Ref. No. : Ex/PG/MEC/PC/T/114E/2025

M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER EXAMINATION – 2025

Subject: INDUSTRIAL OPERATIONS RESEARCH Time: 3 Hours Full Marks: 100

(Answer any **FOUR** questions)

1a) What do you mean by 'initial basic feasible solution'? How will you to determine initial basic feasible solution of a Linear Programming Problem (LPP) ? (3+4)

b) Use Simplex method to solve the following LPP: (18)

Maximize $z = 20x_1 + 6x_2 + 8x_3$

Subject to the constraints:

$$8x_1 + 2x_2 + 3x_3 \leq 250$$

$$4x_1 + 3x_2 \leq 150$$

$$2x_1 + x_3 \leq 50$$

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

2a) Explain the term 'degeneracy' with reference to LPP. How can the problem of degeneracy be solved in LPP ? (3+4)

b) Use Big-M method to solve the following LPP: (18)

Maximize $z = 2x_1 + x_2 + 3x_3$

Subject to the constraints:

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

$$2x_1 + 3x_2 + 4x_3 = 12$$

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

3a) A company makes three products X, Y and Z out of three materials M1, M2 and M3. The three products use units of the three materials according to the following table: (6)

	M1	M2	M3
X	1	2	3
Y	2	1	1
Z	3	2	1

The unit profit contribution of three products X, Y and Z are Rs. 3, Rs. 4 and Rs. 5 respectively and the availabilities of the three materials M1, M2 and M3 are 10 units, 12 units and 15 units respectively. Formulate the above problem into LPP which maximizes the total profit.

b) Prove that the dual of dual is primal. (7)

c) Minimize $z = 2x_1 + 3x_2 + 4x_3$ (12)

Subject to the constraints:

$$2x_1 + 3x_2 + 5x_3 \geq 2$$

$$3x_1 + x_2 + 7x_3 = 3$$

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

$x_1, x_2 \geq 0$ and x_3 is unrestricted

4a) Considering necessary assumptions derive the expression that there are n customers in the system for (M/M/1) : (α/FIFO) queuing model. (16)

b) In a railway marshaling yard, goods trains arrive at a rate of 30 trains per day. Assuming that the inter-arrival time followings an exponential distribution and service time distribution is also exponential with an average 36 minutes, calculate the followings: (9)

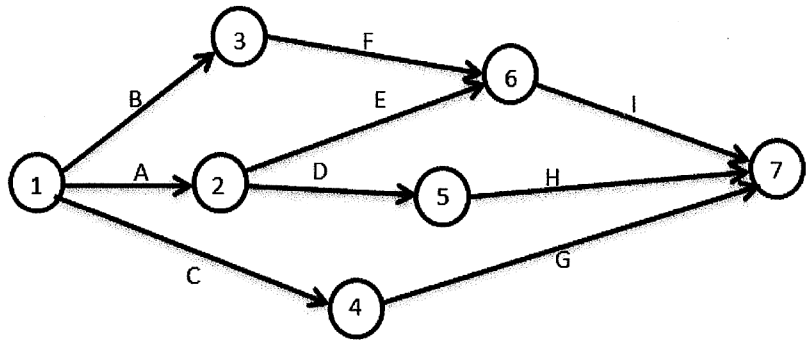
(i) The mean queue size

(ii) The probability that queue size exceeds 6

(iii) Expected waiting time in the queue

5) The network diagram shown below has the following data: (25)

Activities	A	B	C	D	E	F	G	H	I
Least Time (days)	5	18	26	16	15	6	7	7	3
Greatest Time (days)	10	22	40	20	25	12	12	9	5
Most likely Time (days)	8	20	33	18	20	9	10	8	4



Determine the followings:

(a) Expected activity times and their variances

(b) The earliest and latest expected times to reach each node

(c) The critical path and its duration

(d) If the completion time is 41.5 days, calculate the probability of completing the project

(e) What should be the completion time if the probability of completing the project is 95%

6) Consider the following objective function and find optimum solution of the problem using Particle Swarm Optimization (PSO) algorithm. Assume suitable control parameters with swarm size 5 and computations are to be done till 4 iterations. (25)

The objective function : Maximize $f(x) = 2 + 3x - x^2$

7) a) Prove that inter-arrival time for a queuing model follows exponential distribution. (5)

b) Explain the Particle Swarm Optimization (PSO) algorithm. Mention its parameters and their significance. (5)

c) "Classical optimization techniques are not suitable for multimodal objective function but metaheuristics are very efficient" – Explain. (5)

d) Explain free float and independent float. (5)

e) What do you mean by 'Metaheuristic'. Explain briefly about evolutionary algorithms and their classifications. (5)