D 140691 **(Pages : 3)** **Name.................................**

Reg. No...............................

SECOND SEMESTER M.Sc. (CBCSS) REGULAR/SUPPLEMENTARY DEGREE EXAMINATION, APRIL 2026

Mathematics

MTH 2C 10—OPERATIONS RESEARCH

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Part A

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

1. Show that the sum of two convex functions is a convex function.
2. Determine the maximum number of possible basic solutions to the problem :

Maxmize $4x_1 + 3x_2$

subject to
$$3x_1 + 2x_2 \le 10$$
$$5x_1 + x_2 \le 9$$
$$x_1 \ge 0, x_2 \ge 0.$$

3. What is meant by degeneracy in a linear programming problem ?
4. Prove that the dual of the dual is the primal.
5. Briefly describe about the transportation matrix associated with a transportation problem.
6. What is meant by a mixed integer linear programming problem ?
7. Describe the effect of introducing new constraint on the optimal solution of an LP problem.
8. Briefly describe a zero-sum two-person game.

(8 × 1 = 8 weightage)

Part B

Answer any **six** *questions by choosing* **two** *questions from each unit.*
Each question carries a weightage of 2.

Unit I

9. Let $f(X)$ be defined in a convex domain $K \subseteq E_n$ and be differentiable. Prove that $f(X)$ is a convex function if and only if $f(X_2) - f(X_1) \ge (X_2 - X_1)' \nabla f(X_1)$ for all X_1, X_2 in K.

Turn over

10. Show graphically that the problem:

$$\begin{aligned} &\text{Maximize } 3x_1 + 4x_2 \\ &\text{subject to } 4x_1 + 3x_2 \geq 12 \\ &\qquad x_1 + 2x_2 \leq 2 \\ &\qquad x_1 \geq 0, x_2 \geq 0. \end{aligned}$$

has no feasible extreme points.

11. What is meant by simplex multipliers ? Explain with a suitable example.

Unit II

12. If the primal problem is feasible, then prove that it has an unbounded optimum if and only if the dual has no feasible solution and vice versa.

13. There are forest areas F_1, F_2, F_3, F_4 and timber depots D_1, D_2, D_3. The following table gives the produce of each forest area, the minimum timber required at each depot to attract buyers, and the cost of transportation per unit of timber from each forest area to each depot. Find the distribution of the entire forest produce for minimum cost of transportation.

	D_1	D_2	D_3	
F_1	3	4	6	100
F_2	7	3	8	80
F_3	6	4	5	90
F_4	7	5	2	120
	110	110	60	

14. Briefly describe the Caterer problem.

Unit III

15. Tasks A, B, … H. I constitute a project. The notation X < Y means that the task X must be finished before Y can begin. With this notation

A < D, A < E, B < F, D < F, C < G, C < H, F < I, G < I.

Find the minimum time of completion of the project.

16. Briefly describe about parametric linear programming.

17. Solve the game with the payoff matrix

$$\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}.$$

(6 × 2 = 12 weightage)

Part C

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

18. (a) Let $K \subseteq E_n$ be a convex set $X \in K$ and $f(X)$ a convex function. If $f(X)$ has a relative minimum, then prove that it is also a global minimum.

    (b) Solve the following problem using Simplex method :

$$\begin{aligned} &\text{Maximize } 5x_1 + 3x_2 + x_3 \\ &\quad \text{subject to } \; 2x_1 + x_2 + x_3 = 3 \\ &\qquad\qquad\quad -x_1 + 2x_3 = 4 \\ &\qquad\qquad\quad x_1, x_2, x_3 \geq 0. \end{aligned}$$

19. (a) Briefly describe the applications of duality in linear programming.

    (b) Prove that the transportation problem has a triangular basis.

20. (a) Define the spanning tree of a connected graph.

    (b) Prove that for an $m \times n$ matrix game, both $\max_X \min_Y E(X, Y)$ and $\min_Y \max_X E(X, Y)$ exist and are equal.

21. Solve the following problem by cutting plane method :

$$\begin{aligned} &\text{Minimize } -2x_1 - 3x_2 \\ &\quad \text{subject to } \; 2x_1 + 2x_2 \leq 7 \\ &\qquad\qquad\quad 0 \leq x_1 \leq 2 \\ &\qquad\qquad\quad 0 \leq x_2 \leq 2 \\ &\qquad\qquad\quad x_1, x_2 \text{ integers.} \end{aligned}$$

(2 × 5 = 10 weightage)

D 140691-A **(Pages : 4)** **Name..................................**

Reg. No................................

SECOND SEMESTER M.Sc. (CBCSS) REGULAR/SUPPLEMENTARY DEGREE EXAMINATION, APRIL 2026

Mathematics

MTH 2C 10—OPERATIONS RESEARCH

(2019 Admission onwards)

(Multiple Choice Questions for SDE Candidates)

Time : 20 Minutes	**Total No. of Questions : 20**	**Maximum : 5 Weightage**

INSTRUCTIONS TO THE CANDIDATE

1. This Question Paper carries Multiple Choice Questions from 1 to 20.
2. The candidate should check that the question paper supplied to him/her contains all the 20 questions in serial order.
3. Each question is provided with choices (A), (B), (C) and (D) having one correct answer. Choose the correct answer and enter it in the main answer-book.
4. The MCQ question paper will be supplied after the completion of the descriptive examination.

MTH 2C 10—OPERATIONS RESEARCH

(Multiple Choice Questions for SDE Candidates)

1. In a Linear Programmng Problem, the constraints are :

   (A) Linear. (B) Quadratic.

   (C) Cubic. (D) Contants.

2. An $\in$-*nbd* of $x_0 \in R^1$ is :

   (A) $\{x_0\}$. (B) $(x_0 - \in, x_0 + \in)$.

   (C) $(x_0 + \in, x_0 - \in)$. (D) $(-\in, \in)$.

3. An optimum solution to the General Linear Programming Problem is :

   (A) Any feasible solution to a General L.P.P.

   (B) Any feasible solution which optimizes the objective function.

   (C) Any solution to a General L.P.P. which satisfies the non-negative restrictions.

   (D) A particular solution to a General L.P.P. which satisfies the non-negative restrictions.

4. The canonical form of L.P.P. is :

   (A) Maximize $z = c^T x$ subject to cosntraints : A $x \geq b$, $x \geq 0$.

   (B) Maximize $z = c^T x$ subject to cosntraints : A $x \leq b$, $x \geq 0$.

   (C) Minimize $z = c^T x$ subject to cosntraints : A $x = b$, $x \geq 0$.

   (D) Maximize $z = c^T x$ subject to cosntraints : A $x = b$, $x \leq 0$.

5. A degenerate solution to the system A$x = b$ is :

   (A) A basic solution with one or more basic variables vanish.

   (B) A solution with one or more basic variables vanish.

   (C) A particular solution with one or more basic variables vanish.

   (D) A basic solution with no basic variables vanish.

6. A feasible solution to an L.P.P. which is also a basic solution to the problem is called :

   (A) An optimum solution to the L.P.P.

   (B) An standard solution to the L.P.P.

   (C) An basic feasible solution to the L.P.P.

   (D) An feasible solution to the L.P.P.

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7. Big M method is used to solved an L.P.P., if it contains :
   (A) Artificial variables. (B) Variables.
   (C) Surplus variables. (D) Slack variables.
8. A variable x is called unrestricted if :
   (A) x is zero only. (B) x is negative only.
   (C) x is positive, negative or zero. (D) x is positive only.
9. If A is the constraint coefficient matrix associated with primal and B is the constraint coefficient matrix associated with dual, then :
   (A) $B = A^T$. (B) $B = A$.
   (C) $B = A^{-1}$. (D) $A = B^{-1}$.
10. The dual of dual problem is :
    (A) The unsymmetric dual problem.
    (B) The unsymmetric primal problem.
    (C) The dual problem.
    (D) The primal problem.
11. A system of n linear equations $Ax = b$ is called a triangular system if the matrix A is :
    (A) Unit matrix. (B) Zero matrix.
    (C) Diagonal matrix. (D) Triangular matrix.
12. An initial feasible solution to a T.P. is obtained by :
    (A) Method of penalties. (B) North-West corner rule.
    (C) Two-phase simplex method. (D) Big M method.
13. An initial basic feasible solution to a T.P. is obtained by :
    (A) Method of penalities. (B) Column minima method.
    (C) Two-phase simplex method. (D) Big M method.
14. An L.P.P. can be solved using graphical method if it has :
    (A) More than four variables. (B) Only two variables.
    (C) More than two variables. (D) Three variables.

15. In a Linear Programming Problem, all the variables are :

    (A) Non-negative. (B) Negative.

    (C) 0. (D) None of the above.

16. The simplex method is :

    (A) An iterative method.

    (B) A direct method.

    (C) Both direct and iterative method.

    (D) None of the above.

17. In the iteration of simplex method, if there are more than one negative $z_j - c_j$, then we may choose :

    (A) The most negative of them. (B) The largest of them.

    (C) Any one of them. (D) None of the above.

18. If for every pair of vertices, there is a chain connecting the two, then the graph is said to be :

    (A) Tree. (B) Arborescence.

    (C) Cycle. (D) Connected.

19. If we delete an arc from a tree, the resulting graph is :

    (A) Connected. (B) Strongly connected.

    (C) Not connected. (D) A tree.

20. A tree with a centre is called :

    (A) An arborescence. (B) A cycle.

    (C) A circuit. (D) A chain.