# CSE228: Optimization Techniques and Applications

**Program:** B.Tech (CSE) **Year:** II **Semester:** III
**Course:** Program Elective **Credits:** 3 **Hours:** 40 hours (Theory)

**Course Context and Overview (100 words):**

The aim of this course is to provide a rigorous introduction to the fundamental theory of optimization and its real world applications. Engineers, scientists, analysts and managers are often faced with the challenge of making tradeoffs between different factors in order to achieve desirable outcomes. Communication and networking, electronic circuit design, data analysis and modelling, statistics, signal and image processing, and finance are only a few among numerous areas of modern engineering and science, which regularly depend on the techniques of numerical optimization. Whether one is prototyping an electronic circuit or developing an investment portfolio, the desired solution can often be associated with an extremum of a specially designed function, known as a cost or objective function. Consequently, the task of finding an optimal solution can often be cast in the form of finding a point, at which such function reaches its minimum (or, alternatively, maximum) value. Naturally, how tractable and realizable the above task is depends on the properties of the cost function at hand as well as its domain and range, both of which can be either continuous or discrete.

**Prerequisite Courses:** Discrete Mathematical Structures

**Course Outcomes (COs):**

| The Outcomes of this Course are | |
|---|---|
| **CO1:** | Describe the principal concepts of optimization theory and algorithms along with its key numerical techniques. |
| **CO2:** | Discuss the background in optimization methods applicable to a wide range of engineering problems along with experience in solving optimization problems of their own choice. |
| **CO3:** | Formulate and solve Linear and Non-linear optimization problems |
| **CO4:** | Formulate and Solve Integer Programing Problem using various techniques. |
| **CO5:** | Apply the knowledge and techniques of Optimization to solve real life problem |

**Course Topics**

| Contents | | Lecture Hours | |
|---|---|---|---|
| **UNIT-1 (Convex optimization problems)** | | | |
| 1.1 | Basic terminology, standard form of convex optimization problems, local and global optima, optimality criteria, | 2 | 4 |
| 1.2 | Linear optimization problems, Optimization of function of one variable and multiple variables; Gradient vectors | 2 | |
| **UNIT-2 Algorithms: Linear Programming** | | | 12 |
| 2.1 | Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations. | 2 | |
| 2.2 | Graphical method for two variable optimization problem; Examples. Algorithm and construction of simplex tableau | 2 | |
| 2.3 | Simplex criterion; Minimization versus maximization problems. , Revised simplex method; Duality in LP | 2 | |
| 2.4 | Primal-dual relations; Big-M Method, Two Phase Method | 2 | |
| 2.4 | Dual Simplex method; Sensitivity or post optimality analysis. | 2 | |
| 2.5 | Application of LP problem, Formulation and solving using a programing language | 2 | |
| **UNIT-3** Quadratic optimization problems | | | 9 |
| 3.1 | Stationary points maxima, minima and saddle points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables | 3 | |
| 3.2 | Optimization of function of multiple variables subject to equality constraints; Lagrangian function. . | 2 | |
| 3.3 | Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; | 2 | |
| 3.4 | Eigen values. Kuhn-Tucker Conditions; Wolfe's Modified Simplex Method. Applications of Quadratic Optimization Problem. | 2 | |
| **UNIT-4 Integer Programming** | | | |
| 4.1 | Integer linear programming; Concept of cutting plane method. Enumeration and Cutting plane solution concept. | 3 | 9 |

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| 4.2 | Mixed integer programming; Solution algorithms, Method for constructing additional constraint (Cut) | 3 | 9 |
| 4.3 | Gomory's Mixed Integer Cutting Plane method, , Method for constructing additional constraint (Cut), Branch and Bound Method | 3 | |
| **UNIT-5 Application of Integer Programming** | | | 6 |
| 5.1 | Vehicle scheduling in transportation | 2 | |
| 5.2 | Telecommunications networks and Cellular Networks | 2 | |
| 5.3 | Shortest Path Problem-Formulate and solve | 2 | |

**Text Book:**

1. Singiresu S. Rao, JOHN WILEY & SONS, *"Engineering Optimization", Theory and Practice* 4th Edition, , INC, 2009

**Reference books:**

1. David G.Luenbegerger, "*Linear and Non-linear Programming"*, Yinye Ye, 2015
2. J.K. Sharma, "*Operation Research"*, *4th* edition, Macmillan, 2009
3. I. Griva, S. Nash and A. Sofer, *"Linear and Non-Linear Optimization"*, *Society for Industrial and Applied Mathematics* 2nd edition, 2009
4. D. P. Bertsekas, *"Network Optimization: Continuous and Discrete Models", Athena Scientific*, 1998 (freely available online.
5. Lopez, Cesar, "*MATLAB Optimization Techniques"*:

Evaluation Methods:

| Item | Weightage (%) |
|---|---|
| Mid-Term Exam | 30 |
| End-Term Exam | 45 |
| Project-Solving Optimization Problem in MATLAB/Python, | 25 |
| c++ or related programming languages | |

Students are requested to register in www.piazza.com
Some e-books and useful links will be uploaded.

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