Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH. (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, APRIL 2018

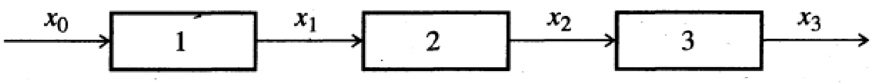
SUBJECT: Optimization of Chemical Processes [CHE5201]

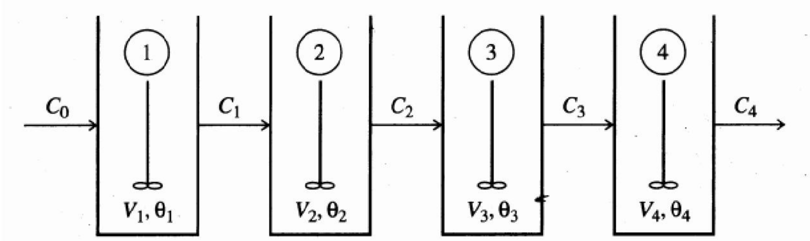
REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** questions.
- Missing data may be suitably assumed.
- Use of graph sheets permitted

1A.	The total annual cost of operating a pump and motor C in a particular piece of equipment is a function of *x*, the size (horsepower) of the motor, namely $C(x)=\$500+\$0.9x+\frac{\$0.03}{x}(150,000)$ Find the motor size that minimizes the total annual cost.	**02**
1B	In a rough preliminary design for a waste treatment plant the cost of the components are as follows (in order of operation)  1. Primary clarifier: Rs. 1200 $x_1^{-1.5}$ 2. Trickling Filter : Rs. 1000 $x_2^{-1.6}$ 3. Activated sludge unit: Rs. 6000 $x_3^{-0.3}$ Where, the x's are the fraction of the 5-day biochemical oxygen demand (BOD) exiting each respective unit in the process, that is, the exit concentrations of material to be removed. The required removal in each unit should be adjusted so that the final exit concentration x_3 must be less than 0.05. Formulate (only) the optimization problem listing the objective function and constraints.	**03**
1C	A series of four well-mixed reactors operate isothermally in the steady state. Examine the figure. All the tanks do not have the same volume, but the sum of V_i = 20 m^3. The component whose concentration is designated by *C* reacts according to the following mechanism: $r = -kC^n$ in each tank.	**05**



Determine the values of the tank volumes (real residence times of the component) in each of the four tanks for steady-state operation with a fixed fluid flow rate of so as to maximize the yield of product C_4. Note $(V_i/q_i) = \vartheta_i$, the residence time. Use the following data for the coefficients in the problem n = 2.5; k = 0.00625 $[m^3/(\text{kg mol})]^{-1.5}$ $(s)^{-1}$; The units for k are fixed by the constant 0.00625.

Evaluate the objective function, the variables, the equality constraints, the inequality constraints.

2A A refinery has available two crude oils that have the yields shown in the following table. Because of equipment and storage limitations, production of gasoline, kerosene, and fuel oil must be limited as also shown in this table. There are no plant limitations on the production of other products such as gas oils. **03**

	Volume percent yields		Maximum allowable product rate (bbl/day)
	Crude #1	Crude #2	
Gasoline	70	31	6,000
Kerosene	6	9	2,400
Fuel oil	24	60	12,000

The profit on processing crude #1 is \$ l.00/bbl and on crude #2 it is \$0.70/bbl. Formulate the optimization problem to find the optimum daily feed rates of the two crudes to this plant .

2B. Solve the following objective function using bounding phase algorithm. Consider initial guess as -5 and increment as 0.5. Show the minimum three iteration of the algorithm. $f(x) = 2x^3 + (5x)^2$ **5**

2C List the relative advantages and disadvantage of derivative and non-derivative optimization methods. **2**

3A	Discuss the Necessary and sufficient conditions for the solution of multivariable object functions.	**4**
3B	Develop a steepest decent algorithm to solve nonlinear optimization problem.	**3**
3C	In steepest ascent algorithm, show that the steepest ascent direction is gradient itself.	**3**
4A	Solve the following objective function using Interval halving method. Consider initial search space [0 5]. Show minimum three iteration of the algorithm. $f(x) = x^2 - 3x - 20$	**4**
4B.	Consider the following problem: $$\begin{aligned} &\text{Minimize:} && f(x) = x_1^2 + x_2 \\ &\text{Subject to:} && g_1(x) = x_1^2 + x_2^2 - 9 \le 0 \\ & && g_2(x) = (x_1 + x_2^2) - 1 \le 0 \\ & && g_3(x) = (x_1 + x_2) - 1 \le 0 \end{aligned}$$ (a) Show that the constraint set form a convex region (b) Feasible region is closed set by plotting the constraints	**4**
4C	Classify the stationary points of $$(a) \quad f(x) = -x^4 + x^3 + 20$$ $$(b) \quad f(x) = x^3 + 3x^2 + x + 5$$	**2**
5A	Solve the following optimization problem using Lagrange multipliers method $$\begin{aligned} &\text{Minimize} && f(x) = 4x_1^2 + 5x_2^2 \\ &\text{subject to} && 2x_1 + 3x_2 - 6 = 0 \end{aligned}$$	**5**
5B.	Prepare a graph of the constraints and objective function, and solve the following linear programming problem $$\begin{aligned} &\text{Maximize} && \mathrm{x}_1 + 2x_2 \\ &\text{subject to} && -x_1 + 3x_2 < 10 \\ & && x_1 + x_2 \le 6 \\ & && x_1 - x_2 \le 2 \\ & && x_1 + 3x_2 \ge 6 \\ & && 2x_1 + x_2 \ge 4 \\ & && x_1 \ge 0;\ x_2 \ge 0 \end{aligned}$$	**5**

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