

INDENG 164: Introduction to Optimization Modeling

Spring 2025

Course Description

This course, designed for upper-division students across science and engineering disciplines, offers an in-depth exploration of optimization models. Emphasizing the importance of modeling in the application of optimization techniques, the course provides a comprehensive introduction to optimization modeling languages and their integration with optimization solvers. A key aspect of this course is its focus on the art and science of modeling, especially in the context of uncertainty, a concept highly relevant to data science. Students will engage in extensive modeling exercises, gaining hands-on experience with software packages and programming that is essential for solving optimization problems.

Course Objectives

- Introduction to optimization concepts: Provide students with a thorough understanding of the fundamental principles of optimization.
- Focus on modeling skills: Emphasize the critical role of modeling in optimization, teaching students to develop and apply models effectively using Python.
- Optimization under uncertainty: Address the specific challenges and methodologies of modeling optimization problems in uncertain environments, an area of significant importance in the field of data science.

Prerequisites

COMPSCI C8 (or any other Python-based programming course), Math 53 and Math 54.

Instructor

Ying Cui

Assistant Professor

Department of Industrial Engineering and Operations Research

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Office hours: Wednesdays 12pm-1pm in my office (Etcheverry 4177), or by appointment

Teaching Assistant

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Office hours: Mondays 2-3 pm, Tuesdays 9-10 am (Etcheverry 4176A)

Lecture

Monday and Wednesday 9:00am - 10:00am, GSPP 150

Discussion

Friday 12:00pm - 1pm, McCone 141

Software

The course will be primarily taught with Python, mainly during the discussion sections/labs.

Course Website

Lecture materials, homework assignments, and all other course materials will be posted on the bCourses site.

Additionally, we will use Ed Discussion as the main electronic communication method for the course, including announcements. If you have any questions regarding the course, please post them on Ed Discussion rather than emailing the course staff. If you have a question or concern that is private in nature (i.e., something you would normally send as an email to the course staff), please use a private post on Ed Discussion so that only the course instructor and GSI can see your message. You are encouraged to use public posts in situations where other students may benefit from the discussion. In very rare exceptional circumstances where your message should be kept confidential from the GSI, please email the course instructor and begin the subject line with [IEOR 164 Confidential]. In summary, you should observe the following priority list for course related communications:

1. Make a public post on Ed Discussion.
2. Make a private post on Ed Discussion that only the course instructor and GSI can see.
3. In exceptional circumstances, send an email to the course instructor using [IEOR 164 Confidential] to start the subject line.

We ask that you also please observe the following etiquette on Ed Discussion:

- Do not post answers: Please do not post any answers or your current results on Ed Discussion. Instead, you should explain the key points of your question in a way that allows other students to figure out the essence of the problem on their own. Post problem spoilers after the due date. If you think that your post might give out too much information about the problem solution, then make it private and let the course staff know.

- No pre-grading: We will not answer any questions of the form “Is this the correct way to solve Homework X, Problem Y?”
- Aim for public posts: Other students may have the same question, so please try to make your posts public.
- Formatting: Please try to format code and mathematical equations using the appropriate tools. Here is a helpful Quick Start Guide.
- Ed Discussion is not office hours: Broad conceptual questions are often best reserved for office hours. If a question is too complex to answer on Ed Discussion, we may ask you to try to attend one of our office hours.
- Discussion and collaboration: We highly encourage you to answer or comment on your fellow students’ posts if you know the answer or would like to discuss.

Textbooks

- There is no required textbook for the course. However, a good reference is:

Hands-On Mathematical Optimization with Python. Krzysztof Postek, Alessandro Zocca, Joaquim Gromicho and Jeffrey Kantor. Available at <https://mobook.github.io/MO-book/>

Most of the examples shown during the lectures will be taken from this book.

- Supplementary references:
 - *Operations Research Applications and Algorithms*. Wayne L. Winston. Indiana University
 - *Pyomo: Optimization Modeling in Python (Third Edition)*. Michael L. Bynum, Gabriel A. Hackebeil, William E. Hart, Carl Laird, Bethany L. Nicholson, John D. Sirola, Jean-Paul Watson, and David L. Woodruff. Springer 2021.

Grading

There will be about 9 assignments, one individual mini-project, one in-class midterm and one take-home final exam. Grades for the course will be composed as follows:

- Homework assignments: 40%
- Mini-project: 20%
- Midterm: 20% (tentatively Wednesday March 19 during the class time)
- Final: 20%

Exams:

Closed book and closed notes. One page double-sided formula sheet prepared by the students are allowed during the exam. No computers are allowed during the exam.

More details on the logistics of the exam will be given in class as the exam date approaches. There is no alternative exam date; if you have a hardship preventing you from taking the exam at the scheduled time, please contact us privately on Ed Discussion.

Assignments:

- There will be about 9 assignments in total.
- All assignments will be turned in using Gradescope.
- The homework is generally due **every Tuesday at 11pm**.
 - If you don't do the problem: 0 point
 - If you attempt the problem but make a major mistake: 1 point
 - If you attempt the problem and do not have major conceptual mistakes: 2 points
- The lowest score will be dropped.
- We will adopt the following slip day policy for late homework submissions:
 - You have a total of 5 slip days that you can use throughout the semester. You can turn in any homework assignment late with no penalty, subject to maintaining your budget of 5 total slip days.
 - Once you use all 5 slip days, then we will no longer accept late submissions except under extreme circumstances that usually require documentation.

Mini-project: In addition to regular assignments, the course includes a mini-project, designed as a practical application of the learned material. **The project will be done in teams of (at most) two students.** Students will be provided a case study that needs to be analyzed using optimization techniques taught in the course. Each team has to submit a comprehensive report that documents the analytical models, optimization methods, and the solutions computed. This report is intended to demonstrate not only the student's grasp of optimization techniques but also their ability to apply these methods effectively in real-world scenarios.

AI Tool Usage Policy

The goal of this policy is to encourage responsible and ethical use of AI in educational settings, preparing students for both the benefits and challenges of these emerging technologies. It is imperative that students view AI tools as supplementary aids that enhance, but do not replace, their own critical thinking and problem-solving abilities.

- **AI Tool Usage Allowed:** Students can use AI for homework, coding and report writing.
- **Critical Evaluation:** Students must critically evaluate and verify the accuracy of AI-generated content.
- **Mandatory Disclosure:** When using AI, students must include a statement detailing the AI tool used, its purpose, and any significant modifications made to the AI output. Clarify what changes were made to ensure academic integrity.
- **Prohibited in Exams:** AI tools are not allowed in examinations; students must demonstrate independent knowledge and skills.
- **Balanced Use Encouraged:** Students should balance AI use with developing the ability to perform academically without it. They should learn to discern when the use of AI is beneficial and when it is not.

Tentative List of Topics

Part 1: Deterministic optimization

- Week 1-2: Linear programs
Discussion 1: Treatment planning for intensity-modulated radiation therapy (IMRT)
Discussion 2: Google Ads
- Week 3-4: (Mixed) integer programs
Discussion: NFL sports scheduling
- Week 5: Network flow
Discussion: Cryptocurrency arbitrage search
- Week 6-7: Convex programs
Discussion: Sparse learning
- Week 8: Conic programs
Discussion: Matrix completion

Week 9 Review & Midterm Exam

Part 2: Optimization under uncertainty

- Week 10: Single-stage stochastic programs
Discussion: Economic dispatch
- Week 11-12: Robust optimization
Discussion: Adversarial machine learning
- Week 13-14: Two-stage stochastic programs
Discussion: Facility location problem

Students with Disabilities

UC Berkeley is committed to creating a learning environment that meets the needs of its diverse student body including students with disabilities. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with me.

If you have a disability, or think you may have a disability, you can work with the Disabled Students' Program (DSP) to determine any accommodations you may need to have equal access in this course. The Disabled Students' Program (DSP) is the campus office responsible for authorizing disability-related academic accommodations, in cooperation with the students themselves and their instructors. You can find more information about the DSP application process. I am available if you have any questions or concerns about your accommodations, but in the event of a disagreement, the proper procedure is for you to work with your DSP Specialist and your DSP Specialist to work with me toward a resolution.

Please submit your DSP letters of accommodation as soon as possible. If you are uncertain as to whether you will use the accommodation, it is much better to have the accommodation in place than to scramble at the last minute should you need it. Accommodations are not retroactive, so your GSIs and I are not

responsible for providing accommodations prior to the receipt of an accommodation letter (although if you have extenuating circumstances, we may be able to make temporary adjustments). The more lead time that you provide me, the easier it is for us to arrange your accommodations. Be mindful that it might not be possible to accommodate last-minute requests, depending on your accommodation needs.

If you have a disability-related absence accommodation, you are still required to attend class and participate in order to receive full credit. An absence accommodation does not authorize unlimited absences, but rather only a reasonable number of absences made necessary by the impact of a disability. In the event of such an absence, be sure to inform your GSI and me that your absence is disability-related as soon as you are able, so that you are not penalized. We will follow up with you and your assigned Disability Specialist if we have concerns about the impact of your absences on your ability to fulfill the course requirements.

Almost all accommodation letters provide for extra time on quizzes and exams. This extra time accommodation applies primarily to assessments or exams that take less than 24 hours to complete. For example, if I give you a 48-hour window to complete an exam that is open in bCourses for 2 hours, a student with a DSP accommodation of 150% time would be allowed to take 3 hours within that 48-hour window to complete the exam; the 48-hour window itself would not generally be extended.

If your DSP letter of accommodation allows for extensions on assignments or make-up exams, be mindful that implementing such accommodations is authorized when the impact of your disability prevents you from completing the assignment or taking the exam as scheduled. There is no presumption that you can have extensions outside these circumstances. In the event that the impact of your disability prevents you from completing an assignment or taking an exam as scheduled, it is your responsibility to contact me to request an extension. Extensions are not automatic and failure to communicate with me can result in a loss of points on the assignment or exam. Extensions should be requested prior to the exam or the deadline for an assignment unless there is a documented disability-related reason that the request could not be made beforehand. You may be asked to provide medical documentation to your DSP Specialist (e.g., a note from urgent care) confirming a disability-related reason why you were unable to complete an assignment or take an exam on the originally scheduled date. Under no circumstances should you ever share the medical documentation related to your disability with me. Extensions are generally for a short period of time (1-5 days) unless I specifically authorize a longer extension.

Academic Integrity

You're a member of an academic community at one of the world's leading research universities. Berkeley creates knowledge that has a lasting impact in the world of ideas and on the lives of others; such knowledge can come from an undergraduate paper as well as the lab of an internationally known professor. One of the most important values of an academic community is the balance between the free flow of ideas and the respect for the intellectual property of others. Scholars and students always use proper citations in papers; professors may not circulate or publish student papers without the writer's permission; and students may not circulate or post materials (handouts, exams, syllabi—any class materials) from their classes without the written permission of the instructor. Any test, paper or report submitted by you and that bears your name is presumed to be your own original work that has not previously been submitted for credit in another course unless you obtain prior written approval to do so from your instructor. In all of your assignments, including your homework or drafts of papers, you may use words or ideas written by other individuals in publications, websites, or other sources, but only with proper attribution. If you're unclear about the expectations for completing an assignment or taking a test or examination, be sure to seek clarification from your instructor or GSI beforehand. For additional information on plagiarism and how to avoid it, read the UC Berkeley Library Citation Page, Plagiarism Section. As a member of the campus community, you're expected to demonstrate integrity in all of your academic endeavors and will be evaluated on your own merits. The consequences of cheating and academic dishonesty—including a formal discipline file, possible loss of future internship, scholarship, or employment opportunities, and denial of admission to graduate school—are simply not worth it. Read more about Berkeley's Honor Code.