Optimization Methods - Web course

COURSE OUTLINE

Optimization is the process of obtaining the best result under given circumstances. In design, construction and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decisions is either to minimize the effort required or to maximize the desired benefit. A number of optimization methods have been developed for solving different types of optimization problems. In this course, after discussing about the optimization problem formulation, Linear Programming, Non Linear Programming, Dynamic Programming techniques are explained in detail along with number of applications in civil engineering. Advanced optimization techniques such as Evolutionary search algorithms, Multi objective optimization are briefly introduced.

COURSE DETAIL

Module	Sub-Module	Hours for Sub-Module	Total Hours
1. Introduction and Basic Concepts	Historical Development; Engineering applications of Optimization; Art of Modeling	1	5
	Objective function; Constraints and Constraint surface; Formulation of design problems as	1	

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Civil Engineering

Pre-requisites:

- Back ground in differential calculus and basic maths.

Additional Reading:

- Vedula, S. and Mujumdar, P. P., Water Resources Systems : Modeling Techniques and Analysis, Tata-McGraw Hill, 2005.

Hyperlinks:

- http://civil.iisc.ernet.in/~nagesh/stwree.htm

Coordinators:

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	mathematical programming problems			
	Classification of optimization problems	1		
	Optimization techniques – classical and advanced techniques	2		
2. Optimization using Calculus	Stationary points; Functions of single and two variables; Global Optimum	1	6	
	Convexity and concavity of functions of one and two variables	1		
	Optimization of function of one variable and multiple variables; Gradient vectors; Examples	1		
	Optimization of function of multiple variables subject to equality constraints; Lagrangian function	1		
	Optimization of function of	1		

	multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values		
	Kuhn-Tucker Conditions; Examples	1	
3. Linear Programming	Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations	1	6
	Graphical method for two variable optimization problem; Examples	1	
	Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems	2	
	Revised simplex method; Duality in LP; Primal-dual relations; Dual Simplex	1	

	method; Sensitivity or post optimality analysis		
	Other algorithms for solving LP problems – Karmarkar's projective scaling method	1	
4. Linear Programming Applications	Use of software for solving linear optimization problems using graphical and simplex methods	1	4
	Examples for transportation, assignment, water resources, structural and other optimization problems	3	
5. Dynamic Programming	Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality	1	4
	Recursive equations – Forward and backward recursions;	2	

	Computational procedure in dynamic programming (DP)		
	Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP	1	
6. Dynamic Programming Applications	Problem formulation and application in Design of continuous beam and Optimal geometric layout of a truss	2	6
	Water allocation as a sequential process	2	
	Capacity expansion and Reservoir operation	2	
7. Integer Programming	Integer linear programming; Concept of cutting plane method	1	3
	Mixed integer programming; Solution algorithms; Examples	2	

8. Advanced Topics in Optimization	Piecewise linear approximation of a nonlinear function	1	6
	Multi objective optimization – Weighted and constrained methods; Multi level optimization	2	
	Direct and indirect search methods	1	
	Evolutionary algorithms for optimization and search	1	
	Applications in civil engineering	1	
Total			**40**

References:

1. S.S. Rao, "Engineering Optimization: Theory and Practice", New Age International P)Ltd., New Delhi, 2000.
2. G. Hadley, "Linear programming", Narosa Publishing House, New Delhi, 1990.
3. H.A. Taha, "Operations Research: An Introduction", 5th Edition, Macmillan, New York, 1992.
4. K. Deb, "Optimization for Engineering Design-Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.
5. K. Srinivasa Raju and D. Nagesh Kumar, "Multicriterion Analysis in Engineering and Management", PHI Learning Pvt. Ltd., New Delhi, India, ISBN 978-81-203-3976-7, pp.288,

2010.