ISYE 4133 ADVANCED OPTIMIZATION

Elective
Credit:
3-0-3
Prepared by:
Prof. Andy Sun, Fall 2013

Prerequisite(s):
ISyE 3133, CS 2316

Catalog Description:
Topics include mathematical foundations of optimization, modeling and solution techniques for very large and/or complex problems, algorithmic solution methods and heuristics, and optimization software.

Text:
Introduction to Mathematical Programming: Applications and Algorithms by Wayne L. Winston, Duxbury Press, 2002 (advanced chapters) or *Optimization in Operations Research* by Ronald L. Rardin, Prentice Hall, 1997 (advanced chapters), or equivalent. Study notes and tutorials posted on T-square.

Objective:
Many real-world problems require advanced techniques to formulate and to solve, and sometimes new optimization algorithms and procedures need to be designed. The objective of this class is to help students become optimizers, who have solid understanding of basic theory and also practical skills to model and solve real-world problems. Students will learn

- a deeper understanding of the key concepts, theory, and algorithms of linear optimization, integer optimization, and some modern convex optimization,
- more advanced modeling techniques,
- ways of solving optimization problems that are too hard, too large for direction solution,
- ways of solving optimization problems faster when speed is essential,
- ways to assess the quality of sub-optimal solutions.

Topical Outline

1. Linear Optimization:
    a. Modeling using linear optimization
    b. Geometry of LP
    c. Revised simplex method
    d. Duality theory
    e. Large scale optimization:
        i. Column generation
        ii. Constraint generation

iii. Dantzig-Wolfe decomposition
iv. Benders decomposition

2. Discrete Optimization:
    a. Application and formulation techniques of discrete optimization
    b. Branch-bound and cutting plane methods
3. Convex Optimization:
    a. Applications of convex optimization
    b. Modeling and fast prototyping using convex optimization

Course Outcomes and their relationships to ISyE Program Outcomes
At the end of this course, students will be able to:

1. Understand the basic theory and some advanced topics in linear optimization, integer optimization, and convex optimization.
2. Identify the proper optimization technique(s) to attempt when problems are too large or too complicated to solve in a straightforward way.
3. Use optimization software and implement solution algorithms involving large-scale optimization techniques..
4. Handle large data sets that accompany real-world optimization problems.

Course outcome \ Program Outcomes	**a. apply math**	**b. Design, conduct experiment, analyze interpret data**	**c. Design system**	**d. team**	**e. problem solving**	**f. prof/ and ethical responsibilities**	**g. communication**	**h. global, eco, envi and soc context**	**i. Life-long learning**	**j. Contemporary issues**	**k. use tools for eng. practice**
Understand theory and advanced topics …					High				Med		
Identify techniques when there is no straightforward method	High						Med				
Use software …			Med		High		Med				High
Handle very large data sets…		High		Med					Med		High

Evaluation of the important course outcomes
The final, course projects,

1. Students should have solid understanding of the basic theory and some advanced topics in linear optimization, integer optimization, and convex optimization.
2. Students should be able to identify the proper optimization technique(s) to attempt when problems are too large or too complicated to solve in a straightforward way.

3. Students should be able to use optimization software and implement solution algorithms to solve large-scale optimization problems.
4. Students should be able to successfully handle large data sets that accompany real-world optimization problems.

ISyE ABET Student Outcomes a - k

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.