BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

Chemical Process Optimization (CHE G558), Comprehensive Examination

Date – 13/12/2023 Maximum Marks - 15 Part – A (Closed Book)

1. Determine if the following function is convex or concave:
   $f(x) = 2x_1 + 3x_2 - x_1^2 - x_2^2$ **[2]**
2. Solve the following linear programming problem using graphical technique.
   Maximize $f(x, y) = 1.75\,x + 1.25y$
   Subject to: $1.2x + 2.25y \leq 14; x + 1.1y \leq 8; 2.5x + y \leq 9; x, y \geq 0$ **[3]**
3. Rewrite the following unconstrained quadratic programming problem in standard form:
   Minimize $f(x_1, x_2) = -4x_1 + 2x_2 + 4x_1^2 - 4x_1x_2 + x_2^2$ **[2]**
4. Explain with example, the different types of integer programming problems? A plant can manufacture four types of products. The manufacturer has to decide whether to produce all four types of products or not based on the following information. Product 1 will yield a net profit of Rs 16,000; product 2, a profit of Rs 22,000; product 3 a profit of Rs 12,000; and product 4 a profit Rs 8,000. Expenses incurred in manufacturing the products are as follows. Product 1, Rs 5,000; product 2, Rs 7,000; product 3, Rs 4,000; and product 4, Rs 3,000. A total of Rs14, 000 is available for expenditure. Formulate an IP whose solution will tell the manufacture how to maximize the profits earned from manufacturing products 1 and/or 2 and/or 3 and/or 4. **[2+2]**
5. Explain the three steps carried out in each iteration of genetic algorithm technique. There are three design variables in an optimization with three sets of data available as given below:

	X1	X2	X3
Sample 1	9	24	15
Sample 2	12	28	13
Sample 3	11	26	8

   Represent each design variable by a string of length five and rewrite the values as initial population data for application of genetic algorithm. **[1+3]**

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Date – 13/12/2023 Maximum Marks - 25 Part – B (Open Book)

1. A chemical plant makes three major products on a weekly basis. Each of these products requires a certain quantity of raw chemical and different production times, and yields different profits. The pertinent information is in Table given below. Note that there is sufficient warehouse space at the plant to store a total of 450 kg/week. [**6**]

	Product 1	Product 2	Product 3	Resource availability
Raw chemical	7 kg/kg	5 kg/kg	13 kg/kg	3000 kg
Production time	0.05 hr/kg	0.1 hr/kg	0.2 hr/kg	55 hr/week
Profit	30/kg	30/kg	35/kg	

   Set up a linear programming problem to maximize profit.

   Solve the linear programming problem with the simplex method.

2. Find the extreme values (maximum or minimum) of the function $f(x_1, x_2, x_3) = x_1^3 + x_2^3 + x_3^3$ over the sphere $x_1^2 + x_2^2 + x_3^2 = 4$ using Lagrangian multiplier method. [**4**]

3. Consider the following problem:

   Minimize $(x_1 - 1)^2 + (x_2 - 5)^2$ subject to $g_1(x) = -x_1^2 + x_2 - 4 \leq 0$ and $g_2(x) = -(x_1 - 2)^2 + x_2 - 3 \leq 0$

   Check whether KKT conditions are satisfied at point (0.75, 4.5625) [**4**]

4. Express the following QPP in standard form and obtain the KKT Conditions. Do not solve. [**5**]

   Minimize: $f(x) = 0.5x^2 + 3x + 4y$

   Subject to

   $x + 3y \geq 15$

   $2x + 5y \leq 100$

   $3x + 4y \leq 80$

   $x, y \geq 0$

5. A furniture company manufactures tables and chairs. A table requires 1 hour of labor and 9 square board meter of wood. A chair requires 1 hour of labor and 5 square board meter of wood. Currently, 6 hours of labor and 45 square board meter of wood are available. Each table contributes Rs 8 to profit, and each chair contributes Rs 5 to profit. Formulate the integer programming problem and solve using branch and bound method to maximize the profit. [**6**]