CML 423: OPTIMIZATION TECHNIQUES

Course No.: CML 423

Course Title: Optimization Technique

Course Type: Elective

Course Credits: 3

Course description:

This course mainly deals with the basics of different optimization techniques and its application for various engineering purpose.

Pre-requisites: Numerical methods, Basic Math's

Objectives:

To understand the basics of optimization techniques, and problem formulation for optimization

To understand the single variable and multivariable optimization techniques and their application

To understand the linear programming application for optimization

To understand the advance optimization technique like the genetic algorithm

Outcomes:

The students will understand the necessary and sufficient condition for optimization and will be able to formulate the optimization problem.

The students will be able to solve different optimization problem and their application to the case studies like heat exchanger, evaporator etc.

Expanded Course description:

Nature and organization of optimization problems: what optimization is all about, Why

optimize, scope and hierarchy of optimization, examples of applications of optimization, the essential features of optimization problems, the general procedure for solving optimization problems, obstacles to optimization.

Classification of models, how to build a model, fitting functions to empirical data, the method of least squares, factorial experimental designs, fitting a model to data subject to constraints.

Basic concepts of optimization: Continuity of functions, unimodal versus Multimodel functions. Convex and Concave functions, Convex region, Necessary and sufficient conditions for an extremum of an unconstrained function, interpretation of the objective function in terms of its quadratic approximation.

Optimization of unconstrained functions: one-dimensional search: Numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of uni-dimensional search, region elimination methods, polynomial approximation methods, how the one- dimensional search is applied in a multi-dimensional problem, evaluation of uni-dimensional search methods.

Unconstrained multivariable optimization: Direct methods, random search, grid search, uni-variate search, simplex method, conjugate search directions, Powell's method, indirect methods- first order, gradient method, conjugate method, indirect method- second order: Newton's method forcing the Hessian matrix to be positive definite, movement in the search direction, termination, summary of Newton's method, relation between conjugate gradient methods and Quasi-Newton method.

Linear programming and applications: Basic concepts in linear programming, Degenerate LP's – graphical solution, natural occurrence of linear
constraints, the simplex method of solving linear programming problems, standard LP form, obtaining a first feasible solution, the revised simplex method, sensitivity analysis, duality in linear programming, the Karmarkar algorithm, LP applications.

Optimization of Unit operations-1 recovery of waste heat, shell & tube heat exchangers,

evaporator design, liquid-liquid extraction process, optimal design of staged distillation column.

Optimization of Unit operations-2 Optimal pipe diameter, the optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat, optimization of thermal cracker using linear programming.

Genetic Algorithms: (Qualitative treatment) Working principles, differences between GAs and traditional methods, similarities between GAs and traditional methods, GAs for constrained optimization, other GA operators, real coded GAs, Advanced Gas.

Textbooks:

1) Edgar, T.F., D.M. Himmelblau, and L.S. Lasdon, Optimization of Chemical Processes, 2nd Edition, McGraw-Hill International Edition, Singapore, 2001.
2) Rao, S.S., Engineering Optimization Theory and Practice, 4th Edition, A Wiley Interscience Publication, Canada, 2009.
3) Reklaitis, G.V., A. Ravindran, and K.M. Ragsdell, Engineering Optimization: Methods and Applications, 2 nd Edition, John Wiley, New York, 2006.
4) Fletcher R., Practical method of optimization, 2 nd Edition, John Wiley, New York, 2000.
5) Chong E.K.P. and Zal S. H., An Introduction to optimization, 2 nd Edition, John Wiley, New York, 2001.
6) Nocedal J. and Wright S.J. Numerical Optimization, 2 nd Edition, Springer,2000.
7) G. Mitsuo and C. Runwei, Genetic Algorithms and Engineering Optimization, John Wiley, New York, 2000.

Class Schedule: 3 Classes a week each of 55 minutes