Time: 3 Hours **Total Marks: 100**

N.B. 1. All questions are compulsory.
2. Figures to the right indicate full marks.
3. Use of non-programmable calculator is allowed.
4. Graph papers will be provided on request.

Q.1 (a) Choose correct Answer for the following (ANY FIVE) **(10)**

i. The best use of linear programming technique is to find an optimal use of **(2)**
a) money b) manpower
c) machine d) all of the above

ii. While solving LPP graphically, the area bounded by constraints is called- **(2)**
a) Feasible region b) infeasible region
c) unbounded region d) none of the above

iii. For maximization LP model, the simplex method is terminated when all values **(2)**
a) $c_j - z_j \leq 0$ b) $c_j - z_j \geq 0$
c) $c_j - z_j = 0$ d) $z_j \leq 0$

iv. The dummy source or destination in a transportation problem is added to **(2)**
a) satisfy rim condition b) prevent solution from becoming degenerate
c) ensure that total cost does not exceed a limit d) none of the above

v. If an opportunity cost value is used for an unused cell to test optimality, it should be **(2)**
a) equal to zero b) most negative number
c) most positive number d) any value

vi. The Hungarian method for solving an assignment problem can also be used to solve **(2)**
a) a transportation problem b) a travelling salesman problem
c) both (a) and (b) d) only (b)

vii. If the job is performed on two machines M_1 and M_2 in the order M_1M_2, then the difference between total elapsed time and the time when last job in sequence finishes on M_1 is **(2)**
a) idle time for machine M_2 b) total elapsed time for machine M_1
c) idle time for machine M_1 d) total elapsed time for machine M_2

Q.1 (b) Answer the following in one/ two sentences (ANY FIVE) **(10)**

i. When do we get unbounded solution in graphical method of L.P.P.? **(2)**

ii. What is meant by decision variables in linear programming problem? **(2)**

iii. When does the alternate solution exist in a Transportation problem? **(2)**

iv. In a transportation problem, each destination must be supplied by one and only one source. Is the statement true? Correct if necessary. **(2)**

v. What is prohibited assignments in assignment problem? **(2)**

vi. Define total elapsed time in sequencing problem for n jobs on 2 machines. **(2)**

vii. Give one example of Sequencing problem. **(2)**

Q2 Attempt Any Two sub-questions: **(20)**

(a) Write the mathematical form of a Linear programming problem. Explain the following terms for a Linear programming Problem(L.P.P.) **(10)**

(1) Basic feasible solution

(2) Optimum basic feasible solution

(3) Slak variable and surplus variable.

(b) (i) Write the dual of the following primal LP problem- **(06)**

Maximize $Z = 2x_1 + 5x_2 + 6x_3$

subject to constraints:

$$5x_1 + 6x_2 - x_3 \leq 3$$
$$-2x_1 + x_2 + 4x_3 \leq 4$$
$$x_1 - 5x_2 + 3x_3 \leq 1$$
$$-3x_1 - 3x_2 + 7x_3 \leq 6$$
$$x_1, x_2, x_3 \geq 0.$$

(ii) What are 'Artificial variable'? Why is it necessary to introduce it in L.P.P.? **(04)**

(c) Two nutrients V_1 and V_2 are found in two foods A and B. One unit of A contains 15 units of V_1 and 20 units of V_2. One unit of B contains 12 units of V_1 and 40 units of V_2. Minimum daily requirement of V_1 and V_2 is 120 and 240 units respectively. Cost per unit of A and B is Rs. 4 and Rs. 6 respectively. **(10)**

Formulate as LPP and solve by graphical method to obtain optimal solution.

Q3 Attempt Any Two sub-questions: **(20)**

(a) A cement company has three factories manufacturing cement which is then transported to four distribution centers. The quantity of monthly production of each factory, the demand of each distribution centre and the associated transportation cost per quintal are given as follows. **(10)**

Factories	Distribution centers				Monthly production (in quintals)
	W	X	Y	Z	
A	10	8	5	4	7000
B	7	9	15	8	8000
C	6	10	14	8	10000
Monthly demand (in quintals)	6000	6000	8000	5000	

Find initial basic feasible solution by Vogel's Approximation method.

Test the initial basic feasible solution for optimality and if required improve it to optimality .

Calculate minimum total transportation cost.

(b) (i) What is an Unbalanced transportation Problem? Explain how to solve unbalanced transportation problem of maximization type. **(05)**

(ii) Obtain an initial basic feasible solution to the following transportation problem using - **(05)**

(1) North-west corner rule

(2) Matrix minima method (Lowest cost method)

Source	Destination					Supply
	A_1	B_1	C_1	D_1	E_1	
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	21

(c) Describe the Transportation problem. Explain the matrix form of transportation problem with 3 origins and 4 destinations. **(10)**

What is degeneracy in transportation problem? How it can be resolved?

Q4 Attempt Any Two sub-questions: **(20)**

(a) What is an assignment problem? Give two examples. **(10)**

Explain the Hungarian method to solve an assignment problem.

(b) (i) A computer centre has got four expert programmers. The centre needs four application programmes to be developed. The head of the computer centre, after studying carefully the programmes to be developed, estimates the computer time in minutes required by the respective experts to develop the application programmes as follows:- **(04)**

Programmers	Programmes			
	A	B	C	D
1	120	100	80	90
2	80	90	110	70
3	110	140	120	100
4	90	90	80	90

Find the assignment which minimizes total computer time required to develop the application programme. Also give the total time taken in completing the task.

(ii) A sales manager has to assign salesman to four territories. He has four candidates of varying experience and capabilities. The manager assesses the possible profit for each salesman in each territory as given below: **(06)**

Salesman	Territory			
	T_1	T_2	T_3	T_4
S_1	35	27	28	37
S_2	28	34	29	40
S_3	35	24	32	33
S_4	24	32	25	28

Find the assignment of salesman to the territories so that total profit is maximum.

(c) What is no passing rule in sequencing problem? **(10)**

Find the sequence that minimizes the total time required in performing the following jobs on three machines in the order ABC. Processing times (in hours) are given in the following table. Find the total elapsed time. Also obtain idle time on three machines.

Processing time on machines	Jobs				
	1	2	3	4	5
Machine A	8	10	6	7	11
Machine B	5	6	2	3	4
Machine C	4	9	8	6	5

Q5 Attempt Any Two sub-questions: **(20)**

(a) (i) Use simplex method to solve the following L.P.P. **(07)**

$$\text{Maximize } Z = 100x_1 + 80x_2$$

Subject to the constraints:

$$6x_1 + 4x_2 \leq 7200$$
$$2x_1 + 4x_2 \leq 4000$$
$$x_1, x_2 \geq 0$$

(ii) What are key column, key row and key element in a simplex table? **(03)**

(b) Explain- (i) Least Cost method (Matrix minima method) **(10)**

(ii) Vogel's Approximation method to obtain initial basic feasible solution for a transportation problem.

(c) (i) Explain the travelling salesman problem. **(05)**

(ii) Determine a sequence that minimizes the total elapsed time required to complete the following tasks. Also find the total elapsed time. **(05)**

Tasks	1	2	3	4	5	6	7
Machine A	3	12	15	6	10	11	9
Machine B	8	10	10	6	12	1	3

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