Reg. No.

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

II SEMESTER M.TECH. (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, APRIL 2019

SUBJECT: Optimization of Chemical Processes [CHE5201]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

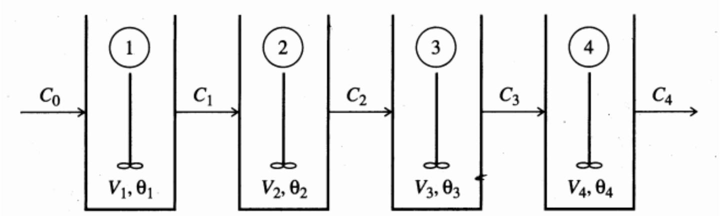
- Answer **ALL** questions.
- Missing data may be suitably assumed.
- Use of graph sheets permitted

1A A trucking company has borrowed \$600,000 for new equipment and is contemplating three kinds of trucks. Truck A costs \$10,000, truck B \$20,000, and truck C \$23,000. How many trucks of each kind should be ordered to obtain the greatest capacity in ton miles per day based on the following data? **05**

Truck A requires one driver per day and produces 2100 ton-miles per day.
Truck B requires two drivers per day and produces 3600 ton-miles per day.
Truck C requires two drivers per day and produces 3780 ton-miles per day.
There is a limit of 30 trucks and 145 drivers.

Formulate a complete mathematical statement of the problem, and label each individual part, identifying the objective function and constraints with the correct units (\$, days, etc.). Make a list of the variables by names and symbol plus units. *Do not solve.*

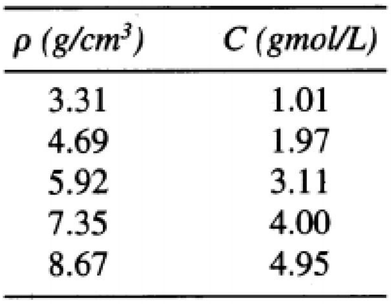
1B A series of four well-mixed reactors operate isothermally in the steady state. Examine the figure. All the tanks do not have the same volume, but the sum of V_i = 20 m^3. The component whose concentration is designated by *C* reacts according to the following mechanism: $r = -kC^n$ in each tank. **05**

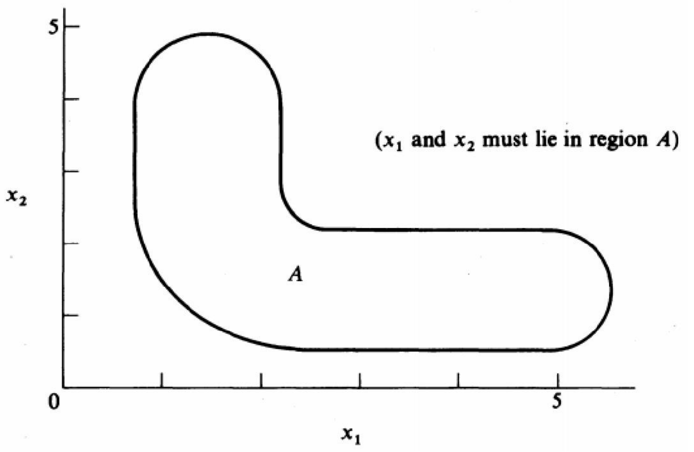


Determine the values of the tank volumes (real residence times of the component) in each of the four tanks for steady-state operation with a fixed fluid flow rate of so as to maximize the yield of product C_4. Note $(V_i/q_i) = \vartheta_i$, the residence time. Use the following data for the coefficients in the problem

n = 2.5; $k = 0.00625$ $[m^3/(kg\ mol)]^{-1.5}$ $(s)^{-1}$; The units for *k* are fixed by the constant 0.00625.

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

<table>
<tr><td>2A</td><td>Explain the gradient decent algorithm to solve multivariate linear regression problem.</td><td>04</td></tr>
<tr><td>2B</td><td>Consider the multivariate objective function as:
$$f(c) = 2c_1^2 + 2c_1c_2 + 1.5c_2^2 + 7c_1 + 8c_2 + 24$$
Evaluate the nature of the convexity.</td><td>02</td></tr>
<tr><td>2C</td><td>Fit the following function for the density ‘ρ’ as a function of concentration ‘C’, that is, determine the value of ‘α’ in $\rho = \alpha + 1.33C$, given the following measurements for density and concentration:

<table>
<tr><th>ρ (g/cm³)</th><th>C (gmol/L)</th></tr>
<tr><td>3.31</td><td>1.01</td></tr>
<tr><td>4.69</td><td>1.97</td></tr>
<tr><td>5.92</td><td>3.11</td></tr>
<tr><td>7.35</td><td>4.00</td></tr>
<tr><td>8.67</td><td>4.95</td></tr>
</table></td><td>04</td></tr>
<tr><td>3A</td><td>Rewrite the following linear programming problems in matrix notation.
(i.e., $f(\mathrm{x}) = \mathrm{a}^T\mathrm{x}$ and $g(\mathrm{x}) = \mathrm{Bx} \geq \mathrm{C}$)
Minimize: $f(\mathrm{x}) = 3x_1 + 2x_2 + x_3$
Subject to: $g_1(\mathrm{x}) = 2x_1 + 3x_2 + x_3 \geq 10$
$g_2(\mathrm{x}) = x_1 + 2x_2 + x_3 \geq 15$</td><td>02</td></tr>
<tr><td>3B</td><td>What is the feasible region for x given the following constraints and Sketch the feasible region for the following two-dimensional problem.
$$h_1(\mathrm{x}) = x_1 + x_2 - 3 = 0$$
$$h_2(\mathrm{x}) = 2x_1 - x_2 + 1 = 0$$</td><td>04</td></tr>
<tr><td>3C</td><td>An objective function is
$$f(\mathrm{x}) = (x_1 - 8)^2 + (x_2 - 5)^2 + 16$$
By inspection, you can find x* = $[8\ 5\mathrm{I}^{\mathrm{T}}$ yields the minimum of <i>f(x)</i>. Show that x* meets the necessary and sufficient conditions for a minimum.</td><td>04</td></tr>
<tr><td>4A</td><td>Given a linear objective function,
$$f = x_1 + x_2$$
Explain why a nonconvex region such as region A in Figure 4A causes difficulties in the search for the maximum off in the region. Why is region A not convex?</td><td>02</td></tr>
</table>

	 Figure 4A.	
4B	Develop a bounding phase algorithm to solve single variable nonlinear unconstrained objective function.	**04**
4C	Solve the following objective function using Interval halving method. Consider initial search space [0 5] and $\in$=0.1. Show minimum three iteration of the algorithm. $f(x) = (2x-8)^2 + (5x-9)^2$	**04**
5A	Solve the following objective function using bounding phase algorithm. Consider initial guess x = -5. Show minimum three iteration of the algorithm. $f(x) = 2x^3 + 5x^2$	**04**
5B	Use the method of Lagrange multipliers to solve the following problem. Find the values of x_1,, x2, and λ that Minimize: $f(\mathrm{x}) = x_1^2 + x_2^2$ Subject to: $h(\mathrm{x}) = 2x_1 + x_2 - 2 = 0$	**04**
5C	Discuss the Necessary and Sufficient conditions for the solution of multivariable object functions.	**02**

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