

# Design and Optimization of Energy systems - Video course

## COURSE OUTLINE

Introduction to system design - Regression analysis and curve fitting - modeling of thermal equipment (very brief) - system simulation (successive substitution - Newton - Raphson method) - examples - economic analysis - optimization - Lagrange multipliers, search methods, linear programming, geometric programming- New generation optimization techniques - simulated annealing, Genetic Algorithms, Bayesian statistics.

Examples applied to heat transfer problems and energy systems such as gas and steam power plants, refrigeration systems, heat pumps and so on.

## COURSE DETAIL

| Sl. No | Topic   | Lectures |
|--------|---|----------|
| 1.     | <b>Module 1: Introduction</b> <ul style="list-style-type: none"> <li>• Introduction to design and specifically system design.</li> <li>• Morphology of design with a flow chart.</li> <li>• Very brief discussion on market analysis, profit, time value of money, an example of discounted cash flow technique.</li> <li>• Concept of workable design, practical example on workable system and optimal design.</li> </ul> | 3-4      |
| 2.     | <b>Module 2 : System Simulation</b> <ul style="list-style-type: none"> <li>• Classification.</li> </ul>   | 6-7      |



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## Mechanical Engineering

### Pre-requisites:

- Thermodynamics.
- Fluid Mechanics.
- Heat Transfer.

### Additional Reading:

1. There is an accompanying text book titled "**Essentials of Thermal System Design and Optimization**" authored by Prof. C. Balaji and Published by Ane Books, New Delhi in India and CRC Press in the rest of the world.

### Coordinators:

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|    | <ul style="list-style-type: none"> <li>• Successive substitution method - examples.</li> <li>• Newton Raphson method - one unknown - examples.</li> <li>• Newton Raphson method - multiple unknowns - examples.</li> <li>• Gauss Seidel method - examples.</li> <li>• Rudiments of finite difference method for partial differential equations, with an example.</li> </ul>   |    |  |
| 3. | <p><b>Module 3: Regression and Curve Fitting</b></p> <ul style="list-style-type: none"> <li>• Need for regression in simulation and optimization.</li> <li>• Concept of best fit and exact fit.</li> <li>• Exact fit - Lagrange interpolation, Newton's divided difference - examples.</li> <li>• Least square regression - theory, examples from linear regression with one and more unknowns - examples.</li> <li>• Power law forms - examples.</li> <li>• Gauss Newton method for non-linear least squares regression - examples.</li> </ul> | 8  |  |
| 4. | <p><b>Module 4: Optimization</b></p> <ul style="list-style-type: none"> <li>• Introduction.</li> <li>• Formulation of optimization problems – examples.</li> <li>• Calculus techniques – Lagrange multiplier method – proof, examples.</li> <li>• Search methods – Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden</li> </ul>   | 22 |  |

section search – numerical examples.

- Method of steepest ascent/ steepest descent, conjugate gradient method – examples.
- Geometric programming – examples.
- Dynamic programming – examples.
- Linear programming – two variable problem –graphical solution.
- New generation optimization techniques – Genetic algorithm and simulated annealing - examples.
- Introduction to Bayesian framework for optimization- examples.

#### References:

1. Essentials of Thermal System Design and Optimization, Prof. C. Balaji, Aue Books, New Delhi in India and CRC Press in the rest of the world.
2. Design and optimization of thermal systems, Y.Jaluria, Mc Graw Hill, 1998.
3. Elements of thermal fluid system design, L.C.Burmeister, Prentice Hall, 1998.
4. Design of thermal systems, W.F.Stoecker, Mc Graw Hill, 1989.
5. Introduction to optimum design, J.S.Arora, Mc Graw Hill, 1989.
6. Optimization for engineering design - algorithms and examples, K.Deb, Prentice Hall, 1995.