

OPTIMIZATION TECHNIQUES
(MEC3221)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Which of the following represents the earliest stage in the evolution of optimization techniques?
 - (a) Genetic Algorithms
 - (b) Linear Programming
 - (c) Calculus-based methods
 - (d) Machine Learning
- (ii) A problem with more than one objective function is called:
 - (a) Linear problem
 - (b) Constrained problem
 - (c) Multi-objective optimization
 - (d) Deterministic problem
- (iii) In single-variable optimization, the necessary condition for optimality is:
 - (a) First derivative = 1
 - (b) First derivative = 0
 - (c) Second derivative = 0
 - (d) Function = 0
- (iv) The Golden Section Search method is a/an _____ method.
 - (a) Gradient-based
 - (b) Elimination
 - (c) Interpolation
 - (d) Direct search
- (v) Which method is considered the “best” in terms of reduction per iteration for single variable optimization?
 - (a) Bisection method
 - (b) Golden Section Search
 - (c) Fibonacci Search
 - (d) Newton Method
- (vi) Grey Relational Analysis (GRA) is primarily used for:
 - (a) Solving single variable problems only
 - (b) Multi objective optimization
 - (c) Linear programming only
 - (d) Statistical hypothesis testing
- (vii) Which normalization method is used when the objective is to minimize a response?
 - (a) Large the better
 - (b) Smaller the better
 - (c) Nominal is the best
 - (d) None of the above

- (viii) In Genetic Algorithm, crossover is used to:
 (a) Evaluate fitness (b) Select individuals
 (c) Combine two parent solutions (d) Remove weak solutions
- (ix) Particle Swarm Optimization is based on:
 (a) Evolution of species (b) Cooling of metals
 (c) Bird flocking behavior (d) Neural activity
- (x) Which algorithm is most prone to premature convergence?
 (a) Genetic Algorithm (b) Particle Swarm Optimization
 (c) Ant Colony Optimization (d) Simulated Annealing

Fill in the blanks with the correct word

- (xi) In multivariable optimization, partial derivatives are set equal to ____.
- (xii) In optimization, the set of all feasible solutions is called the ____ region.
- (xiii) In Simulated Annealing, temperature is gradually ____.
- (xiv) The process of selecting the best individuals in GA is called ____.
- (xv) Grey Relational Grade (GRG) is obtained by taking the ____ of the Grey Relational Coefficients (GRC).

Group - B

2. (a) Explain the evolution and progress of optimization techniques. [[C01](Understand/LOCQ)]
- (b) A company produces two products x and y. Profit per unit is ₹40 and ₹30 respectively. Each unit of product x requires 2 hours of machining and 1 hour of assembly, while product y requires 1 hour of machining and 2 hours of assembly. Available machining hours = 100, assembly hours = 80. Formulate the optimization problem. [[C06](Apply/IOCQ)]
6 + 6 = 12
3. (a) Explain multivariable optimization with constraints using classical methods with an example. [[C01](Understand/LOCQ)]
- (b) Minimize the objective function: $f(x,y,z) = x^2 + y^2 + z^2$
 Subject to the constraint: $x + y + z = 6$. [[C02](Apply/IOCQ)]
6 + 6 = 12

Group - C

4. (a) Minimize $f(x) = x^5 - 5x^3 - 20x + 5$ for two iteration by Fibonacci method in the range (0,5). Assume $n = 10$ and $k = 2$. [[C03](Apply/IOCQ)]
- (b) Write the Fibonacci series. Write an algorithm to show how the series can be used for single variable optimization problems. [[C03](Apply/IOCQ)]
6 + 6 = 12

5. (a) Discuss Cauchy's (steepest descent) Method for multivariable optimization problems. [[CO3](Understand/LOCQ)]
 (b) Write the algorithm for Newton's method for multivariable optimization. [[CO3](Understand/LOCQ)]
6 + 6 = 12

Group - D

6. A manufacturing company wants to optimize the performance of a machining process based on three quality characteristics: Surface Roughness (Ra) (to be minimized), Material Removal Rate (MRR) (to be maximized), and Tool Wear (TW) (to be minimized). Four experimental trials were conducted with the following results:

Experiment	Ra (μm)	MRR (mm^3/min)	TW (mm)
1	2.5	120	0.30
2	2.0	150	0.25
3	3.0	110	0.35
4	2.2	140	0.28

Use Grey Relational Analysis to do the followings:

- (i) Perform normalization of the data for each response
- (ii) Calculate the Grey Relational Coefficient for each response (assume distinguishing coefficient $\zeta = 0.5$).
- (iii) Determine the Grey Relational Grade for each experiment.
- (iv) Identify the optimal experiment based on GRG.

[[CO4](Apply/IOCQ)]
12

7. A car buyer wants to select the best car based on two objectives: Fuel Efficiency (in km/ltr) and Engine Performance (in horsepower). The data for four cars is given below:

Car	Fuel Efficiency	Performance
C1	15	100
C2	18	120
C3	20	140
C4	22	160

Both objectives are important and are positively correlated.

Calculate:

- (i) Compute the covariance matrix.
- (ii) Determine the eigenvalues and eigenvectors.
- (iii) Obtain the first principal component (PC1).
- (iv) Use PCA to convert this multi-objective problem into a single-objective problem.
- (v) Identify the best car based on PC1.

[[CO4](Apply/IOCQ)]
12

Group - E

8. (a) Explain selection, crossover, and mutation in Genetic Algorithm with an example. [[CO1](Understand/LOCQ)]
- (b) Solve the following optimization problem using Genetic Algorithm.
 Maximize the function:
 $f(x) = 2x + 3$
 where $0 \leq x \leq 7$
 Use:
 ● Binary encoding (3 bits)
 ● Population size = 4
 ● Crossover probability = 1 (single-point crossover)
 ● Mutation probability = 0
 Initial population:
 $P_0 = \{000, 011, 100, 110\}$
 Find the best solution. [[CO4](Apply/IOCQ)]
6 + 6 = 12
9. (a) Explain Ant Colony Optimization algorithm. [[CO1](Understand/LOCQ)]
- (b) Compare Genetic Algorithm, Particle Swarm Optimization, and Differential Evolution. [[CO5](Analyze/IOCQ)]
6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	68.75	0