University of California, Berkeley
Department of Electrical Engineering and Computer Sciences

EECS 127: Optimization Models in Engineering

Course Number: EECS 127
Course Title: Optimization Models in Engineering
Units: 4
Course Format: 3 hours of lecture, 1 hour discussion
Instructors: Gireeja Ranade, Alex Bayen
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Prerequisites: 16A, 16B, 70, Math 53
Grading: Letter
Online resources: Piazza, bCourses, Gradescope, and course website

Course Description

This course offers an introduction to optimization models and their applications, ranging from machine learning and statistics to decision-making and control, with emphasis on numerically tractable problems, such as linear or constrained least-squares optimization. (4 Units.)

Course Objectives

1. Develop a practical understanding of the applications and limitations of optimization as a solution approach to engineering analysis and design.
2. Develop an ability to use rapid prototyping software to guide optimization solutions.

Desired Course Outcome:

By the end of the term, students having taken **Optimization Models in Engineering** are expected to be able to:

1. Understand the basic concepts of linear algebra: vectors, matrices, rank, projections; symmetric matrices, positive semidefinite matrices, eigenvalues; singular value decomposition and principal component analysis.
2. Understand four basic optimization models: least-squares, linear, quadratic and second-order cone programming, and have a general understanding of the more general convex optimization.
3. Be aware of the wide-ranging applications where optimization models are useful, including in machine learning applications.
4. Be able to use prototyping software such as CVX to develop optimization-based solutions in concrete applications.

Content

1. Overview
2. Vectors, matrices
3. Symmetric matrices and their eigenvalue decomposition
4. Singular value decomposition for general matrices
5. Principal component analysis, low-rank approximations, and applications
6. Linear programming
7. Linear programming in discrete optimization
8. Least-squares and variants
9. Quadratic programming
10. Second-order cone programming
11. Robustness
12. Applications in learning
13. Applications in decision-making and control

Homework

Homework will be assigned every Thursday and will be due the following Thursday by 11pm. Homework will be electronically submitted to Gradescope. Late homework will not be accepted.

We will drop the lowest homework score from your final grade calculation. This drop is meant for emergencies such as illness, conflicting assignments, family and personal situations etc. If you use this drop half-way into the semester, and then request another, we cannot help you. We recommend not thinking of this as doing one less homework, but to be used only in case of a real emergency.

You need to turn in both your code and written solutions. This includes your .py or .ipynb file as well as a attached pdf "printout" of any code you wrote. Non-coding problems should be written up cleanly and scanned or typed up using latex. **Any homework submissions that are turned in without both .ipynb file and .pdf of the solutions along with the code "printout" (or screenshot) attached will receive a zero on the coding portions of the homework.** If you have any questions about the format of a homework submission, please go to office hours or homework party.

Late homework will not be accepted.

Discussion and collaboration, as opposed to copying, of homework is encouraged. In other words, you are encouraged to discuss the homework with your classmates but you must write your own derivations and do your own calculations, etc. Do not hesitate to ask the professor or the GSIs for clarifications and hints for the homework problems during Homework Parties and Office hours. We encourage cooperation rather than competition.

Homework Grading – Self-Grading

The point of homework in this class is for you to learn the material. To help you in doing this each student will grade their own homework in addition to being graded by the 127 readers. After the HW deadline, official solutions will be posted online. You will then be expected to read them and enter your own scores and comments for every part of every problem in the homework on a simple coarse scale:

0 = Didn't attempt or very very wrong,

2 = Got started and made some progress, but went off in the wrong direction or with no clear direction,

5 = Right direction and got half-way there,

8 = Mostly right but a minor thing missing or wrong,

10 = 100% correct.

Note: You must justify every self-grade score with a comment. If you are really confused about how to grade a particular problem, you should post on Piazza. This is not supposed to be a stressful process.

Your self-grades will be due on the Thursday following the homework deadline at 11 PM sharp. If you don't enter a proper grade by this deadline, you are giving yourself a zero on that assignment. Merely doing the homework is not enough, you must do the homework; turn it in on time; read the solutions; do the self-grade; and turn it in on time. **Unless all of these steps are done, you will get a zero for that assignment.**

Just like we encourage you to use a study group for doing your homework, we strongly encourage you to have others help you in grading your assignments while you help grade theirs.

Course readers are going to be grading and sending you occasional comments. Because we have reader grades, we will catch any attempts at trying to inflate your own scores. This will be considered cheating and is definitely not worth the risk. Your own scores will be used in computing your final grade for the course, adjusted by taking into account reader scores so that everyone is fairly graded effectively on the same scale. For example, if we notice that you tend to give yourself 5s on questions where readers looking at your homeworks tend to give you 8s, we will apply a proportional upward correction to adjust.

Exam Policies

The 127 Spring 2019 semester will have two midterms and one final. The midterm times will be Feb 26 during class hours and April 11. The final will be held during the designated final exam slot released by campus. Makeup exams will not be scheduled.

Please plan for exams at these times and **email the Head GSI at eecs127class@gmail.com during the first two weeks of the semester per university policy if you know about any exam conflicts.** If an emergency

arises that conflicts with the exam times, email the Head GSI as soon as possible. Emergency exam conflicts will be handled on a case-by-case basis. Exam conflicts originating from a lecture conflict will not be accommodated.

Course Evaluation

The course grade will be based on the following evaluation:

- Homework (30%)
- Midterm 1 (20%)
- Midterm 2 (20%)
- Final (30%)

Schedule

For up-to-date scheduling information, please refer to the course's google calendar:
https://tinyurl.com/eecs127class

Office Hours

Tuesdays: Helen (2-3pm, 258 Cory)
Wednesdays: Armin (11-12pm, 367 Cory), Tanya (4-5pm, 367 Cory)
Thursdays: Kamil (2-3pm, 367 Cory), Suvansh (4-5pm, 367 Cory)

Homework Party

Wednesdays 2-4pm in the Wozniak Lounge

Policies

Disabled Students' Program (DSP): We are happy to accommodate students with special needs as determined by the DSP office. Please contact the Head GSI in the first two weeks of class to request appropriate accommodations. Please share your accommodation letter with the Head GSI in this email.

Course Materials

- Boyd, Stephen, and Lieven Vandenberghe. *Convex optimization*. Cambridge university press, 2004.
- Calafiore, Giuseppe and El Ghaoui, Laurent. Optimization Models.
- Livebook: http://livebooklabs.com/keeppies/c5a5868ce26b8125 (you can register on the livebook platform for free)

Course Communication

The instructors and TAs will post announcements, clarifications, hints, etc.

on Piazza. You must check the EE127 Piazza page frequently throughout the term. (You should already have access to the EE127 Spring 2019 forum. If you do not, please let us know.)

If you have a question, your best option is to post a message there. The staff will check the forum regularly, and other students will be able to help you too. When using the forum, please avoid off-topic discussions, and please **do not post answers to homework questions before the homework is due**. Also, always look for a convenient category to post the question to (for example, each homework will have its own category, so please post there). That will ensure you get the answer faster.

If your question is personal or not of interest to other students, you may mark your question as private on Piazza, so only the instructors will see it. If you wish to talk with one of us individually, you are also welcome to come to our office hours. Please reserve email for the questions you can't get answered in office hours, in discussion sections, or through the forum.

It can be challenging for the instructors to gauge how smoothly the class is going. We always welcome any feedback on what we could be doing better. **If you would like to send anonymous comments or criticisms, feel free to use this anonymous form.**

Collaboration

We encourage you to work on homework problems in study groups of two to four people; however, you must **always** write up the solutions on your own. Similarly, you may use books or online resources to help solve homework problems, but you must always credit all such sources in your writeup, and you may never copy material verbatim. **Using previous homework and exam solutions is strictly prohibited, and will be considered academic dishonesty. This is not how you want to start your career as an engineer.**

We expect that most students can distinguish between helping other students and cheating. Explaining the meaning of a question, discussing a way of approaching a solution, or collaboratively exploring how to solve a problem within your group is an interaction that we encourage strongly. But you should write your homework solution strictly by yourself so that your hands and eyes can help you internalize the subject matter. You should acknowledge everyone whom you have worked with, or who has given you any significant ideas about the homework. This is good scholarly conduct.

Don't Be Afraid to Ask for Help

Are you struggling? Please come talk with us! The earlier we learn about your struggles, the more likely it is that we can help you. Waiting until right before an exam or the last few weeks of the semester to let us know about your problems is not an effective strategy - the later it is, the less we will be able to help you.

Even if you are convinced that you are the only person in the class who is struggling, please overcome any feelings of embarrassment or guilt, and come ask for help as soon as you need it – we can almost guarantee you're not the only person who feels this way. Don't hesitate to ask us for help – we really do care that you thrive!

Advice

The following tips are offered based on our experience.

Do the homeworks! The homeworks are explicitly designed to help you to learn the material as you go along. There is usually a strong correlation between homework scores and final grades in the class.

Keep up with lectures! Discussion sections, labs and homeworks all touch on portions of what we discuss in lecture.**Students do much better if they stay on track with the course.** That will also help you keep the pace with your homework and study group.

Take part in discussion sections! Discussion sections are not auxiliary lectures. They are an opportunity for interactive learning. The success of a discussion section depends largely on the willingness of students to participate actively in it. As with office hours, the better prepared you are for the discussion, the more you are likely to benefit from it.

Come to office hours! We love to talk to you and do a deep dive to help you understand the material better.

Form study groups! As stated above, you are encouraged to form small groups (two to four people) to work together on homeworks and on understanding the class material on a regular basis. In addition to being fun, this can save you a lot of time by generating ideas quickly and preventing you from getting hung up on some point or other. Of course, it is your responsibility to ensure that you contribute actively to the group; passive listening will likely not help you much. Also recall the caveat above, that you must write up your solutions on your own. We strongly advise you to spend some time on your own thinking about each problem before you meet with your study partners; this way, you will be in a position to compare ideas with your partners, and it will get you in practice for the exams. **Make sure you work through all problems yourself**, and that your final write-up is your own. Some groups try to split up the problems ("you do Problem 1, I'll do Problem 2, then we'll swap notes"); not only is this a punishable violation of our collaboration policies, it also ensures you will learn a lot less from this course.