..)		
27	UNIT - 5 : DUALITY THEORY AND	The role of duality in sensitive analysis		
28		The essence of sensitivity analysis		
29		The essence of sensitivity analysis(contd..)		
30		Applying sensitivity analysis		

31	**SENSITIVITY ANALYSIS, OTHER ALGORITHMS FOR LP**	The dual simplex method	13.46%	63.38%
32		parametric linear programming		
33		The upper bound technique.		
34	**UNIT - 6 :TRANSPORTATION AND ASSIGNMENT PROBLEMS**	The transportation problem	13.46%	76.84%
35		The transportation problem(contd..)		
36		A streamlined simplex method for the transportation problem		
37		A streamlined simplex method for the transportation problem(contd..)		
38		The assignment problem		
39		A special algorithm for the assignment problem		
40		A special algorithm for the assignment problem		
41	**UNIT - 7 : GAME THEORY, DECISION ANALYSIS**	Game Theory: The formulation of two persons, zero sum games	11.5%	88.34%
42		Solving simple games- a prototype example; Games with mixed strategies		
43		Graphical solution procedure		
44		Solving by linear programming Extensions		
45		Decision Analysis: Decision making with experimentation		
46		Decision trees		
47	**UNIT - 8 :METAHEURISTICS**	The nature of Metaheuristics	11.5%	100%
48		Tabu Search		
49		Tabu Search (contd...)		
50		Simulated Annealing		
51		Genetic Algorithms		
52		Genetic Algorithms		

Literature:

Book Type	**Titlle & Author**	**Publication Information**
		Edition
Text Book	**Introduction to Operations Research** – Frederick S. Hillier and Gerald J. Lieberman Tata McGraw Hill, 2005. (Chapters: 1, 2, 3.1 to 3.4, 4.1 to 4.8, 5, 6.1 to 6.7, 7.1 to 7.3, 8, 13,	8^{th}

	14, 15.1 to 15.4)	
Reference Book	**Operations Research Applications and Algorithms** – Wayne L. Winston Cengage Learning, 2003	4th
Reference Book	**Operations Research: An Introduction** – Hamdy A Taha Pearson Education, 2007.	8th

Question Bank

1. Explain the role of computers in OR.
2. Briefly explain various phases of Operations Research?
3. What are the limitations of Operations research?
4. Define operation research. Explain the characteristics of Operation Research
5. Define OR Explain the steps of OR study

A. LINEAR PROGRAMMING

1. Consider the following constraints $x_1 - 2x_2 \geq 10; -x_1 + x_2 \geq 10$ and $x_2 \geq 0$. Represent the constraints graphically and clearly show the feasible region. Draw two Iso-Z lines if $Z = x_1 + x_2$. Show the direction of improvement of Z if Z is to be minimized. Find the minimum value of Z. what can be the maximum value of Z?
2. A company manufactures two types of cloth, using three different colours of wool. One yard length of type A cloth requires 4 oz. of red wool, 5 oz. of green wool and 3 oz. of yellow wool. One yard length of type B cloth requires 5 oz. red wool, 2 oz. of green wool and 8 oz of yellow wool. The wool available for manufacture is 100 oz. of red wool, 1000 oz. of green wool and 1200 oz. of yellow wool. The manufacturer can make a profit of Rs. 5 on one yard of type A cloth and Rs. 3 on one yard of type B cloth. Formulate the problem to maximize profit and solve it graphically. How does the graphical solution work and what are its limitations
3. A company makes mobile phones and cordless phones and has a machine that can operate 48 hrs. per week. Production of a mobile phone requires 2 hrs and production of a cordless phone requires 3 hrs. The profit is Rs 40/- and Rs 80/- respectively. The marketing department has determined that a maximum of 15 mobiles and 10 cordless can be sold. Formulate as an LPP and solve the problem graphically.
4. A cold drinks company has two bottling plants. Each plant produces 3 different types of drinks A B and C. The following table summarizes the data:

	Product A/day	Product B/day	Product C/day	Operating cost/day
Plant 1	3000	1000	2000	600
Plant 2	1000	1000	6000	400
Demand/ month	24000	16000	48000	

How many days in a month should the company run each plant so as the production cost is minimized. Solve using graphical method.

5. A farmer is engaged in breeding pigs. In view to ensure certain nutrient constituents in the diet of the pigs it is necessary to buy products A and B. The contents of the two products in terms of nutrients is given in the following table:

Nutrients	Nutrient content in		Min. Amount of nutrient
	A	B	
M1	36	6	108
M2	3	12	36
M3	20	10	100

If the products A and B cost Rs 20 nd Rs 4 per unit respectively, how much of each of these two products should be bought so as to minimize the total cost. Formulate as an LPP and solve

6. A firm plans to purchase at least 200 quintals of scrap containing high quality metal X and low quality metal Y. It decides that the scrap to be purchased must contain at least 100 quintals of X metal and not more than 35 quintals of Y metal. The firm can purchase the scrap from two suppliers A and B in unlimited quantities. The percentage of X and Y metals in terms of weight in the scraps supplied by A and B is given below:

Metals	**Supplier A**	**Supplier B**
X	**25%**	**75%**
Y	**10%**	**20%**

The price of A's scrap is Rs.200 per quintal and that of B's is Rs. 400 per quintal. Formulate this problem as LP model and solve it by graphical method to determine the quantities that the firm should buy from the two suppliers so as to minimize total purchase cost.

7. Two food products A & B have different quantities of ingredients P & Q which are to be provided in certain quantity. The products also contain another Ingredients R, which is harmful if present in excessive quantities. The following table give necessary data.

Ingredient	**Quantities present**		**Quantities Reserved**	**Remarks**
P	18	06	45	Minimum
Q	2	8	32	Minimum
R	4	4	40	Maximum
Cost/Unit In Rs	20	40		

8. Use graphical method to determine optimum product mix. $(x_1 = 1.29, x_2 = 3.69)$ A small plant makes two types of automobile parts. Part A and part B. it buys castings that are machined, bored and polished. You are given the following Data:

Capacity	**Part A**	**Part B**
Machining Capacity	25/hr.	40/hr.
Boring Capacity	28/hr.	35/hr.
Polishing Capacity	25/hr.	25/hr.

Casting for part A cost Rs.20/- each and for part B they cost Rs.30/-each. Finished products sell at Rs.50/- and Rs.60/-respectively. The three machine have running costs of Rs.200/-, Rs.140/- and Rs.175/-per hours. Assuming that any combination of part A and part B can be sold, formulate as an LPP and solve graphically $(x_1 = 12, x_2 = 14)$

9. Explain graphical method of finding solution to a linear programming problem. What are its limitations?
10. Formulate the following linear programming problem
    A used car dealer wishes to stock up his lot to maximize his profit. He can select cars A,B and C which are valued wholesale at Rs.5000, Rs. 7000 and Rs 8000 respectively. These can be sold at Rs.60000 Rs.8500 and Rs, 10500 respectively. These can be sold at Rs.6000, Rs.8500 and Rs. 10,500 respectively. For each car type, the probabilities of sale are:

Type of car	A	B	C
Prob.of sale in 90 days	0.7	0.8	0.6

B. SIMPLEX PROBLEMS

1. Solve the following LPP

   Min $Z = x_1 - 3x_2 + 2x_3$

   Subject to constraints $3x_1 - x_2 + 3x_3 \le 7$

   $-2x_1 + 4x_2 \le 0$

   $-4x_1 + 3x_2 + 8x_3 \ge 10$ $\qquad x_1, x_2, x_3 \ge 0$

2. Solve the following LPP2

   Min $Z = x_1 + 2x_2 + 3x_3 - 4x_4$

   Subject to constraints $x_1 + 2x_2 + 3x_3 = 15$

   $2x_1 + x_2 + 5x_3 \ge 20$

   $x_1 + 2x_2 + x_3 + x_4 \ge 10$

   $x_1, x_2 x_3, x_4 \ge 0$

3. Max $Z = 2x_1 + 3x_2 + 4x_3$

   Subject to constraint $-x_1 - x_2 - x_3 \ge -1$

   $x_1 + x_2 + 2x_3 = 2$

   $3x_1 + 2x_2 + x_3 \ge 4$

   $x_1, x_2 \ge 0 x_3$ Unrestricted

4. Solve the following LP problem by graphical method

   Max $Z = 5x_1 + 3x_2$

   Subject to $3x_1 + 2x_2 \le 15,$

   $5x_1 + 2x_2 \le 10$

   $x_1 x_2 \ge 0$

5. solve the following LPP by Big M method

   Max $Z = x_1 + 2x_2 + 3x_3$

   Subject to constraints $x_1 + 2x_2 + 3x_3 = 5$

$$2x_1 + x_2 + 5x_3 = 20$$
$$x_1 - 2x_2 + x_3 \le 8$$

6. Solve the following LPP using simplex method.

$MaxZ = 3x_1 + 2x_2 + 5x_3$

Subject to $= x_1 + 2x_2 + x_3 \le 430$

$= 3x_1 + 2x_3 \le 10$

$= x_1 x_2 x_3 \ge 0$

11. Write the dual of: Min $Z = 3x_1 + 2x_2 + 7x_3$ s.t. $(1) - x_1 + x_2 = 10$; (2) $2x_1 - x_2 + x_3 \ge 10$; (3) $x_3 \ge 0$.
12. Use dual simplex method to solve:
    Min $Z = 5x_1 + 2x_2 + 4x_3$ s.t: $(1) 3x_1 + x_2 + 2x_3 \ge 4$; $(2) 6x_1 + 3x_2 + 5x_3 \ge 10$; $(3) x_1, x_2, x_3 \ge 0$.
13. Solve by revised simplex: Max $Z = x_1 + x_2$ s.t: $(1) 3x_1 + 3x_2 \le 6$; (2) $x_1 + 4x_2 \le 4$; (3) $x_1, x_2 \ge 0$.
14. Solve by simplex the following LPP

    Min $7 = 2x_1 + 5x_2$

    $x_1 + 2x_2 \le 4$

    $2x_1 + 3x_2 \le 6$ where x_1, x_2 are unrestricted in sign

1. Solve the following problem by the simplex method
   Maximize $Z = 3x_1 + 2x_2$
   subject to the constraints:

$$2x_1 + 3x_2 \le 8$$
$$2x_2 + 5x_3 \le 10$$
$$3x_1 + 2x_2 + 4x_3 \le 15$$
$$x_1, x_2, x_3 \ge 0$$

2. Solve the following problem by the Big – M and two phase method:

   $Min \quad Z = 2x_1 + 3x_2 + x_3$

   subject to

   $x_1 + 4x_2 + 2x_3 \le 8$

   $3x_1 + 2x_2 \ge 6$

   $x_1, x_2, x_3 \ge 0$

7. With reference to the solution of LPP by simplex method / table. When one can conclude as the problem has

   i) unbounded solution and ii) no feasible solution

8. Define 'Basic feasible solution'. Find all basic solutions for the following problem and group them into basic feasible solution and basic feasible solution

   $Minimise \quad Z = x_1 + x_2 + 7x_3$

   Subject to $x_1 + x_2 + 2x_3 \le 10$ and

   $x_1 x_2 x_3 \ge 0$

9. Write the steps followed to solve the simplex problem.
10. Explain the following
    a. Explain degeneracy and unbounded solution with respect to LPP
    b. Define (i) Feasible solution (ii) Optimal Solution (iii) Basic Feasible solution

c. Explain (i) Artificial Variable (ii) Duality (iii) Alternate Optimal Solution
d. State the characteristics of the Linear Programming Problem
e. How do you identify that an LPP has non-unique optimal solutions when solving by simplex method?

11. Solve the following LPP using simplex algorithm.

$$Max \quad Z = -2x_1 - 2x_2 + 5x_3$$

Subject to: $X_1 + 2X_2 - X_3 \geq 430$

$$3x_1 - x_2 + x_3 \geq 460$$

$$x_1 + 4x_2 - x_3 \geq 420, \qquad x_1, x_2, x_3 \geq 0$$

C. DUALITY

1. solve the following LPP using big M Method

$$MaxZ = 3x_1 + 2x_2 + 3x_3$$

Subject to $2x_1 + x_2 + x_3 \leq 2$

$$3x_1 + 4x_2 + 2x_3 \leq 8$$

$$x_1 x_2 x_3 \geq 0$$

2. solve the following LPP using two phase simplex method

$$Minimize \quad Z = \frac{15}{2} x_2 - 3x_2$$

Subject to $3x_1 - x_2 - x_3 \geq 3$

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

$$x_1 x_2 x_3 \geq 0$$

3. Explain in brief the term 'Artitificial variable' used in Big-M-Method.
4. solve the following LPP using big M Method

$$MinZ = \frac{15}{2} x_1 - 3x_2$$

Subject to $3x_1 - x_2 - x_3 \leq 3$

$$x_1 - x_2 + x_3 \leq 2 \text{ and}$$

$$x_1 x_2 x_3 \geq 0$$

5. Use revised simplex method to solve: Maximize $Z = 4x_1 + 3x_2 + 6x_3$; subject to: (i) $3x_1 + x_2 + 3x_3 \leq 30$; (ii) $2x_1 + 2x_2 + 3x_3 \leq 40$; (iii) $x_1, x_2, x_3 \geq 0$.

6. Use dual simplex method to solve: Minimize $Z = -4y_1 - 12y_2 - 18y_3$; subject to: (i) $y_1 + 3y_3 \geq 3$; (ii) $2y_2 + 2y_3 \geq 5$; (iii) $y_1, y_2, y_3 \geq 0$.

7. Write the dual for the following LPP, solve the dual and write the solution of the primal from the solution of the dual. Minimize $Z = x_1 + x_2$; subject to: (i) $2x_1 + x_2 \geq 4$; (ii) $x_1 + 7x_2 \geq 7$; (iii) $x_1, x_2 \geq 0$.

8. State weak duality property, strong duality property and duality theorem. Write the dual of the LPP Minimize $Z = 2x_1 + 3x_2 + 4x_3$; subject to: (i) $2x_1 + 3x_2 + 5x_3 \geq 2$; (ii) $3x_1 + x_2 + 7x_3 = 3$; (iii) $x_1 + 4x_2 + 6x_3 \leq 5$, (iv) $x_1 \geq 0$, $x_2 \leq 0$ and x_3 is unrestricted.

1. Solve the following problem using the revised simplex method:

$Max \quad Z = 5x_1 + 8x_2 + 7x_3 + 4x_4 + 6x_5$

subject to

$2x_1 + 3x_2 + 3x_3 + 2x_4 + 2x_5 \leq 20$

$3x_1 + 5x_2 + 4x_3 + 2x_4 + 4x_5 \leq 30$

$x_1, x_2, x_3, x_4, x_5 \geq 0$

2. Consider the following problem:

$Max \quad Z = x_1 - x_2 + 2x_3$

subject to

$2x_1 - 2x_2 + 3x_3 \leq 5$

$x_1 + x_2 - x_3 \leq 3$

$x_1 - x_2 + x_3 \leq 2$

$x_1, x_2, x_3 \geq 0$

Let x_4, x_5, x_6 denote the slack variables for the respective constraints. After you apply the simplex method, a portion of the final simplex tableau is as follows:

Basic Variable	Coefficient of						RHS
	X_1	X_2	X_3	X_4	X_5	X_6	
Z	1			1	1	0	
X_2	0			1	3	0	
X_6	0			0	1	1	
X_3	0			1	2	0	

Use the fundamental insight to identify the missing numbers in the final simplex tableau. Show your calculations. Identify the defining equations of the CPF solutions corresponding to the optimal basic feasible solution in the final simplex tableau.

D. SENSITIVITY ANALYSIS

1. Write the dual of

Max $Y = 3y_1 + 4Y_2 + 3Y_3$

Subject to constraint $3y_1 + 4Y_2 + Y_3 \leq 2$

$y_1 + 3Y_2 + 2Y_3 \leq 1$

$Y_1 Y_2 Y_3 \geq 0$

2. Consider the following problem:

$Max \quad Z = -5x_1 + 5x_2 + 13x_3$

subject to

$-x_1 + x_2 + 3x_3 \le 20$

$12x_1 + 4x_2 + 10x_3 \le 90$

$x_1, x_2, x_3 \ge 0$

If we let x_4 and x_5 be the slack variables for the respective constraints the simplex method yields the following final set of equations:

$Z + 2x_3 + 5x_4 = 100$

$-x_1 + x_2 + 3x_3 + x_4 = 20$

$16x_1 - 10x_3 - 4x_4 + x_5 = 10$

You are to conduct sensitivity analysis by independently investigating each of the following changes in the original model. For each change use the sensitivity analysis procedure to revise the set of equations and convert it to proper form from Gaussian elimination for identifying and evaluating the current basic solution. Then test this solution for feasibility and optimality. Do not reoptimize.

(a) Change the RHS of constraint 1 to $b_1 = 30$

(b) Change the RHS of constraint 2 to $b_2 = 70$

(c) Change the RHS to $b_1 = 10$ and $b_2 = 100$

(d) Change the coefficient of x_3 in the objective function to $c_3 = 8$

(e) Change the coefficients of x_1 to $c_1 = -2$, $a_{11} = 0$, $a_{21} = 5$.

(f) Introduce a new variable x_6 with coefficients $c_6 = 10$, $a_{16} = 3$, $a_{26} = 5$.

(g) Change the coefficients of x_2 to $c_2 = 6$, $a_{12} = 2$, $a_{22} = 5$.

(h) Introduce a new constraint $2x_1 + 3x_2 + 5x_3 \le 50$.

(i) Change constraint 2 to $10x_1 + 5x_2 + 10x_3 \le 100$

3. Write the dual to the following problem and hence solve by dual simplex method.

Max $x_1 + x_2 + 3x_3$

$x_1 + x_2 + x_3 \le 10$

$2x_1 - x_3 \le 2$

$2x_1 - 2x_2 + 3x_3 \le 6$

$x_1, x_2, x_3 \ge 0$

6. Consider the following problem:

Maximize $Z = x_1 - x_2 + 2x_3$ subject to: (1) $2x_1 - 2x_2 + 3x_3 \le 5$; (2) $x_1 + x_2 - x_3 \le 3$; (3) $x_1 - x_2 + x_3 \le 2$; (4) $x_1, x_2, x_3 \ge 0$. A portion of the final simplex tableau is as follows:

Basic Variable	Z	x_1	x_2	x_3	x_4	x_5	x_6	RHS
Z	1				1	1	0	
x_2	0				1	3	0	
x_6	0				0	1	1	
x_3	0				1	2	0	

Use the fundamental insight to identify the missing numbers in the above table.

1. Solve the following problem either by Big method or by dual simplex method.

$Minimize \quad Z = 2x_1 + 2x_2 + 4x_3$

Subject to $2x_1 + 3x_2 + 5x_2 \geq 2$

$3x_1 + x_2 + 7x_3 \leq 3$

$x_1 + 4x_2 + 6x_3 \leq 5$

2. Find the solution of the following LPP by solving the dual problem

$Max \ x_0 = 2x_1 + 3x_2$

Subject to $-4x_1 + x_2 \leq 4$

$-5x_1 + 6x_2 \leq 30$

$-x_1 - 5x_2 \leq 30$

$x_1 + x_2 \geq 15$

$x_1 \geq 10$

$x_2 \geq 7$

$(x_2, x_2 \geq 0)$

4. Solve by Dual simplex method

Min $Z = 3x_1 + 2x_2 + x_3 + 4x_4$

Subject to constraint $2x_1 + 4x_2 + 5x_3 + x_4 \geq 10$

$3x_1 - x_2 + 7x_3 + 2x_4 \geq 2$

$5x_1 + 2x_2 + x_3 + 6x_4 \geq 24$

$x_1, x_2 x_3, x_4 \geq 0$

Solve the dual of the above by dual simplex method

E. TRANSPORTATION

1. A Company has factories at A,B, and C. while supply ware houses are at DEF and G monthly factory capacities are 160, 150 and 190 units respectively. Monthly warehouse requirements are 80,90,110 and 160 units respectively. Unit shipping costs are given in the table (in Rs). Determine the optimum distribution for this company to minimize shipping costs.

	TO			
	D	**E**	**F**	**G**
A	42	48	38	37
B	40	49	52	51
C	39	38	40	43

2. Solve the following transportation problem:

	D_1	D_2	D_3	D_4	**Supply**
O_1	2	2	2	1	**3**
O_2	10	8	5	4	**7**
O_3	7	6	6	8	**5**

Demand	**4**	**3**	**4**	**4**	

3. Solve the following assignment problem. The data given in the table refer to production in certain units.

Operator	Machine			
	A	**B**	**C**	**D**
1	10	5	7	8
2	11	4	9	10
3	8	4	9	7
4	7	5	6	4
5	8	9	7	5

4. A company has three factories at Amethi, Baghpat and Gwalior and four distribution centers at Allahabad, Mumbai, Kolkata and Delhi. With identical cost of production at the three factories the only variable cost involved is transportation cost. The production at three factories is 5,000 tonnes respectively. The transportation costs per tonne from different factories to different centers are given below.

Factory	Distribution centers			
	Allahabad	Mumbai	Kolkata	Delhi
Amethi	3	2	7	6
Baghpat	7	5	2	3
Gwalior	2	5	4	5

Suggest the optimum transportation schedule and fine the minimum cost of transportation.

3. Solve the following assignment problem.

	A	B	C	D	E
P	3	8	2	10	4
Q	8	7	5	6	9
R	7	8	4	9	6
S	8	6	3	5	7

5. Find the optimal assignment for the following problem :

	I	II	III	IV	V
1	11	17	8	16	20
2	9	7	12	6	15
3	13	16	15	12	16
4	21	24	17	28	25
5	14	10	12	11	15

6. Find the optimal solution for the assignment problem with the following cost matrix.

	I	**II**	**III**	**IV**	**V**
A	11	17	8	16	20
B	9	7	12	6	15
C	13	16	15	12	16
D	21	24	17	28	26
E	14	10	12	11	15

7. On a given day district Head Quarters has the Information that one ambulance is stationed at each of the five locations A,B,C,D and E.A dispatch order is to be issued for the ambulance van to reach 6 locations, Viz, I,II,III,IV,V and VI one each. The distance (Kms) between present locations of ambulance vans and destinations are given in the table below.

8. State the transportation problem in general terms and explain the conditions to solve the problem

9. Goods are to be supplied from warehouses W1, W2, W3 to six customers C1, C2, C3, C4, C5, and C6. The availability at the warehouses are 100,120 and 150 units respectively. While the demands of customers are 50, 40,50,90,60 7 80 units respectively. The unit costs of transportation are given in the following table.

		Customer					
		C1	C2	C3	C4	C5	C6
Ware House	W1	15	25	18	35	40	23
	W2	22	36	40	60	50	38
	W3	26	38	45	52	45	48

(a) Develop an optimum transportation schedule and given transportation cost. List possible to have more than one optimal schedule? If so at least one more optimum schedule.

10. A Company has factories at A,B, and C. while supply ware houses are at DEF and G monthly factory capacities are 160, 150 and 190 units respectively. Monthly warehouse requirements are 80, 90,110 and 160 units respectively. Unit shipping costs are given in the table (in Rs). Determine the optimum distribution for this company to minimize shipping costs.

	TO			
	D	**E**	**F**	**G**
A	42	48	38	37
B	40	49	52	51
C	39	38	40	43

11. There are four territories I,II,III and IV and there are four salesman A,B,C and D annual sales in territories I,II,III and IV are Rs.60,000-00 (6 in units of Rs.10,000),Rs. 50,000-00 (5 in units of Rs.10,000-00), Rs.40,000-00 (04 in units of Rs.10,000-00) and Rs.30,000-00 (03 in units of Rs.10,000-00) respectively. The sales proportions of A,B,C and D are 7,5,5 and 4 respectively. The effectiveness matrix ix given below.

Sales proportions		6	5	4	3 (sales in Rs.10,000-00)
		I	II	III	IV
7	A	42	35	28	21
5	B	30	25	20	15
5	C	30	25	20	15
4	D	24	20	16	12

Determine how the territories should be assigned to salesmen so that the sale is maximized

12. Solve the following assignment problem. The data given in the table refer to production in certain units.

Operator	Machine			
	A	**B**	**C**	**D**
1	10	5	7	8
2	11	4	9	10
3	8	4	9	7
4	7	5	6	4
5	8	9	7	5

13. A company has three factories at Amethi, Baghpat and Gwalior and four distribution centers at Allahabad, Mumbai, Kolkata and Delhi. With identical cost of production at the three factories the only variable cost involved is transportation cost. The production at three factories is 5,000 tonnes respectively. The transportation costs per tonne from different factories to different centers are given below.

Factory	Distribution centers			
	Allahabad	Mumbai	Kolkata	Delhi
Amethi	3	2	7	6
Baghpat	7	5	2	3
Gwalior	2	5	4	5

Suggest the optimum transportation schedule and fine the minimum cost of transportation.

1. Consider the transportation problem with the following parameter table:

Source\Destn	1	2	3	4	Supply
1	3	7	6	4	5
2	2	4	3	2	2
3	4	3	8	5	3
Demand	3	3	2	2	

Use the Northwest corner rule, Vogel's approximation method and Russell's approximation method to obtain an initial basic feasible solution. In each case apply the transportation simplex method starting with this initial solution to obtain an optimal solution. Compare the number of iterations.

2. Apply the Hungarian algorithm to solve the assignment problem having the following cost table:

Man\Job	1	2	3	4
A	4	6	5	5
B	7	4	5	6
C	4	7	6	4
D	5	3	4	7

14. Find the optimal assignment for the following problem :

	I	II	III	IV	V
1	11	17	8	16	20
2	9	7	12	6	15
3	13	16	15	12	16
4	21	24	17	28	25
5	14	10	12	11	15

15. A machine operator processes five types of items on his machine each week and must choose a sequence for them. The setup cost per change depends on the item presently on the machine and the setup to be made according to the following table:

		To items				
		A	B	C	D	E
From	A	∞	4	7	3	4
	B	4	∞	6	3	4
Item	C	7	6	∞	7	5
	D	3	3	7	∞	7
	E	4	4	5	7	∞

If he process each type of item once and only one each week, how should he sequence the items on his machine in order to minimize the total setup cost?

F. GAME THEORY

1. The following matrix represents the pay off of P1. find the optimal strategy of both and the value of the game

	1	2	3	4
1	3	2	4	0
2	3	4	2	4
3	4	2	4	0
4	0	4	0	8

2. Explain the following :
   a. Pure Strategy b) Mixed Strategy C) Saddle point

3. Solve the following 2 x 3 game

		B		
		I	II	III
A	I	1	3	11
	II	8	5	2

4. Solve the game whose pay off matrix is given below.

		B			
		I	II	III	III
A	I	2	2	3	-1
	II	4	3	2	6

5. Reduce the following game by dominance to 2 x 4 & hence solve graphically

8	15	-1	-2
19	15	17	16
0	20	15	5

6. Solve the game

	1	2	3	4	5
I	-2	0	0	4	3
II	4	2	1	5	5
III	-4	0	0	2	6
IV	5	2	-5	-3	-6

7. Explain (i) pure strategy ii) Two person zero-sum game iii) Mixed strategy
8. Explain the principles of Dominance
9. What are the basic assumptions made while solving problems in the game theory?
10. Explain clearly Min-max and Max-Min principle.
11. Explain the criterion of dominance of strategy in a game.
12. Solve the following transportation problem. The demand at destination 1 must be shipped only from source 4.

	D1	D2	D3	Availability
S1	5	1	0	20
S2	3	2	4	10
S3	7	5	2	15
S4	9	6	0	15
Requirement	5	10	15	

13. Explain the principle of dominance in Game Theory and solve the below game

8	10	9	14
10	11	8	12
13	12	14	13

G. METAHEURISTICS

1. Describe the Tabu search algorithm
2. Describe the genetic algorithm and compare it with the other algorithms.

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