

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI  
(END SEMESTER EXAMINATION)**

**CLASS: B.TECH.  
BRANCH: CHEMICAL ENGINEERING**

**SEMESTER : VII  
SESSION : MO/2025**

**SUBJECT: CL407 PROCESS MODELING, SIMULATION AND OPTIMIZATION**

**TIME: 3 Hours**

**FULL MARKS: 50**

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
  2. Attempt all questions.
  3. The missing data, if any, may be assumed suitably.
  4. Before attempting the question paper, be sure that you have got the correct question paper.
  5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.
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|---|------|----|----|
| Q.1(a) Consider a tubular reactor in which a first order homogeneous reaction takes place $A \rightarrow B$ . Density, velocity and concentration all vary with time and axial position. Assume plug-flow conditions and develop a mathematical model for this system.  | [5]  | 1  | 3  |
| Q.1(b) Surge tanks are generally used to dampen pressure fluctuations caused by erratic operations of large air compressors. Figure shows one such configuration with two surge tanks and air is supplied to a process furnace. If the discharge pressure of the compressor is $P_d(t)$ and the operating pressure of the furnace is $P_f$ (constant), develop a dynamic model for the pressures in the two surge tanks. Assume ideal gas law holds. Use the relation, flow = driving force/resistance. $R_a$ , $R_b$ and $R_c$ are resistances across the valves. $w_a$ , $w_b$ and $w_c$ are mass flow rates. | [5]  | 1  | 3  |
|   |      |    |    |
| Q.2(a) Minimize the function,   | [5]  | 3  | 3  |
| $f(x) = (100 - x)^2$  |      |    |    |
| Q.2(b) Minimize the function,   | [5]  | 3  | 3  |
| $f(x) = x^2 - \frac{25}{x}$   |      |    |    |
| Using interval halving Method in the interval [60,150]. Perform only two iterations.  |      |    |    |
| Using Newton's Method. Perform two iterations with the initial point as 2.  |      |    |    |
| Q.3(a) Minimize the function,   | [5]  | 4  | 3  |
| $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$  |      |    |    |
| using Simplex Pattern Search method. Perform only two iterations. Take initial point as (0,0) and scale factor, $\alpha = 2$ .  |      |    |    |
| Q.3(b) Minimize the function,   | [5]  | 4  | 3  |
| $f(x, y) = x - y + 2x^2 + 2xy + y^2$  |      |    |    |
| using conjugate gradient Method. Perform only two iterations. Take initial point as (0,0).  |      |    |    |
| Q.4 Solve the Linear Programming Problem using Simplex Method.  | [10] | 5  | 3  |

Maximize,  $Z = 5X_1 + 3X_2$

Subject to constraints:

$$\begin{aligned} 2X_1 + X_2 &\leq 10 ; \\ X_1 + 4X_2 &= 12 ; \\ X_1 \geq 0; X_2 &\geq 0 \end{aligned}$$

PTO

Q.5 An oil refinery makes two blends of fuel (premium petrol and regular petrol) by mixing three types of crude oils (A, B and C) as shown in two tables: [10] 2 5

**Table-1:**

Crude Oil	Cost (INR/L)	Maximum Daily Availability (L)
A	30	6,000
B	40	10,000
C	50	12,000

**Table-2:**

Petrol type	Minimum daily market demand (L)	Selling price (INR/L)	Composition
Regular	10,000	80	At least 30% of A; At most 50% of B; At least 30% of C
Premium	10,000	85	At most 40% of A; At least 35% of B; At most 40% of C

How to blend crude oils so that the refinery can maximize its profit? (Only formulate the optimization problem)

:::::20/11/2025:::::M