Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, May- June 2023

SUBJECT: Optimization of Chemical Processes [CHE5251]

REVISED CREDIT SYSTEM

Time: 3 Hours   Date: 22/05/2023   Time: 9:30 -12:30 PM   MAX. MARKS: 50

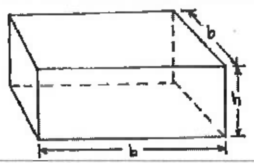
Instructions to Candidates:

- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A Differentiate between the following cases with an example for each one: **05**

a. Constraint optimization Vs. unconstrained optimization problems
b. Linear Vs. nonlinear optimization problem
c. Unimodal Vs. Multimodal optimization problem
d. Data-driven model vs. Mechanistic model
e. Linear Model Vs Nonlinear model

1B A box with a square base and open top is to hold 1000 cm3. Find the dimensions that require the least material (assume a uniform material thickness) to construct the box. (Note: $b > 0 \,\&\, h > 0$) **03**



1C Explain the scope of optimization in five different areas with one example for each area **02**

2A Find the model parameter with the following data using the normal equation for least squares method: i.e. $\hat{\theta} = \left[x^T x\right]^{-1} x^T y$ **03**

$$y = \theta_0 + \theta_1 x$$

xi	0.5	1	2.1	3.4
Yi	0.6	1.4	2.0	3.6

2B A certain gas contains moisture, which you need to remove by compression and cooling so that the gas will finally contain no more than 1% moisture (by volume). If the cost of the compression equipment is **02**

Cost in Rs. = $(\text{Pressure in atm})^{1.40}$

And the cost of the cooling equipment is

Cost in Rs. = $(350 - \text{Temperature in Kelvin})^{1.9}$

What is the best temperature must use.?

Define the objective function, the independent and the dependent variables, and the constraints.

2C

a. Show that Newton's algorithm will converge to the solution in one iteration for the quadratic objective function. **02**

b. Consider minimizing the function $f(\mathbf{x}) = x_1^2 + x_2^2$. Use the formula $\mathbf{x}^{k+1} = \mathbf{x}^k - \alpha\, \nabla f(\mathbf{x}^k)$, where α is chosen to minimize *f(x)*. Show that $\mathbf{x}^{k+1}$ will be the optimum *x* after only one iteration. You should be able to optimize *f(x)* with respect to α analytically. Start from $\mathbf{x}^0 = [3 \quad 5]^T$ **03**

3A	Discuss the Necessary and sufficient conditions for the solution of multivariable nonlinear problems.	02
3B	Are the following functions convex? Strictly convex? Why? $(a) f(x_1, x_2) = 2x_1^2 + 2x_1x_2 + 3x_2^2 + 7x_1 + 8x_2 + 25$ $(b) f(x) = e^{5x}$	 02 02
3C	An objective function is $f(\mathbf{x}) = (x_1 - 8)^2 + (x_2 - 5)^2 + 16$ By inspection, **x*** = $[8\ 5]^T$ yields the minimum of *f(x)*. Show that **x*** meets the necessary and sufficient conditions for a minimum.	04
4A	a. Use the method of Lagrange multipliers to solve the following problems. Find the values of $x_1, x_2,\ and\ \omega$ that(where ω is the lagrangian multiplier) $\text{Minimize}: f(x) = x_1^2 + x_2^2$ $\text{subject to}: h(x) = 2x_1 + x_2 - 2 = 0$ b. $\text{Maximize}: f(x) = x_1^2 + x_2^2 + 4x_1x_2$ $\text{subject to}: h(x) = x_1 + x_2 = 8$	03 03
4B	Formulate the KKT conditions for the following problem for a minimum, and solve for the optimum. $\text{Minimize}: f(x) = x_1^2 + 2x_2^2 + 3x_3^2$ $\text{subject to}: h_1(x) = x_1 - x_2 - 2x_3 \le 12$ $h_2(x) = x_1 + 2x_2 - 3x_3 \le 8$	04
5A	What is the feasible region for x given the following constraints, sketch the feasible region for the following two-dimensional problem. $h_1(\mathbf{x}) = x_1 + x_2 - 3 = 0$ $h_2(\mathbf{x}) = 2x_1 - x_2 + 1 = 0$	02
5B	Solve the following objective function using Interval halving method. $f(x) = x^2 - 3x - 20$ Consider initial search space [0 5]. Show a minimum of three iterations of the algorithm.	03
5C	A chemical manufacturing firm has discontinued production of a certain unprofitable product line. This has created considerable excess production capacity on the three existing batch production facilities. Management is considering devoting this excess capacity to one or more of three new products: Call them products 1,2, and 3. The available capacity on the existing units that might limit output is summarized in the following table: (see tables below)	05

Unit	*Available time (h/week)*
A	20
B	10
C	5

Each of the three new products requires the following processing time for completion:

Productivity (h/batch)			
Unit	*Product -1*	*Product-2*	*Product-3*
A	0.8	0.2	0.3
B	0.4	0.3	--
C	0.2	--	0.1

The sales department indicates that the sales potential for products 1 and 2 exceeds the maximum production rate and that the sales potential for product 3 is 20 batches per week. The profit per batch is Rs20, Rs 6, and Rs 8, respectively, on products 1, 2, and 3.

Formulate a linear programming model for determining how much of each product the firm should produce to maximize profit.

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