Seat No.: _____   Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER–VIII (NEW) EXAMINATION – WINTER 2022
Subject Code:2180503   **Date:16-12-2022**
Subject Name:Process Modeling, Simulation & Optimization
Time:10:30 AM TO 01:00 PM   **Total Marks:70**
Instructions:
1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	Explain equation solving approach to simulation with proper examples.	**03**
	(b)	Describe in detail the principles of formulation of mathematical models.	**04**
	(c)	Explain the fundamental laws of physics and chemistry with their application to simple chemical systems.	**07**

Q.2	**(a)**	Explain the Lagrange multiplier method and the Kuhn Tucker condition.	**03**
	(b)	Define the different measures of profitability/economic performance along with their significance.	**04**
	(c)	An irreversible, exothermic reaction $A \xrightarrow{k} B$ is carried out in a single perfectly mixed CSTR as shown in figure.	**07**
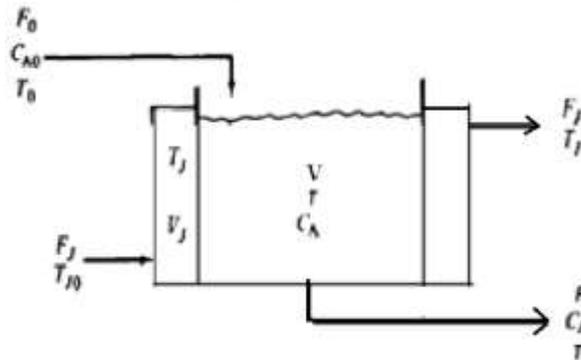
The reaction is n^{th}-order in reactant A and has a heat of reaction λ (Btu/lbmol of A reacted). Negligible heat losses and constant densities are assumed. To remove the heat of reaction, a cooling jacket surrounds the reactor. Cooling water is added to the jacket at a volumetric flow rate F_J, and with an inlet temperature of T_{Jo}. The volume of water in the jacket V_J is constant. The mass of the metal walls is assumed negligible so the thermal inertia of the metal need not be considered. Derive the model equations with the assumption of a perfectly mixed cooling jacket and a plug flow cooling jacket.

OR

(c) Consider a batch reactor in which the following first-order consecutive reactions are carried out. **07**

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$
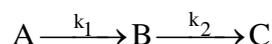
Reactant A is charged into the vessel. Steam is fed into the jacket to bring the reaction mass up to a desired temperature. Then cooling water must be added to the jacket to remove the exothermic heat of reaction and to make the reactor temperature follow the prescribed temperature-time curve. This temperature profile is fed into the temperature controller as a set-point signal. Derive a mathematical model for the batch reactor described above.

Q.3 (a) Explain lumped parameter model and distributed parameter model. **03**

(b) Explain the steps for finding the optimum L/D ratio for a pressurized **04** cylindrical storage vessel. List all the variables and the important assumptions.

(c) List out multivariable analytical methods for optimization problems with **07** restricted variables equality constraints and explain any one of them with example.

OR

Q.3 (a) Explain the uses of mathematical models. **03**

(b) List various professional simulation packages available and explain features **04** of any one briefly.

(c) What is Optimization? List the six general steps for the analysis and solution **07** of optimization problems.

Q.4 (a) Minimize the quadratic function: $f(x) = x^2 - x$ using quasi-newton method. **03**

(b) Solve the following non-linear function with constraints using Lagrange **04** multiplier method.

Minimize: $f(x, y) = kx^{-1}y^{-2}$

subject to $g(x, y) = x^2 + y^2 = a^2$

(c) Prepare a graph of the constraints and objective function, and solve the **07** following linear programming problem:

Maximize: $x_1 + 2x_2$

Subject to: $-x_1 + 3x_2 \leq 10$

$x_1 + x_2 \leq 6$

$x_1 - x_2 \leq 2$

$x_1 + 3x_2 \geq 6$

$2x_1 + x_2 \geq 4$

$x_1 \geq 0, x_2 \geq 0$

OR

Q.4 (a) Mention the conditions to be satisfied for extremum of the function of a single **03** variable and find extremum for $f(x) = x^4$.

(b) Explain random search and grid search method for unconstrained **04** multivariable optimization.

(c) The following data have been collected: **07**

x	10	20	30	40	50
y	1	1.26	1.86	3.31	7.08

Fit the above data into model $y = \alpha x^\beta$. Estimate the values of the constants α and β.

Q.5 (a) Differentiate between deterministic and stochastic models. **03**

(b) Explain (i) digraph and (ii) signal flow graph, with diagram. **04**

(c) Derive the mathematical expression an ideal binary distillation column. List **07** all assumptions.

OR

Q.5 (a) A poster is to contain 300 cm^2 of printed matter with margin of 6 cm at the **03** top and bottom and 4 cm at each side. Find the overall dimensions that minimize the total area of poster.

(b) Develop the equations for the series of isothermal, variable holdup CSTRs. **04**

(c) Explain partitioning and tearing with examples. **07**

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