University of Wisconsin, Madison

Agricultural and Applied Economics 526

INTRODUCTION TO OPTIMIZATION

Fall Semester, 2017

Thomas F. Rutherford

Lectures
MWF 8:50–9:40am, Birge B302

Office Hours

Tuesday Afternoons (2:30-4:00pm)	WID 4243 (phone 608 616-4362)
Thursday Mornings (10:00-12:00pm)	330 Taylor Hall (phone: 608 890-4576)

rutherford@aae.wisc.edu

Overview:

In this course, students will learn to recognize and solve optimization problems that arise in industry and research applications. The course will cover convex problems such as linear and quadratic programming, least squares, and semidefinite programs, as well as non-convex problems such as mixed-integer programs and discrete/combinatorial optimization. Examples will be drawn from a variety of disciplines, including computer science, operations research, control and mechanical engineering, machine learning, finance and quantitative economics.

Prerequisites:

Knowledge of basic linear algebra and calculus is required. Familiarity with a modeling language such as GAMS or AMPL or with Matlab, Python, or Julia is expected, as you will be writing simple scripts as part of your homework. Although the problems covered in class are broad, no specic area knowledge is required.

Course assignments and the term project will be based on an *algebraic modeling language*, GAMS (`http://www.gams.com`). A limited term license will be provided to course participants.

Grading:

- Homework: 45%. There will be bi-weekly homework assignments which will be a mix of theory and practical problem-solving (with GAMS programming). You may discuss problems with classmates and work in groups, but the work you turn in must be your own. Assignments are each graded out of 4 points.
- Exam: 25%. The exam will be held on Thursday, November 16 from 7 to 9pm, location TBA. Mostly theory questions, covering material from the first two thirds of the course.
- Final project: 30%. You will work in groups of 3 or 4, and you will develop an application of methods covered in the course to a specific problem of your choosing. The project will involve the formulation and application of mathematical programming model, and you will provide a writeup with motivates the model formulation, describe how the model parameters are established, and summarizes what you have learned from your model.

Tentative Schedule:

The course will be roughly split into three modules. The first module will cover the mathematical preliminaries of optimization and linear programming as well as an introduction to modeling languages. The second module will cover quadratic and second order cone problems and their applications. The third module will cover nonlinear optimization and a limited number of nonconvex problems, including mixed-integer programs. Time permitting, the final section of the course will introduce sample applications in dynamic and stochastic programming.

Week 1 (Sep 6-8)	Introduction, review of math concepts
Week 2 (Sep 11-15)	Convex functions and sets
Week 3 (Sep 18-22)	Optimization problems and modeling languages
Week 4 (Sep 25-29)	Linear programming and duality
Week 5 (Oct 2-6)	Estimation and least squares
Week 6 (Oct 9-13)	Regularization and quadratic programs (QPs)
Week 7 (Oct 16-20)	Other applications of LP and QP models
Week 8 (Oct 23-27)	General nonlinear programs (NLPs)
Week 9 (Oct 30-Nov 3)	Network models
Week 10 (Nov 6-10)	Optimization over time
Week 11 (Nov 13-17)	Review and Exam
Week 12 (Nov 20-22)	Intro to nonconvex and combinatorial problems
Week 13 (Nov 27-Dec 1)	Assignment problems
Week 14 (Dec 4-8)	Mixed-integer programs
Week 15 (Dec 11-15)	Optimization with uncertainty

Textbooks

The course will draw on a couple of textbooks as well as material provided on the course web page. There is no required texbook for the course. However, there are plenty of good references. Here are a few:

- *Model Building in Mathematical Programming* by H.P. Williams, 5th Edition. Wiley, 2013.
- *Optimization in Operations Research*, by R.L. Rardin. Prentice Hall, 1998.
- *Introduction to Operations Reseach*, by Frederick Hillier and Gerald Lieberman.
- *Linear Programming with MATLAB*, by Michael Ferris, Olvi Mangasarian and Stephen Wright,