IEOR E4004: Introduction to Operations Research: Deterministic Models

Jay Sethuraman; email: jay@ieor.columbia.edu
338 Mudd; tel: 212-854-4931

Description. This class is (intended to be) an introduction to the fundamental methods used in "deterministic" operations research. Topics covered will include linear programming, network flows, dynamic programming, and nonlinear programming. While we shall discuss the underlying theory with some (occasional) proofs, the emphasis will be on modeling. Applications of these ideas in various settings will be discussed.

Objectives. Our aim is to provide you with:

- informal and formal modeling skills;
- the ability to build, analyze, and reason logically with models;
- the ability to create and work with large-scale models;
- the skills to design and analyze algorithms, and to distinguish good algorithms from not-so-good ones;
- the ability to understand and appreciate proofs; and
- an appreciation for the capabilities and limitations of deterministic models in operations research.

Textbooks. The required textbook for the course is

Paul A. Jensen and Jonathan F. Bard, *Operations Research: Models and Methods*, John Wiley & Sons, Inc., 2003. ISBN: 0-471-38004-0

All other assigned readings will be made available to the students at the appropriate time. Some useful reference textbooks are:

Chvatal, *Linear Programming*, W. H. Freeman, 1983.

Bertsimas & Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997.

S. P. Bradley, A. C. Hax, and T. L. Magnanti, *Applied Mathematical Programming*, Addison-Wesley Publishing Company, 1977.

Lenstra, Rinnooy Kan, & Schrijver (eds.), *History of Mathematical Programming: A Collection of Personal Reminiscences*, Elsevier, 1991.

The textbook and the first two references are on reserve at the Engineering library. The third reference is available online.

Grading. Your final grade will depend on three major components: homework (30%); a mid-term exam (30%), and a final exam (40%). The "homework" component includes weekly problem sets, in-class participation, and may include a project as well.

Lecture Plan. Lectures will be held in 303 Mudd on Tuesdays and Thursdays, 9:10-10:25 a.m. A more detailed (tentative) outline is as follows:

Lecture 01: Course overview; Modeling; Introduction to Optimization Models

Lecture 02: Preview of the Simplex method, Duality

Lecture 03: Formulating problems as mathematical programs

Lecture 04: Mathematical programming formulations (contd.)

Lecture 05: Simplex method for LPs: first steps

Lecture 06: Simplex method for LPs: details, pitfalls

Lecture 07: Duality: motivation, formulation

Lecture 08: Strong duality theorem for LPs; complementary slackness conditions

Lecture 09: Duality: economic interpretation; game theory

Lecture 10: Sensitivity analysis; relationship to duality theory

Lecture 11: Dual simplex method; revised simplex method

Lecture 12: LP theory

Lecture 13: Network models: transportation, assignment, matching

Lecture 14: Network models: shortest paths; spanning trees

Lecture 15: Max flows, Max flow Min cut theorem; min. cost flows

Lecture 16: Cycle canceling algorithm; network simplex algorithm

Lecture 17: Integer programming: formulation techniques, examples

Lecture 18: IP: cutting-plane methods, related topics

Lecture 19: IP: branch-and-bound, related topics

Lecture 20: Dynamic programming: examples, solved problems

Lecture 21: Dynamic programming: solved problems (contd.)

Lecture 22: Nonlinear programming: basics

Lecture 23: Nonlinear programming: algorithms

Lecture 24: Special topics: Decomposition, large-scale optimization

Lecture 25: Special topics: multiobjective optimization; goal programming

Lecture 26: Special topics: constraint programming