

Syllabus: STAT 8810

Topics in Convex Optimization

Autumn 2020

Course overview

Instructor

Instructor: Yunzhang Zhu

Email address: zhu.219@osu.edu

Class website: <https://osu.instructure.com/courses/84643>

Lectures: On CarmenZoom, Tuesday and Thursday, 11:30am-1:20pm (some of these lectures will be presented asynchronously; see *Course delivery* below)

Office hours: Virtual Hours via Carmen Zoom

- Wednesday 2:00pm-3:00pm
- Thursday 2:00pm-3:00pm
- by appointment

Course Description

Statistics 8810 will cover various topics in convex optimization and its applications to statistics. This course is designed to give graduate-level student an introduction to convex optimization. We will start with basic concepts and theory in convex optimization, including convex set, convex function, convex optimization problem, and duality theory. Then we will talk about some applications in statistics to illustrate that many important problems in statistics can be formulated as convex optimization problem. After that, we will move on to practical algorithms that can solve certain class of convex optimization problems efficiently. In particular, we will cover interior point method and various first-order methods.

Prerequisites

Students are expected to have a working knowledge of basic probability theory (STAT 6801 or equivalent), statistical inference (STAT 6802 or equivalent), linear algebra (STAT 6860 or equivalent), and basic knowledge of a scientific programming language (R, Python, or MATLAB). Students are also expected to be comfortable with rigorous mathematical arguments. Also, having taken a statistical machine learning class (STAT 6500 or equivalent) will be very helpful, as we will use applications in machine learning and statistics to illustrate the key concepts in convex optimization.

Course learning outcomes

Upon completing the course, students will be able to

1. formulate a statistics problem into an optimization problem
2. identify appropriate optimization algorithms to efficiently solve the problem
3. make efficient use of existing optimization software

Course materials

Required

Convex optimization by Stephen Boyd and Lieven Vandenberghe, Cambridge university press, 2004 (available online for free at <http://www.stanford.edu/~boyd/cvxbook/>)

Other useful references will be provided at the end of each lecture notes.

Course technology

For help with your password, university e-mail, Carmen, or any other technology issues, questions, or requests, contact the OSU IT Service Desk. Standard support hours are available at <https://ocio.osu.edu/help/hours>, and support for urgent issues is available 24x7.

- **Self-Service and Chat support:** <http://ocio.osu.edu/selfservice>
- **Phone:** 614-688-HELP (4357)
- **Email:** 8help@osu.edu
- **TDD:** 614-688-8743

Baseline technical skills necessary for online courses

- Basic computer and web-browsing skills
- Navigating Carmen

Technology skills necessary for this specific course

- CarmenZoom

Necessary equipment

- Computer: current Mac (OS X) or PC (Windows 10+) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed
- Microphone: built-in laptop or tablet mic or external microphone

Necessary software

- This class requires you to use the statistical software package called R (The R Project for Statistical Computing; <http://www.r-project.org/>). This software package is available as Free Software.

- You can download R for Windows, Mac, and Linux, from the CRAN archive at <https://cran.r-project.org>.
- An in-depth introduction to R is available at <http://cran.r-project.org/doc/manuals/R-intro.pdf>
- Hands-on tutorials are available in the Swirl system, which you can learn about at <http://swirlstats.com/>. In particular, “R Programming: The basics of programming in R” is an appropriate first tutorial for students who have never used R.
- An easier to use interface to R is available in the software package RStudio. This package is available for Windows, Mac, and Linux and can be downloaded for free from <http://rstudio.org>. **Note that RStudio requires R to be installed.**
- You could also use Python or MATLAB for the course. More details will be given in live or recorded lectures and on the class website.

Course delivery

The course will be a mix of synchronous and asynchronous content. Synchronous content will be presented live over CarmenZoom, and asynchronous content will be delivered by recorded lectures posted on the class website. **Details of the weekly schedule will be announced at the start of each week.**

Each week we will cover approximately 220 minutes of content in total. You will be responsible for watching any live content or recorded videos and studying the material that is assigned. In addition to the lecture videos, assignments will be posted on the class website. You will be given ample time to complete the assignments.

The instructor may elect to deliver live CarmenZoom lectures in place of videos for certain topics. In this case, the lecture will be recorded and posted on the class website soon after. The instructor will hold weekly office hours via CarmenZoom. The times are provided above.

Grading and faculty response

Homework and exams

Evaluations will be based on weekly homework assignments and one take-home final project.

Assignment or category	Percentage
Homework	60
Final project	40
Total	100

Grades will be posted on Canvas.

Assignment information. Evaluations will be based on weekly homework assignments and one take-home final project. Each assignment includes 1-3 problems, and the final project may involve solving a practical problem and writing up a short report on your solution. Both the assignments and final project may involve mathematical derivations/proofs, as well as programmatic implementation of the algorithms being studied in the course. All assignments will be posted on Canvas, and must be submitted online as a PDF file through Canvas. Each student must produce his/her own homework to be handed in. Feel free to ask me for help after you have made an attempt of the questions.

Late assignments. Typically, no late homework assignment will be accepted. However, if you are unable to complete an assignment on time, please get in touch with me as soon as possible so we can discuss your situation.

Assignment preparation rules. Put your name and the homework assignment number on the top right-hand corner of every page. Submit the problems in order, making sure that the computer output and discussion is placed together (do not put the computer output at the end of homework). Raw computer output is not acceptable. Make it clear what parts of the output are relevant and show how they answer the questions posed in the homework.

Faculty feedback and response time

I am providing the following list to give you an idea of my intended availability throughout the course. (Remember that you can call 614-688-HELP at any time if you have a technical problem.)

Grading and feedback. For large weekly assignments, you can generally expect feedback within **7-10 days**.

E-mail. I will reply to e-mails within **24 hours on school days**.

Attendance, participation, and discussions

Students may miss class, for a variety of reasons related to COVID-19. As much as possible, please stay in contact with the instructor so that we can discuss accommodations should they be needed.

Student participation requirements

Because this is a distance-education course, your attendance is based on your online activity and participation. The following is a summary of everyone's expected participation:

- **In live lectures:**
Students will be expected to participate, discuss, and answer questions in online live lectures.
- **Logging in: AT LEAST ONCE PER WEEK** Be sure you are logging in to the course in Carmen each week, including weeks with holidays or weeks with minimal online course activity. (During most weeks you will probably log in many times.) If you have a situation that might cause you to miss an entire week of class, discuss it with me *as soon as possible*.
- **Office hours and live sessions: OPTIONAL OR FLEXIBLE** All office hours, are optional. If you are required to discuss an assignment with me, please contact me at the beginning of the week if you need a time outside my scheduled office hours.

Discussion and communication guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- **Writing style:** While there is no need to participate in class discussions as if you were writing a research paper, you should remember to write using good grammar, spelling, and punctuation. Informality (including an occasional emoticon) is fine for non-academic topics.
- **Tone and civility:** Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across online.
- **Citing your sources:** When we have academic discussions, please cite your sources to back up what you say. (For the textbook or other course materials, list at least the title and page numbers. For online sources, include a link.)

- **Backing up your work:** Consider composing your academic posts in a text editor or word processor, where you can save your work, and then copying into the Carmen discussion.

Other course policies

Health and safety

The Ohio State University Wexner Medical Center's Coronavirus Outbreak site (<https://wexnermedical.osu.edu/features/coronavirus>) includes the latest information about COVID-19 as well as guidance for students, faculty and staff. Guidelines and requirements for campus safety from the University's COVID-19 Transition Task Force were published on July 1 on the Safe and Healthy website (<https://safeandhealthy.osu.edu>).

Potential disruptions to instruction

- As much as is possible, students will have access to material online if they are unable to attend class because of positive diagnosis, symptoms, or quarantine required following contact tracing.
- If the instructor is unable to be present in person because of positive diagnosis, symptoms, or quarantine following contact tracing a new instructor will be assigned to the course. Details will be given on the course website.

Student academic services

Student academic services offered on the OSU main campus: <http://advising.osu.edu/welcome.shtml>.

Student support services

Student support services offered on the OSU main campus: <http://ssc.osu.edu>.

Academic integrity policy

Policies for this online course

- **Exams:** You must complete the final exams yourself, without any external help or communication.
- **Written assignments:** Your written assignments, including discussion posts, should be your own original work.
- **Reusing past work:** In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you have explored in previous courses, please discuss the situation with me.
- **Falsifying research or results:** All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your library research look more successful than it was.
- **Collaboration and informal peer-review:** The course will include opportunities for formal collaboration with your classmates. While study groups are encouraged, remember that comparing

answers on a quiz or assignment is not permitted. If you are unsure about a particular situation, please feel free just to ask ahead of time.

Ohio State’s academic integrity policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term “academic misconduct” includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct <http://studentlife.osu.edu/csc/>.

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at <http://titleix.osu.edu> or by contacting the Ohio State Title IX Coordinator, Kellie Brennan, at titleix@osu.edu.

Accessibility accommodations for students with disabilities

The university strives to make all learning experiences as accessible as possible. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university’s request process, managed by Student Life Disability Services. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; <http://slds.osu.edu>; 098 Baker Hall, 113 W. 12th Avenue.

Accessibility of course technology

This online course requires use of Carmen (Ohio State’s learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- Carmen (Canvas) accessibility

- Streaming audio and video
- Synchronous course tools

Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273-TALK or at suicidepreventionlifeline.org

Disclaimer

This syllabus should be taken as a fairly reliable guide for the course content. However, you cannot claim any rights from it and in particular I reserve the right to change due dates or the methods of assessment. Official announcements will ALWAYS be those made in class.

Course schedule (tentative)

Week	Dates	Topics
1	Oct 15	Course overview
2	Oct 20, 22	Convex set and convex function
3	Oct 27, 29	Convex optimization problem
4	Nov 3, 5	Duality theory
5	Nov 10, 12	Applications in statistics and machine learning
6	Nov 17, 19	Interior point methods and CVX
7	Nov 24	First-order methods (GD, stochastic GD, ADMM, etc)
8	Dec 1, 3	First-order methods and applications