Course Title: Fundamentals of Optimization with GAMS Practice

Course Description:

This course provides a comprehensive exploration of optimization techniques and their wide-ranging applications across various fields, including Engineering, Economics, Business, and more. It covers the fundamentals of optimization, encompassing unconstrained optimization, linear programming, integer programming, nonlinear programming, and sensitivity analysis. Practical experience is a key component as learners gain hands-on skills using the General Algebraic Modeling System (GAMS) to model and solve optimization problems, enabling them to interpret results effectively.

For learners navigating complex design problems, this course offers a deep understanding of both theory and practical application in the realm of engineering optimization. Topics include formulating optimization problems, interpreting results, conducting sensitivity analysis, exploring cost functions, evaluating figures of merit, comparing optimization techniques, and recognizing multi-objective optimization challenges.

Course Objectives:

- Grasp fundamental concepts of optimization and their real-world applications.
- Explore various optimization techniques, understanding their strengths and weaknesses.
- Develop proficiency in modeling and solving optimization problems using GAMS.
- Apply optimization principles to address complex issues in economics, business, engineering, and other domains.
- Foster critical thinking and problem-solving skills.

Prerequisites:

A basic knowledge of calculus and linear algebra is recommended.

Course Outline:

Module 1: Introduction to Optimization

- What is Optimization?
- Types of Optimization Problems
- The Significance of Optimization in Real-World Applications

Module 2: Unconstrained Optimization

- Introduction to Unconstrained Optimization
- Optimization Algorithms (e.g., Gradient Descent, Newton's Method)

- Convergence and Stopping Criteria

Module 3: Linear Programming (LP)

- Introduction to Linear Programming
- Formulating LP Problems
- Graphical Solution Methods
- The Simplex Method

Module 4: Integer Programming (IP)

- Introduction to Integer Programming
- Formulating IP Problems
- The Branch and Bound Algorithm
- Mixed-Integer Programming (MIP)

Module 5: Nonlinear Programming (NLP)

- Introduction to Nonlinear Programming
- Formulating NLP Problems
- Optimality Conditions (KKT Conditions)
- NLP Solvers

Module 6: Sensitivity Analysis

- Sensitivity Analysis in LP
- Sensitivity Analysis in IP
- Sensitivity Analysis in NLP

Module 7: Advanced Topics (Optional)

- Multi-objective Optimization
- Stochastic Optimization
- Global Optimization

GAMS Practice

Module 1: Introduction to GAMS

- GAMS Environment and Syntax
- Data and Model Definitions in GAMS

Module 2: Problem Formulation and Mathematical Modeling

- Defining Engineering Design Problems
- Mathematical Modeling Techniques
- Constraints, Objectives, and Decision Variables

Module 3: Interpretation and Practical Application with GAMS Practice (Examples)

- Translating Optimization Results to Real-World Solutions
- Practical Problem Solving
- Setting up and Solving LP Problems in GAMS
- Solving IP and MIP Problems in GAMS
- Modeling and Solving NLP Problems in GAMS
- Sensitivity Analysis in GAMS
- Real-World Applications in GAMS (e.g., Farm Planning, Vehicle Routing, Transportation Problems, Computable General Equilibrium Model, etc.)

Recommended Textbooks:

- Rao, S.S., Optimization – Theory and Applications, 5th ed., John-Wiley, 2019.
- GAMS User Guide by GAMS Development Corporation
- Various research papers and GAMS codes will be provided during the course.

Note: The course duration and the number of GAMS modeling projects can be adjusted based on the course length and depth desired. Additional real-world applications and GAMS modeling projects can be incorporated as needed.