Department of Industrial Engineering & Operations Research

IEOR262A Mathematical Programming I

Semester: Fall 2017 *Instructor: Alper Atamtürk*

Prerequisites: Real analysis and linear algebra at the level of Math104/Math110

Required textbooks:
1. Introduction to Linear Optimization by Dimitris Bertsimas and John N. Tsitsiklis, Athena Scientific, 1997. ISBN-13: 978-1886529199
2. Nonlinear Programming: Theory and Algorithms (third edition) by Mokhtar S. Bazaraa, C. M. Shetty and Hanif D. Sherali, Wiley, 2006. ISBN-13: 978-0471486008

Recommended book:
AMPL: A Modeling Language For Mathematical Programming, Robert Fourer, David M. Gay, and Brian W. Kernighan, 2nd ed., Duxbury Press/Brooks/Cole Publishing Company, 2002. ISBN 0-534-38809-4
Available online at `http://ampl.com/resources/the-ampl-book/`

Instructor: Alper Atamtürk (email: `atamturk@berkeley.edu`)
Lectures: Tue Thr 12:30–2 PM (3111 Etcheverry)
Office hrs: Tue 2–4 PM (423 Sutardja Dai Hall)

Discussion hrs: Sec 101: Fri 9–10 AM (3113 Etcheverry)

Course web page: Maintained at `https://bcourses.berkeley.edu/`
Final exam: Thursday, December 14, 2017 3–6 PM

Course description

This course is an introduction to optimization at a graduate level. The course will cover fundamental concepts in optimization theory, generic algorithmic approaches, as well as modeling optimization problems and their numerical solution. In particular, the topics will include elements of convex analysis, linear programming, sensitivity analysis, Lagrangian duality, local optimality conditions for unconstrained and constrained nonlinear problems, and introduction to discrete optimization. Optimization algorithms, including the simplex method and its variants, steepest descent method, Newton's method, and branch-and-bound method will be introduced.

Students will be assigned theoretical, modeling as well as computational problems. There will be a midterm exam and a final exam.

Grading

- Problem Sets: 30%
- Midterm Exam: 30% [October 17, 2017, 12:30–2:00 PM (tentative)]
- Final Exam: 40% [December 14, 2017, 3–6 PM]

Outline

1. Elements of convex analysis
   - Basic terminology
   - Convex sets and convex functions (NLP: Ch2, Ch3)
   - Projection, separating hyperplanes, Farkas' lemma (LP: Sec 4.6, 4.7)
   - Polyhedral sets (LP: Ch 2)
2. Linear programming
   - Introduction to linear programming (LP: Ch 1)
   - Duality, certificates of optimality and unboundedness (LP: Ch 4)
   - Simplex method and its variants (LP: Ch 3)
   - Sensitivity analysis and parametric programming (LP: Ch 5)
3. Nonlinear programming
   - Unconstrained optimization (NLP: Ch 1)
     - Local optimality conditions (NLP: Sec 4.1)
     - Steepest descent method (NLP: Sec 8.6)
     - Newton's method and its variants (NLP: Sec 8.6)
   - Constrained optimization (NLP: Ch 3, Ch 4)
     - Local optimality conditions for equality constrained problems
     - Karush-Kuhn-Tucker conditions & constraint qualification (NLP: Ch 4, Ch 5)
     - Lagrangian duality and saddle point optimality conditions (NLP: Ch 6)
4. Discrete optimization
   - Computational complexity (LP: Secs 8.1, 11.8)
   - Modeling techniques (LP: Ch 10)
   - Network problems and total unimodularity (LP: Ch 7)
   - Relaxation and search (LP: 11)
   - Dynamic programming (LP: 11)
   - The art and joy of optimization: applications (LP: Ch 12)

This syllabus may be modified as time and interests dictate.