M.Sc. 4th Semester Examination, 2025

APPLIED MATHEMATICS

[Lab : *Operations Research*]

[Practical]

PAPER — MTM-497(A)

Full Marks : 25

Time : 2 hours

Answer from **both** Groups

The figures in the right hand margin indicate marks

The questions are to be selected by lottery.

GROUP—A

Answer **one** question :　　　　　　6 × 1

1. Write a code in LINGO to find Nash equilibrium strategy and Nash equilibriam outcome of the following bi-matrix game.

$$A = \begin{bmatrix} 8 & 0 \\ 30 & 2 \end{bmatrix} \quad B = \begin{bmatrix} 8 & 30 \\ 0 & 2 \end{bmatrix}$$

2. Write a code in LINGO to solve the following Geometric Programming Problem.

Minimize $f(x) = 5x_1 x_2^{-1} x_3^2 + x_1^{-2} x_2^{-1} + 10x_2^2 + 2x_1^{-1} x_2 x_3^{-2}$

$$x_1, x_2, x_3 > 0.$$

3. Write a code in LINGO to solve the following Stochastic Programming Problem.

A manufacturing firm produces two machines' parts using lathes, milling machines and grinding machines. The machining times required on different machines for each part

and the profit on machine part are given below. If the machining times available on different machines are probabilistic (normally distributed) with parameters as given in the following table, find the number of machine parts I and II to be manufactured per week to maximize the profit. The constraint have to be satisfied with a probability of at least 0.99.

Type of Machine	Machining time required per piece (minutes)		Maximum time available per week (minutes)	
	Part-I	Part-II	Mean	Standard deviation

Lathes $\qquad$ $a_{11} = 10$ $a_{12} = 5$ $b_1 = 2500$ $\sigma_{b1} = 500$

Milling Machines $a_{21} = 4$ $a_{22} = 10$ $b_2 = 2000$ $\sigma_{b2} = 400$

Grinding Machines $a_{31} = 1$ $a_{32} = 1.5$ $b_3 = 450$ $\sigma_{b3} = 50$

Profit per unit (Rs.) $\quad c_1 = 50$ $\qquad c_2 = 100$

4. Write a code in LINGO to solve the following QPP using Wolfe's modified simplex method.

$$\text{Max } Z = 2x_1 + x_2 - x_1^2$$

$$\text{Subject to,} \quad 2x_1 + 3x_2 \le 6$$
$$2x_1 + x_2 \le 4$$
$$x_1, x_2 \ge 0.$$

5. Write a code in LINGO and then to solve the following fuzzy LPP.

$$\text{Max } Z = \tilde{3}x_1 + \tilde{4}x_2$$

$$\text{Subject to,} \quad x_1 + x_2 \le 10$$
$$2x_1 + 3x_2 \le \widetilde{18}$$
$$x_1 \le 8$$
$$x_2 \le 6$$
$$x_1, x_2 \ge 0.$$

Here, $\tilde{3}$, $\tilde{4}$ and $\widetilde{18}$ are symmetric triangular fuzzy numbers with spread 1.5.

6. Write a code in LINGO and then to the following Stochastic Programming Problem.

    A manufacturing firm produces two machines parts using lathes, milling machines and grinding machines. The machining times available per week on different machines and the machining times required on different machines for each part are given below. Assuming that the profit per unit of each of the machine parts I and II is a normally distributed random variable, find the number of machine parts to be manufactured per week to maximize the profit. The mean value and standard deviation of profit are Rs. 50 and 20 per unit for part I and Rs. 100 and 50 per unit for part II.

Type of Machine	Machining time required per piece (minutes)		Maximum time available per week (minutes)
	Part-I	Part-II	
Lathes	$a_{11} = 10$	$a_{12} = 5$	$b_1 = 2500$
Milling Machines	$a_{21} = 4$	$a_{22} = 10$	$b_2 = 2000$
Grinding Machines	$a_{31} = 1$	$a_{32} = 1.5$	$b_3 = 450$

7. Write a code in LINGO to solve the following goal programming problem :

$$\text{Min } Z = P_1 u_1 + P_2(u_2 + O_2) + P_3 u_3$$

$$\text{Subject to } 8x_1 + 6x_2 + u_1 - O_1 = 36$$
$$x_1 - 2x_2 + u_2 - O_2 = 0$$
$$2x_1 + 4x_2 + u_3 = 20$$
$$3x_1 + 4x_2 + u_4 = 24$$
$$x_1, x_2, u_1, u_2, u_3, u_4, O_1, O_2 \geq 0.$$

(*Continued*)

8. Write a code in LINGO to solve the following LPP.

$$\text{Max } Z = 61x_1 + 209x_2 + 324x_3 + 33x_4 + 276x_5$$
$$+ 285x_6 + 250x_7 + 100x_8 + 12x_9 + 282x_{10}$$

Subject to constraints

$$16x_1 + 25x_2 + 22x_3 + 4x_4 + 9x_5 + 8x_6 + 11x_7$$
$$+ 29x_8 + 20x_9 + 22x_{10} \le 18$$

$$5x_1 + 22x_2 + 15x_3 + 30x_4 + 24x_5 + 15x_6 + 14x_7$$
$$+ 28x_8 + 31x_9 + 25x_{10} \le 53$$

$$22x_1 + 17x_2 + 9x_3 + 32x_4 + 26x_5 + 20x_6 + 16x_7$$
$$+ 16x_8 + 26x_9 + 24x_{10} \le 50$$

$$32x_1 + 30x_2 + 10x_3 + 30x_4 + 7x_5 + 29x_6 + 15x_7$$
$$+ x_8 + 2x_9 + 23x_{10} \le 4$$

$$14x_1 + 9x_2 + 32x_3 + 22x_4 + 30x_5 + 18x_6 + 18x_7$$
$$+ 32x_8 + 15x_9 + x_{10} \le 40$$

$$12x_1 + 4x_2 + 30x_3 + 11x_4 + 23x_5 + 29x_6 + 8x_7$$
$$+ 2x_8 + 23x_{10} \le 31$$

$$22x_1 + 23x_2 + 26x_3 + 13x_4 + 6x_5 + 13x_6 + 32x_7$$
$$+ 11x_8 + 8x_9 + 5x_{10} \le 39$$

$0 \le X \le U$ where $U^T = (0.125, \; 0.133, 0.04,$
$0.133, 0.571, 0.138, 0.266, 0.62,$
$0.21, 0.153)$

GROUP—B

Answer **one** question : 9×1

9. Write a code in MATLAB to solve the following LPP using simplex method.

$$\text{Max } Z = 1200x_1 + 1300x_2 + 1300x_3 + 1200x_4$$
$$+ 899x_5 + 999x_6 + 899x_7 + 1099x_8$$

Subject to $12x_1 + 13x_2 + 13x_3 + 12x_4 +$
$$9x_5 + 10x_6 + 9x_7 + 11x_8 \le 39$$

$$x_1 + x_2 + x_3 + x_4 + 0x_5 + x_6 + x_7 + x_8 \le 3$$
$$x_1 + x_2 + x_3 + x_4 + x_5 + 0x_6 + x_7 + x_8 \le 3$$
$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + 0x_7 + x_8 \le 3$$
$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + 0x_8 \le 3$$
$$0 \le x_i \le 1 \text{ for } 1, 2, \ldots\ldots, 8$$

(*Continued*)

10. Write a code in MATLAB to find the Nash equilibrium strategy and Nash equilibrium outcome of the following bi-matrix game.

$$A = \begin{bmatrix} 1 & 0 \\ 2 & -1 \end{bmatrix} \quad B = \begin{bmatrix} 3 & 2 \\ 0 & 1 \end{bmatrix}$$

11. Write a code in MATLAB to solve the following Stochastic Programming Problem.

A manufacturing firm produces two machines' parts using lathes, milling machines and grinding machines. The machining times available per week on different machines and the profit on machine part are given below. The machining times required on different machines for each part are not known precisely (as they vary from worker to worker) but are known to follow normal distribution with mean and standard deviations as indicated in the following table.

Type of Machine	Machining time required per unit (minutes)				Maximum time available per week (minutes)
	Part-I		Part-II		
	Mean	Standard deviation	Mean	Standard deviation	

Lathes $\bar{a}_{11} = 10$ $\sigma_{a11} = 6$ $\bar{a}_{12} = 4$ $\sigma_{a12} = 4$ $b_1 = 2500$

Milling machines $\bar{a}_{21} = 4$ $\sigma_{a21} = 6$ $\bar{a}_{22} = 10$ $\sigma_{a22} = 7$ $b_2 = 2000$

Grinding machines $\bar{a}_{31} = 1$ $\sigma_{a31} = 2$ $\bar{a}_{32} = 1.5$ $\sigma_{a31} = 3$ $b_3 = 450$

Profit per unit (Rs) $c_1 = 50$ $\qquad$ $c_2 = 100$

Determine the number of machine parts I and II to be manufactured per week to maximize the profit without exceeding the available machining times more than once in 100 weeks.

12. Write a code in MATLAB to solve the following Geometric Programming Problem.

Minimize $f(x) = 7x_1x_2^{-1} + 7x_2x_3^{-2} + 5x_1^{-3}x_2x_3$
$$+ x_1x_2x_3$$
$$x_1, x_2, x_3 > 0.$$

13. Write a code in MATLAB to solve the following QPP using Wolfe's modified simplex method.

Max $Z = 18x_1 + 3x_2 - 0.001x_1^2 - 0.005x_2^2 - 100$

Subject to, $2x_1 + 3x_2 \le 2500$
$$x_1 + 2x_2 \le 1500$$
$$x_1, x_2 \ge 0.$$

14. Write a code in MATLAB to solve the following Goal Programming problem.

$$\text{Min } Z = P_1\,(2d_2^- + 3d_3^-) + P_2 d_1^-$$

$$\text{Subject to} \quad 20x_1 + 10x_2 \le 60$$
$$10x_1 + 10x_2 \le 40$$
$$30x_1 + 60x_2 + d_1^- - d_1^+ = 600$$
$$x_1 + d_2^- - d_2^+ = 4$$
$$x_2 + d_3^- - d_3^+ = 4$$
$$x_1, x_2, d_i^-, d_i^+ \ge 0, \quad i = 1, 2, 3.$$

15. Write a code in MATLAB to solve the following fuzzy LPP using simplex method.

$$\text{Max } Z = \tilde{2} x_1 + \tilde{3} x_2 - \tilde{1} x_3$$

$$\text{Subject to,} \quad 2x_1 + 5x_2 - x_3 \le 5$$
$$x_1 + x_2 + 2x_3 = \tilde{6}$$
$$2x_1 - x_2 + 3x_3 = 7$$
$$x_1, x_2 \ge 0.$$

Here, $\tilde{2}$, $\tilde{3}$, and $\tilde{1}$, $\tilde{6}$ are symmetric triangular fuzzy numbers with spread 2.

(Continued)

16. Laboratory Note Book.   5

17. Viva.   5