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.

Student Outcome Assessment Plan

Course outcome \ Program Outcomes	**1. identify, formulate solve engg prob by engg, sci & Math**	**2. produce solutions consider public health, safety, welfare, global, cultural, social, environ & economic**	**3 communicate with a range of audience**	**4 recognize ethical & professional responsibilities, make informed judgement consider resolutions in global, economic, environ and societal context.**	**5. effective on a team provide leadership, collaborative and inclusive envirn, plan tasks & meet objectives**	**6. develop and conduct experiment, analyze and interpret data & use engineering judgement to draw conclusions.**	**7. acquire and apply new knowledge using appropriate learning strategies**
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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..							
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Evaluation of the important course outcomes

This elective course will not be used for assessment.

The approximate relationship from prior ABET a – k to new ABET 1 – 7.

OLD Criterion 3. Student Outcomes The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.	NEW Criterion 3: Student Outcomes The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.
(a) an ability to apply knowledge of mathematics, science, & engineering (e) an ability to identify, formulate, and solve engineering problems	(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
(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 & safety, manufacturable, & sustainable	(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration for public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
(d) an ability to function on multidisciplinary teams	(5) An ability to function effectively on a team whose members together provide leadership, create a collaborative & inclusive environment, establish goals, plan tasks, and meet objectives.
(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engg solutions in a global, economic, environmental, & societal context (j) a knowledge of contemporary issues	(4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
(g) An ability to communicate effectively.	(3) An ability to communicate effectively with a range of audiences.
(i) a recognition of the need for, and an ability to engage in life-long learning	(7) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	Implied in 1, 2 and 6