25P205 (Pages: 2) Name: ……………………………

Reg. No: ………………………..

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2026

(CBCSS - PG)

(Regular/Supplementary/Improvement)

CC19PMTH2C10 – OPERATIONS RESEARCH

(Mathematics)

(2019 Admission onwards)

Time: Three Hours Maximum:30 Weightage

PART A

Answer ***all*** questions. Each question carries 1 weightage.

1. Define concave function. Give one example for concave function.
2. Prove that $f(X) = x_1^2 + x_2^2 + 4x_3^2 - 2x_1x_2$ is a convex function.
3. Define the term cost coefficients associated with a linear programming problem.
4. If $f(X)$ is minimum at more than one of the vertices of S_F, then show that it is minimum at all those points which are the convex linear combination of these vertices.
5. Write the dual of the following LP problem.

   Minimize $x_1 - 3x_2 - 2x_3$

   Subject to $2x_1 - 4x_2 \geq 12, 3x_1 - x_2 + 2x_3 \leq 7, -4x_1 + 3x_2 + 8x_3 = 10,$

   $x_1 \geq 0, x_2 \geq 0, x_3$ unrestricted
6. Prove that the dual of the dual is primal.
7. Briefly describe degeneracy in transportation problem.
8. Describe dominance in Game Theory.

(8 × 1 = 8 Weightage)

PART B

Answer any ***two*** questions from each unit. Each question carries 2 weightage.

UNIT I

9. Let $f(X)$ be defined in a convex domain $K \subseteq E_n$ and be differentiable. State and prove the necessary and sufficient condition for $f(X)$ to be a convex function.
10. Prove that a vertex S_F is a basic feasible solution of the LP problem.
11. Explain the method of simplex multipliers for finding the optimal solution of linear programming problem.

UNIT II

12. If the primal problem is feasible prove that it has an unbounded minimum if and only if the dual has no feasible solution.

13. Solve by the dual simplex method.

Minimize $f = 3x_1 + 5x_2 + 2x_3$

Subject to $-x_1 + 2x_2 + 2x_3 \geq 3, x_1 + 2x_2 + x_3 \geq 2, -2x_1 - x_2 + 2x_3 \geq -4,$

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

14. Prove that the transportation problem has a triangular basis.

UNIT III

15. Explain cutting plane method in integer linear programming.

16. Find the maximum non-negative flow in the network described below, arc (v_j, v_k) being denoted as $(j, k), v_a$ is the source and v_b the sink

Arc :	(a, 1)	(a, 2)	(1,2)	(1,3)	(1,4)	(2,4)	(3,2)	(3,4)	(4,3)
Capacity :	8	10	3	4	2	8	3	4	2
Arc :	(3, b)	(4, b)							
Capacity :	10	9							

17. State and prove the fundamental theorem of rectangular games.

(6 × 2 = 12 Weightage)

PART C

Answer any ***two*** questions. Each question carries 5 weightage.

18. Solve by Simplex Method.

Maximize $2x_1 + 3x_2 + 5x_3$

Subject to $x_1 + x_2 - x_3 \geq -5, -6x_1 + 7x_2 - 9x_3 \leq 4,\ x_1 + x_2 + 4x_3 \leq 10,$

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

19. Solve the following transportation problem for minimum cost.

	D_1	D_2	D_3	
O_1	4	5	2	30
O_2	4	1	3	40
O_3	3	6	2	20
O_4	2	3	7	60
	40	50	60	

20. a) Describe the effect of deletion of constraints in the optimal solution of an LP problem.

b) Describe parametric linear programming.

21. Solve graphically the matrix game with pay off matrix $\begin{bmatrix} 1 & -1 & 2 \\ 2 & 3 & 1 \end{bmatrix}$.

(2 × 5 = 10 Weightage)

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