

ISYE 4133 ADVANCED OPTIMIZATION

Concentration depth elective for Operations Research and Analytics and Data Sci.

Credit: 3-0-3

Prepared by: Prof. Matthieu Dahan, George Lan and Johannes Milz, Fall 2026

Prerequisite(s): ISyE 3133, CS 2316

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 Canvas.

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.

Course Description

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 Learning 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.

The Mapping from the Course Outcomes to ABET Student Learning Outcomes

The table below shows the relationship between course outcomes and ABET student learning outcomes. The table has 8 columns. The first column lists the course learning outcomes listed above. The next 7 columns list the abbreviated ABET Student Learning Outcomes. The entry of H in a row with specific course learning outcome and column with specific ABET Student Learning Outcomes indicate the importance of attaining this outcome is high and will be assessed.

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 envirm, 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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Evaluation of the important course outcomes

This elective course will not be used for assessment.