Kadi Sarva Vishwavidyalaya

Faculty of Engineering & Technology

Second Year Master of Engineering (Computer Engineering)

(Semester-III)

(With effect from: Academic Year 2018-19)

Subject Code: MECE-301-N	**Subject Title**: Optimization Techniques
Pre-requisite	Fundamental knowledge of Calculus and Linear Algebra is required

Teaching Scheme (Credits and Hours)

Teaching Scheme				Total Credit	Evaluation Scheme					
L	T	P	Total		Theory		Mid Sem Exam	CIA	Practical	Total
Hours	Hours	Hours	Hours		Hours	Marks	Marks	Marks	Marks	Marks
04	01	00	05	05	03	70	30	20	0	120

Learning Objectives:

- To enable students to learn and implement various optimization techniques
- To enable students to model real-world problems in optimization framework
- To enable students to apply various optimization models in computer-science context

Outline of the Course:

Sr. No	Title of the Unit	Minimum Hours
1	Mathematical preliminaries – linear algebra and multivariable calculus	06
2	Unconstrained and constrained optimization	15
3	Genetic algorithms	11
4	Linear programming	16
5	Non-linear programming	16
	Total	**64**

Total hours (Theory): 64
Total hours (Tutorials): 16
Total hours (Lab): 00
Total hours: 80

Detailed Syllabus:

Sr. No	Topic	Lecture Hours	Weight age (%)
1	**Mathematical preliminaries:** Linear algebra and matrices, Vector space, eigen analysis**,** Elements of probability theory**,** Elementary multivariable calculus	06	10
2	**Unconstrained and constrained optimization:** One-dimensional search methods, Gradient-based methods, Conjugate direction and quasi-Newton methods.	15	23
3	**Genetic Algorithms:** Basics of genetic algorithms, Analysis	11	17
4	**Linear Programming:** Introduction to linear programming model, Introduction to single and multi-objective optimization and its methods, Simplex method, Duality, Karmarkar's method.	16	25
5	**Non-linear problems:** Problems with Equality Constraints, Problems with Inequality Constraints, Convex Optimization Problems, Algorithms for Constrained Optimization.	16	25
	Total	64	100

Instructional Method and Pedagogy:

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Attendance is compulsory in lecture and laboratory which carries 10 marks in overall evaluation.
- One internal exam will be conducted as a part of internal theory evaluation.
- Assignments based on the course content will be given to the students for each unit and will be evaluated at regular interval evaluation.
- Surprise tests/Quizzes/Seminar/tutorial will be conducted having a share of five marks in the overall internal evaluation.
- The course includes a laboratory, where students have an opportunity to build an appreciation for the concepts being taught in lectures.
- Experiments shall be performed in the laboratory related to course contents.

Learning Outcome:

On successful completion of this course, the student should be able to:

1. Be able to learn and implement various optimization techniques
2. Be able to learn model real-world problems in optimization framework
3. students will apply various optimization models in computer-science context

Reference Books:

1. Introduction to Optimization – Edwin K P Chong, Stainslaw H Zak
2. Nonlinear programming – DimitryBertsekas

Tutorial List:

1. Solve the following problem using the Simplex method:

   Maximize: Z = 3x + 2y
   Subject to: 2x + y ≤ 18,
   2x + 3y ≤ 42
   3x + y ≤ 24
   x ≥ 0 , y ≥ 0

2. Solve the LP problem using Simplex method. Determine the following:
   (a) What is the optimal solution?
   (b) What is the value of the objective function?
   (c) Which constraint has excess resources and how much?

   $z_{max} = 5x_1 + 6x_2$
   Subject to constraints,
   $2x_1 + x_2 \leq 2000$
   $x_1 \leq 800$
   $x_2 \leq 200$
   where $x_1, x_2 \geq 0$

3. A company manufactures two products (A and B) and the profit per unit sold is Rs.3 and Rs.5 respectively. Each product has to be assembled on a particular machine, each unit of product A taking 12 minutes of assembly time and each unit of product B 25 minutes of assembly time. The company estimates that the machine used for assembly has an effective working week of only 30 hours (due to maintenance/breakdown).
   Technological constraints mean that for every five units of product A produced at least two units of product B must be produced.
   Formulate the problem of how much of each product to produce as a linear program.Solve this linear program graphically.
   The company has been offered the chance to hire an extra machine, thereby doubling the effective assembly time available. What is the *maximum* amount you would be prepared to pay (per week) for the hire of this machine and why?

4. Obtain the dual for following LPP and obtain the solution to the dual from the tableau:

   Maximize: *Z* = 3x1+5x2+7x3
   Subject to:*X1+x2+3x3≤ 10*
   4x1-x2+2x3 ≥ 15
   3x + y ≤ 24
   X1,x2≥ 0 , x3 unrestricted in sign.

5. Consider the problem

   Minimize $f(x)$ subject to $x \in \Omega$, where $f \in C^2$. For each of the following specifications for Ω, x^* and f, determine if the given point x^* is: (i) definitely a local minimizer, (ii) definitely not a local minimizer; or (iii) possibly a local minimizer. Fully justify your answer.

   (i) $f: R^2 \to R$, $\Omega = \{x = [x1,x2]^T : x1 \geq 0, x2 \geq 2\}$, $x^* = [1,2]^T$ and gradient $f(x^*) \nabla [1,1]^T$.

   (ii) $f: R^2 \to R$, $\Omega = \{x = [x1,x2]^T : x1 \geq 0, x2 \geq 2\}$, $x^* = [0,2]^T$ and gradient $f(x^*) = [1,1]^T$.

6. Write down the Taylor series expansion of the following functions about the given point x_0. Neglect terms of order three or higher.
   (i) $f(x) = x_1^4 + 2 x_1^2 x_2^2 + x_2^4$, $x_0 = [1,1]^T$
   (ii) $f(x) = x_1 e^{-x2} + x_2 + 1$, $x_0 = [1,0]^T$
7. Let $f(x) = x^2 + 4 \cos x$, $x \in R$. Find the minimizer x^* of f over the interval [1,2]. Use the Fibonacci method to locate x^* to within an uncertainty of 0.2. Consider $\varepsilon = 0.05$.
8. Use the method of Steepest descent to find the minimizer of $f(x1, x2, x3) = (x1-4)^4 + (x2-3)^2 + 4(x3+5)^4$. The initial point is $[4, 2, -1]^T$.
9. Find the minimizer of
   $f(x1,x2) = \frac{1}{2} x^T \begin{bmatrix} 4 & 2 \\ 2 & 2 \end{bmatrix} x - x^T \begin{bmatrix} -1 \\ 1 \end{bmatrix}, x \in R^2,$ using the conjugate direction method withthe initial point $[0,0]^T$ and Q-conjugate directions $d^{(0)} = [1,0]^T$ and $d^{(1)} = \left[-\frac{3}{8}, \frac{3}{4}\right]^T$.
10. Consider the problem Minimize $f(x)$ subject to $x \in \Omega$, where $f : R^2 \to R$ is given by $f(x)=5x2$ with $x=[x1,x2]^T$ and $\Omega = \{ x=[x1,x2]^T : x1^2+x2 >=1\}$. Answer each of the following questions, showing complete justification:(i) Does the point $x^* = [0,1]^T$ satisfy the first-order necessary condition?
    (ii) Does the point $x^* = [0,1]^T$ satisfy the second-order necessary condition?
    (iii) Is the point $x^* = [0,1]^T$a local minimizer?
11. Study of two research paper to discuss the need and applicability of optimization techniques in engineering research.