

Course title: CST5020 - Optimization and Applications
Term: Spring 2025
Credits: 3
Time: 9:50 - 12:15 on Thursdays
Location: E10-305
Website: Piazza, <https://piazza.com/westlake.edu.cn/spring2025/cst5020>

Course instructor: **Fangzhou Xiao**
Contact info: xiaofangzhou@westlake.edu.cn
Office location: E1-321
Office hours: by email appointment

Course description

Introduction to concepts and methods in optimization, especially convex optimization. Focuses on formulating problems in applications into optimization problems. The basic analysis methods for optimization problems needed for this goal will be covered, such as optimality conditions, duality theory, theorems of alternatives, and so on. The last one-third of the course will focus on in-depth applications of optimization methods we learned to specific domains, such as control, bioengineering, machine learning, and finance, featuring guest lecturers that are cutting-edge practitioners of optimization in these domains.

Course schedule

Lecture #	Topic
1	Introduction, Convex sets
2	Convex functions, Convex optimization problems
3	Duality
4	Approximation and fitting
5	Statistical estimation, geometric problems
6	Unconstrained minimization
7	Equality constrained minimization
8	Interior point method
9	Application: statistical and machine learning 1
10	Application: statistical and machine learning 2
11	Application: Control 1 - optimal control
12	Application: Control 2 - distributed control, system level synthesis
13	Application: bioengineering 1 - analysis and design of biocircuits
14	Application: bioengineering 2 - metabolic networks, flux balance analysis, and flux exponent control
15	Application: finance 1
16	Application: finance 2

Learning objectives

- To understand the structure of optimization problems so as to formulate them to solve problems that arise in applications
- To have tools of analysis for formulated convex optimization problems
- To understand how convex optimization problems are solved, computationally
- To have experience in solving some convex optimization problems.

Learning resources

- Textbook: Stephen Boyd and Lieven Vandenberghe. *Convex optimization*.
 - o Available at this link: <https://web.stanford.edu/~boyd/cvxbook/>
- The course that we will mostly follow for the basics of convex optimization:
 - o <https://web.stanford.edu/class/ee364a/lectures.html>
- Another course that introduces convex optimization with a more machine learning perspective:
 - o <https://www.stat.cmu.edu/~ryantibs/convexopt/>

- For some background on basics of linear algebra: Stephen Boyd and Lieven Vandenberghe. *Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares*
- Further references on a different presentation on convex optimization: Dimitri P. Bertsekas. *Convex Optimization Theory*, 2009

Assignments

- Roughly one problem set every two weeks, and each is expected to take at least 20 hours, so please do them on-time.
- You are expected to do some python coding and use CVXPY as the optimization package.
- Write in latex, upload as one pdf. (For intro to latex, overleaf is a good resource.)
- Upload on canvas.

Grading

- Problem sets 10% x 8
- Active participation 10%
- Final take-home exam 10%

You can always choose to not hand in one problem set (or the final exam) and get 10% for free.

Course policies

- You are encouraged to work in small groups, or talk to AI, but please write up your solutions independently and make sure you understand what you write.
- The final exam is take-home, so you can work on it for a fixed duration in any time and any location that you prefer, during the final weeks.