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GANDHI INSTITUTE OF ENGINEERING AND TECHNOLOGY UNIVERSITY, ODISHA, GUNUPUR

(GIET UNIVERSITY)

Ph.D. (First Semester-Winter) Examinations, June – 2025

23WPPECA1015 – Optimization Techniques

(CSA)

Time: 3 hrs Maximum: 70 Marks

The figures in the right hand margin indicate marks.

Answer *ANY FIVE* Questions. (14 x 5 = 70 Marks) **Marks**

1.a. Engineering design problems often require optimal solutions that can be obtained using mathematical programming techniques. Outline the major steps involved in converting an engineering design problem into a mathematical programming formulation. Support your explanation with a relevant real-world engineering application, clearly highlighting how each step applies to the chosen case. 8

b. Critically analysed the role of optimization as a strategic tool in advanced engineering design processes. Discuss how multi-objective and constraint-based optimization approaches contribute to innovative solutions. Support your analysis with two detailed case studies from distinct engineering domains, emphasizing measurable improvements in performance, cost-efficiency, or sustainability. 6

2. With reference to engineering design optimization, critically evaluate the fundamental differences among linear programming (LP), nonlinear programming (NLP), integer programming (IP), and dynamic programming (DP) models. For each category, discuss the nature of problems they are best suited to solve, along with one in-depth engineering example illustrating its real-world application, complexity, and solution approach. 14

3.a. Real -world engineering design problems are often characterized by uncertainty, complexity, and competing criteria. Critically examine the key challenges involved in mathematically formulating such problems, particularly in the presence of incomplete data, nonlinear system behaviour, and conflicting design objectives. Propose and evaluate potential strategies or methodologies to effectively address these challenges in practical optimization scenarios. 7

b. With the help of a detailed example, show how genetic algorithms or other heuristic methods are used for solving complex optimization problems where traditional methods fail. 7

4. Find the solution of the following quadratic programming problem: Minimize $f = -4x1 + x2$ $1 - 2x1x2 + 2x2$ 2 subject to $2x1 + x2 \leq 6$, $x1 - 4x2 \leq 0$, $x1 \geq 0$, $x2 \geq 0$ 14

5.a. Ant Colony Optimization (ACO) algorithms use a probabilistic selection mechanism influenced by pheromone intensity to guide solution construction. Given the pheromone values τ_{ij} = {1, 2, 4, 3, 5, 2} for arcs emanating from node i to nodes j = 1 to 6, compute the probability distribution over the arcs and determine which arc is selected using the roulette-wheel selection method for a random number r = 0.4921. Further, discuss the implications of pheromone initialization and update strategies on the convergence behaviour and exploration-exploitation balance in ACO 7

b. Explain how a heuristic algorithm such as Ant Colony Optimization or Nearest Neighbor could be applied to solve this problem. Discuss the pros and cons of using heuristics vs exact methods. 7

6.a.	Particle Swarm Optimization (PSO) is a population-based stochastic optimization technique inspired by social behaviour in nature. Develop the step-by-step algorithmic framework for PSO and critically analyze the role of its key controlling parameters, including inertia weight, cognitive and social acceleration coefficients. Further, discuss how these parameters influence the convergence speed, solution quality, and the balance between exploration and exploitation.	7
b.	Explain the method to compute the probability of selecting a path in Ant colony optimization based on pheromone and visibility criteria. How can we control these criteria?	7
7.	Critically evaluate the butterfly optimization algorithm, illustrating its working with an example and discussing its effectiveness compared to other optimization methods.	14
8.a.	Discuss real-world applications of ACO in network routing and logistics. How does ACO contribute to finding optimal or near-optimal solutions in dynamic and complex systems?	7
b.	Compare Genetic Algorithms and Ant Colony Optimization in terms of their problem-solving approach, application areas, and convergence behavior. Use real-world examples to justify your comparison.	7

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