Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII EXAMINATION – SUMMER 2025

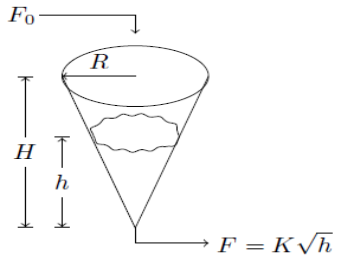
Subject Code:3170513 Date:08-05-2025

Subject Name:Process Modelling, Simulation and Optimization

Time:02:30 PM TO 05:00 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 the uses of mathematical models.	**03**
	(b)	Compare linear model and non linear model.	**04**
	(c)	Find the minimum of the function $\mathbf{f(x) = 0.65 - \frac{0.75}{1+x^2} - 065x \tan^{-1}\frac{1}{x}}$ Use Quasi Newton method with the starting point $x1 = 0.1$ and step size $\Delta x = 0.01$ in central difference formula use $\varepsilon = 0.01$ for checking the convergence.	**07**
Q.2	**(a)**	Explain equation oriented mode in simulation.	**03**
	(b)	Describe any one chemical process simulator and its salient features.	**04**
	(c)	A fluid of constant density **ρ** is pumped into a cone-shaped tank of total volume **H** $\pi R^2/3$. The flow out of the bottom of the tank is proportional to the square root of the height **h** of liquid in the tank. Derive the equations describing the system**.** 	**07**
		OR	
	(c)	Benzene is nitrated in an isothermal CSTR in three sequential irreversible reactions: $\text{Benzene} + \text{HNO}_3 \xrightarrow{k_1} \text{nitrobenzene} + \text{H}_2\text{O}$ $\text{Nitrobenzene} + \text{HNO}_3 \xrightarrow{k_2} \text{dinitrobenzene} + \text{H}_2\text{O}$ $\text{Dinitrobenzene} + \text{HNO}_3 \xrightarrow{k_3} \text{trinitrobenzene} + \text{H}_2\text{O}$ Assuming each reaction is linearly dependent on the concentrations of each reactant, derive a dynamic mathematical model of the system. There are two feed streams, one pure benzene and one concentrated nitric acid (98 wt %). Assume constant densities and complete miscibility.	**07**
Q.3	**(a)**	State objective functions in terms of the adjustable variable for chemical reactor.	**03**
	(b)	Discuss Distributed V/S Lumped Parameter models.	**04**
	(c)	A manufacturer produces three types of plastic fixtures. The time required for molding, trimming, and packaging is given in Table. (Times are given in hours per dozen fixtures). Use simplex method and find how many dozen of each type of fixture should be produced to obtain a maximum profit?	**07**

Process	Type A	Type B	Type C	Total time available
Molding	1	2	$\frac{3}{2}$	12000
Trimming	$\frac{2}{3}$	$\frac{2}{3}$	1	4600
Packaging	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{2}$	2400
Profit	Rs. 11	Rs. 16	Rs. 15	-

OR

Q.3 **(a)** Classify the methods to solve unconstrained multivariable problems. **03**

(b) Explain the fundamental laws of physics and chemistry with their applications to simple chemical systems. **04**

(c) Using Hooke-Jeeves method minimize $\mathbf{Z = f(x,y) = (x^2+y-11)^2 + (x+y^2-7)^2}$. **07**
Take initial point $\mathbf{x^{(0)} = (x^{(0)}, y^{(0)}) = (0,0)}$ and increment vector Δ = **(0.5 , 0.5)**.

Q.4 **(a)** State objective functions in terms of the adjustable variable for chemical reactor. **03**

(b) Write short note on decomposition of networks. **04**

(c) Use Lagrange Multipliers to find the global maximum and minimum values of $\mathbf{f(x,y) = x^2 + 2y^2 - 4y}$ subject to constraint $\mathbf{x^2 + y^2 = 9}$. **07**

OR

Q.4 **(a)** Explain primal-dual relationship in LP Problem. **03**

(b) Explain black box model. **04**

(c) Find the quadratic approximation to $\boldsymbol{w}$ at the point (1, 0, 2). **07**

$$\boldsymbol{w = x \sin(y) + y^2 + xyz + z}$$

Q.5 **(a)** Explain Random search method and its significance. **03**

(b) Draw the flow chart for implementing Fibonacci method. **04**

(c) Explain mathematical modelling of ideal binary distillation column. **07**

OR

Q.5 **(a)** Explain digraph and signal flow graph, with diagram. **03**

(b) Define the different measures of profitability/economic performance along with their significance. **04**

(c) List the structural components of general purpose sequential modular program. **07**

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