ORF 523, Spring 2025

Convex and Conic Optimization

Course description

A mathematical introduction to convex, conic, and nonlinear optimization. Topics include convex analysis, duality, theorems of alternatives and infeasibility certificates, semidefinite programming, polynomial optimization, sum of squares relaxation, robust optimization, computational complexity in numerical optimization, and convex relaxations in combinatorial optimization. Applications drawn from operations research, dynamical systems, statistics, and economics.

Course website

- http://aaa.princeton.edu/orf523
- The course will also be on Canvas
- Can register for Ed Discussion via Canvas

Lecture schedule

T, Th 1:30 pm-2:50 pm EST; Friend 004.

Instructor

Amir Ali Ahmadi, Professor at ORFE. Web: http://aaa.princeton.edu/ Email: aaa@p...
Office hours: Wed, 3-6 PM EST, Sherrerd 122 (jointly with Yixuan).

TAs

- Yixuan Hua (graduate AI)
- Email: yh7422@p...
- Office hours: Mon, 5-7 PM EST, Sherrerd 122

- Joah Macosko (UCA)
- Email: jm4896@p...
- Office hours: Tue, 5-7 PM EST, Sherrerd 122.

Ed Discussion

Please sign up via Canvas. Please take advantage of Ed Discussion to initiate mathematical discussions with your teaching staff and classmates.

Prerequisites

- Linear optimization (e.g., at the level of ORF 522).
- Mathematical maturity, familiarity with MATLAB or similar software (e.g., Python), and comfort with linear algebra and multivariate calculus.

Tentative set of topics

- Optimality conditions
- Convex analysis and convex optimization
- Duality and infeasibility certificates
- Computational complexity
  - Focus on complexity in numerical optimization
- Conic programming
- More in depth coverage of semidefinite programming
- A module on combinatorial optimization
- Selected topics:
  - Robust optimization
  - Polynomial optimization
  - Sum of squares programming
  - Optimization in dynamical systems
  - Optimal control
  - The ellipsoid method or interior point methods
- Various applications of convex and conic optimization

References

- A. Ben-Tal and A. Nemirovski, Lecture Notes on Modern Convex Optimization [link]
- S. Boyd and L. Vandenberghe, Convex Optimization [link]
- M. Laurent and F. Vallentin, Semidefinite Optimization [link]
- R. Vanderbei, Linear Programming and Extensions [link]

Course grade

- 50% homework (5-6 problem sets; will drop the lowest score)
- 20% midterm exam (during regular lecture time; one page of cheat sheet allowed)
- 30% final exam/assignment (take-home)

Homework

Homework will be due at the beginning of lecture (1:30 PM EST) on Gradescope. Unless there is a *valid* reason, requests for extension on homework will not be accepted. To help stick with this policy, we drop your lowest homework score. Assignments should always be submitted as a single PDF file, including your code.

Midterm exam

There will be a midterm exam (date TBA), which will be during one of our lectures and for the usual duration of lecture. This exam is closed-book and closed-notes. However, you can have a single sheet of A4 paper with you (double-sided) with anything you want written or typed on it. There will be no computer exercises on the midterm exams.

Final exam/assignment

You can think of the final exam as a longer, cumulative problem set that needs to be done individually. It will be given out after the last week of class. Exact dates are to be announced. A solution to any of the open problems of the class can also replace the final exam (and all other exams and assignments).

Collaboration policy

Homework: You are allowed and in fact encouraged to collaborate on the homework. You have to turn in your individual assignment and you have to write the name of the students with whom you worked with on the first page of your homework. Full credit will be given to all members of the team.

Midterm and final exams: No collaboration allowed.

Policy on use of artificial intelligence based tools

The use of AI-based tools such as ChatGPT is allowed but discouraged. We have tried entering examples of homework questions into such tools and have repeatedly received wrong answers. The wrong answers include proofs that seem correct but are flawed and counterexamples that are not valid. Even with back-and-forth instructions, ChatGPT continues to make mathematical/logical mistakes. We are concerned that this can confuse our students as the mistakes are sometimes subtle.

If you use an AI tool, you must specify this on your solution sheet. You are responsible for any mistakes such tools might make. You cannot simply enter your question into an AI tool and ask the (human) AIs or the instructor if the response is correct.

You are allowed to have an AI tool help you with coding as long as you (i) declare it, (ii) check its correctness, and (iii) try to learn from it.

We reserve the right to change our policy as we learn more about how these tools work. Most importantly, when deciding how you approach a homework problem, make sure your primary objective is to *learn*.

Honor code

We strictly adhere to Princeton University's Honor System.