Introduction to Engineering Optimization (CE 4920)

Fall 2009

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Office Hours: Tuesday and Thursday, 11:00-1:30 and by appointment
Course Website: TBA

Welcome to CE 4920! This course will expose you to the tools of optimization, which underlies almost any civil engineering problem. What is the least expensive way to design a truss to support a given load? How should water be released from a reservoir to serve people and businesses without its level dropping too low? In a construction schedule, what are the "critical tasks" which cannot be delayed if the project is to finish on time? How should a traffic signal be timed to minimize delay to drivers?

By the end of this course, you will have the tools to answer these, and many other questions which arise in civil engineering. You will be able to formulate a variety of engineering problems as optimization models, and have the practical knowledge needed to solve them. Furthermore, you will have a conceptual understanding of optimization models which allows you to understand and critically evaluate model results which others may present to you. This course will require you to both understand the basic concepts of optimization, and to apply them in a project involving an oral presentation and written report.

Course Materials

The required text for the course is *Applied Mathematical Programming*, which is available for free download online (`http://web.mit.edu/15.053/www/`) as well as supplementary notes which I will provide when needed. You may find the following textbooks useful for more detail on specific topics, but they are not required:

- Ahuja, R., T. Magnanti, and J. Orlin. (1993) *Network Flows.* Prentice-Hall, Englewood, NJ.
- Bertsimas, D. and J. N. Tsitsiklis. (1997) *Introduction to Linear Optimization.* Athena Scientific, Cambridge, MA.
- Revelle, C. S., E. E. Whitlatch, and J. R. Wright. (1999) *Civil and Environmental Systems Engineering.* Prentice-Hall, Upper Saddle River, NJ.

You will also learn how to use AMPL, a software program commonly used to solve large optimization problems. A free student version may be downloaded from the AMPL website, and I will arrange to have AMPL available in the civil engineering computer labs. If you are a Windows user, I would recommend the GUI version of AMPL found at `http://www.ampl.com/GUI/amplvb.zip`. Versions for other operating systems can be downloaded from `http://www.ampl.com/DOWNLOADS/index.html`. Each Friday, part of the lecture will teach you how to use AMPL for solving optimization problems.

Grading

Final course grades are determined by performance on homeworks, an in-class exam, a term project, and class participation. The weight of each of these factors is as follows:

Category	Weight
Homeworks	30%
Exam	30%
Project	30%
Participation	10%

These components are designed to work together: the exam focuses on concepts, while the course project involves application and skills involved in engineering practice. The homeworks and lectures give you a chance to learn these skills and practice them throughout the semester.

Six homeworks will be assigned throughout the semester, each worth 5% of your final grade. Homeworks are assigned, collected, and returned on a two-week cycle. Each homework will be graded and returned before the next is assigned. Parts of assignments involving computer work (including spreadsheets, graphs, and AMPL code) will need to be typed (although you are certainly welcome to type the rest of the assignment as well!). You are encouraged to work together on homeworks, but you must submit solutions in your own words. These homeworks will require a significant amount of time and effort — do not wait until the night before to start! Late homeworks are only accepted if you notify me of a time conflict or need for extension *before* the due date.

The exam will take place before the Thanksgiving break, and is comprehensive. No final exam is scheduled during finals week. This exam is open-notes, and no calculators will be needed or permitted.

The project will culminate in oral presentations and a written report, both due in the last week of class. Potential project topics include application of one or more of these optimization models to a real-world scenario, comparison of different solution methods for the same problem, development of a computer tool to automate a solution method, or another optimization-related topic of interest. Please send your project topic to me for approval by November 6 *at the very latest*, but you are strongly encouraged to start earlier. At the end of the semester, you will be required to present your project to the rest of the class, and complete a written report documenting all of your work.

Miscellanea

The University of Wyoming is built upon a strong foundation of integrity, respect and trust. All members of the university community have a responsibility to be honest and the right to expect honesty from others. Any form of academic dishonesty is unacceptable to our community and will not be tolerated [from the UW General Bulletin]. Teachers and students should report suspected violations of standards of academic honesty to the instructor, department head, or dean. Other University regulations can be found at: `http://uwadmnweb.uwyo.edu/legal/universityregulations.htm`

If you have a physical, learning, or psychological disability and require accommodations, please let me know as soon as possible. You must register with, and provide documentation of your disability to University Disability Support Services (UDSS) in SEO, room 330 Knight Hall.)

Schedule

A tentative class schedule is shown below. All dates and topics are subject to change. The readings listed for a given day are to be done after the class, in preparation for the next lecture. Unless specified otherwise, the readings are sections from *Applied Mathematical Programming*. “Notes” indicates that I will distribute a set of notes for you to read.

Tentative class schedule

Date	Topic	Assignment	Reading
8/24	Course overview, engineering applications		1.1-1.3
8/26	Engineering applications, formulating models		1.4-1.5
8/28	Formulating models, introduction to AMPL	HW1 assigned	AMPL notes
8/31	Formulating models		13.1, Notes
9/2	Intro to nonlinear programming		Notes
9/4	One-dimensional optimization	HW 1 due	Notes
9/7	**NO CLASS: Labor Day**		
9/9	Lagrange multipliers	HW 1 returned	Notes
9/11	Karush-Kuhn-Tucker conditions	HW 2 assigned	Notes
9/14	Newton's method		Notes
9/16	Descent methods		Notes
9/18	Lagrangian methods	HW 2 due	Notes
9/21	Introduction to linear programming		Notes
9/23	Linear programming geometry	HW 2 returned	Notes
9/25	Linear programming algebra	HW 3 assigned	2.1,2.2
9/28	Simplex method: Concepts		2.3
9/30	Simplex method: Application		2.4
10/2	Simplex method: Application	HW 3 due	3.1-3.2
10/5	LP sensitivity analysis		3.3
10/7	LP sensitivity analysis	HW 3 returned	3.4
10/9	LP sensitivity analysis	HW 4 assigned	
10/12	**NO CLASS**: INFORMS conference		
10/14	**NO CLASS**: INFORMS conference		11.1
10/16	Dynamic programming	HW 4 due	11.2
10/19	Dynamic programming		11.4
10/21	Dynamic programming	HW 4 returned	11.7
10/23	Dynamic programming	HW 5 assigned	Notes
10/26	Introduction to graph theory		Notes
10/28	Minimum spanning trees		Notes
10/30	Minimum spanning tree algorithms	HW 5 due	Notes
11/2	Introduction to shortest paths		Notes
11/4	Label setting algorithms	HW 5 returned	Notes
11/6	Label correcting algorithms	HW 6 assigned	Notes
11/9	Introduction to max flow		Notes
11/11	Max flow/min cut duality		Notes
11/13	Practical max flow algorithms	HW 6 due	Notes
11/16	Stochastic programming	HW 6 returned	Notes
11/18	Stochastic programming		Notes
11/20	Stochastic programming		Notes
11/23	**IN-CLASS EXAM**		
11/25	**NO CLASS: Thanksgiving break**		
11/27	**NO CLASS: Thanksgiving break**		
11/30	Project presentations		
12/2	Project presentations		
12/4	Project presentations, course wrap-up	Project report due	