WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Introduction to Optimization

CS/ECE/ISyE 524 — Spring 2017–18

Official information

- **Meets:** Tuesday/Thursday 1:00pm–2:15pm, Ingraham Hall B10.
- **Canvas course URL:** We will not use Canvas for this course. The course website is: `http://www.laurentlessard.com/teaching/524-intro-to-optimization/`
- **Piazza:** Online forum for asking and answering questions about course material: `https://piazza.com/wisc/spring2018/cseceisye524`
- **Official course description:** Introduction to mathematical optimization from a modeling and solution perspective. Formulation of applications as discrete and continuous optimization problems and equilibrium models. Survey and appropriate usage of basic algorithms, data and software tools, including modeling languages and subroutine libraries.
- **Requisites:** (COMP SCI 200, 300, 301, 302, or 310) and (MATH 320, 340, 341, or 375) or graduate or professional standing.
- **Course designations and attributes:**
  - Elective course in CS, ECE, and ISyE.
  - *Breadth*: Natural Science.
  - *Level*: Intermediate.
  - *L&S Credit:* Counts as Liberal Arts and Science credit in L&S.
- **Instructional mode:** All face-to-face.
- **Credits:** 3 credits and 37.5 contact hours.
- **Repeatable for credit:** No.
- **How this course meets the credit hour policy standard:** This class meets for two 75-minute class periods each week over the spring semester and carries the expectation that students will work on course learning activities (reading, writing, problem sets, studying, etc.) for about 3 hours out of classroom for every class period. This syllabus includes more information about meeting times and expectations for student work.

Course staff

Instructor: Laurent Lessard (`laurent.lessard@wisc.edu`)
TAs: Jui-Yang Chang (`jchang38@wisc.edu`) and Emad Sadeghi (`ssadeghi@wisc.edu`)

Office hours: (see class website for up-to-date location)
Laurent: Tuesdays, 3:00–4:00pm
Jui-Yang: Mondays and Thursdays, 9:45–10:45am
Emad: Wednesdays and Thursdays, 4:00–5:00pm

Learning outcomes

Course learning outcomes: These apply to both graduate and undergraduate students enrolled in the class. Upon successful completion of this course, students will be able to:

- Extract a sensible mathematical model from a problem description provided in plain text, and solve the problem. Specifically:
  - Identify decision variables, algebraic constraints, and an objective function.
  - Categorize the model type (LP, MIP, QP, NLP, etc.).
  - Simplify the model if possible.
  - Implement and solve the problem in a modeling language.
  - Interpret the solution and provide an answer in plain text.
- Demonstrate an intuitive understanding for broad classes of optimization models. Specifically:
  - Visualize and illustrate algebraic constraints geometrically.
  - Summarize the general algorithmic techniques used to solve different classes of optimization problems and comment on their efficiency, reliability, and scalability.
  - Perform appropriate sensitivity and trade-off analyses.

ABET student outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering

e) an ability to identify, formulate, and solve engineering problems

g) an ability to communicate effectively

k) an ability to use the techniques, skills, and modern engr. tools necessary for engr. practice

Brief list of topics

The course is divided in three roughly equal parts. Here is a list of topics covered in each part.

I. Linear Programming: linear equations and constraints, linear programs, polyhedra, feasibility/boundedness, minimax and planning problems, assignment problems, network flow problems, LP duality, dual flows, simplex algorithm.

II. Convex Programming: least squares, tradeoffs and Pareto curves, regularization, quadratic programs, second-order cone programs, semidefinite constraints, general convex programming, duality theory, interior point methods.

III. Nonconvex and Combinatorial Models: rounding and relaxation, fixed costs and variable bounds, modeling integer constraints and logic constraints, set cover and the Traveling Salesman Problem, quadratic assignment problems, special ordered sets, cutting plane and branch & bound methods, nonlinear programming, iterative optimization algorithms.

Required materials

There is no required textbook for the class. All course material will be presented in class and/or provided online as notes. That being said, several textbooks cover parts of what we will see in class, and you may find it helpful to use them as references. Here are a few:

- S. Boyd and L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. The book is available for free here: `http://stanford.edu/~boyd/cvxbook/`.
- H.P. Williams. *Model Building in Mathematical Programming*, 5th Edition. Wiley, 2013.
- R.L. Rardin. *Optimization in Operations Research*. Prentice Hall, 1998.

Evaluation

Graduate and undergraduate students will be expected to perform at the graduate level and will be evaluated equally. Students will be evaluated by weekly homework assignments (45%), a midterm exam (25%), and a final project (30%). There is *no final exam*. More in-depth descriptions:

- *Homework*: 45%. There are roughly weekly homework assignments (about 10 total). Homework problems will include mathematical derivations as well as more applied problems that involve writing code and working with real or synthetic data sets. You may work in groups to complete the assignments but the work and code you turn in must be your own. All homework must be turned in electronically using Gradescope (will be explained in class).
- *Midterm Exam*: 25%. The midterm exam is a two-hour exam that will take place right before spring break and will cover all material seen up to that point. The exam is closed-book and closed-notes with the exception of one double-sided handwritten sheet of notes. Each student may bring one such sheet that they wrote themselves. The date of the midterm exam is: **Thursday March 22, 7:15pm–9:15pm, Ingraham Hall B10**.
- *Final project*: 30%. Students will work in groups (up to 3 students per group) to produce a final project report. In this report, each group will select an optimization problem, describe it, model it, solve it, interpret the solution, and discuss implications and generalizations. Details regarding report format, evaluation, and project samples from past years will be made available to students during the class. The final project report is due at the end of the semester at the beginning of exam week: **Monday May 7, 11pm**.

Letter grades will be assigned using the following hard cutoffs:

A:	93% or higher	C:	60% or higher
AB:	87% or higher	D:	50% or higher
B:	80% or higher	F:	less than 50%
BC:	70% or higher		

I reserve the right to **lower** any of these cut-offs at my discretion. In other words, any changes I make can only cause your letter grade to stay the same or improve.

Rules, rights, and responsibilities

See the Guide's Rules, Rights and Responsibilities:
http://guide.wisc.edu/undergraduate/#rulesrightsandresponsibilitiestext

Academic integrity

By enrolling in this course, each student assumes the responsibilities of an active participant in UW-Madisons community of scholars in which everyones academic work and behavior are held to the highest academic integrity standards. Academic misconduct compromises the integrity of the university. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these acts are examples of academic misconduct, which can result in disciplinary action. This includes but is not limited to failure on the assignment/course, disciplinary probation, or suspension. Substantial or repeated cases of misconduct will be forwarded to the Office of Student Conduct & Community Standards for additional review. For more information, refer to https://conduct.students.wisc.edu/academic-integrity/

Accommodations for students with disabilities

McBurney Disability Resource Center syllabus statement: "The University of Wisconsin–Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty [I], will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA."
http://mcburney.wisc.edu/facstaffother/faculty/syllabus.php

Diversity & inclusion

Institutional statement on diversity: "Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin–Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world." https://diversity.wisc.edu/