

Welcome to EECS 127/227A



Lecture 0: orientation

Topics to be covered today

- What is EECS 127/227A?
- Instructors, GSIs, UGSIs, readers, team
- How to learn the material?
- Labs, supplement, discussion sessions
- Office hours
- DSP
- Grading
- Schedule
- Exams
- Cheating
- Misc. administrative stuff

What is EE127/227A (in one slide)?

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. The course covers two main topics: practical linear algebra and convex optimization.

In this class you will learn how to formulate engineering problems as optimization programs

You will learn how to solve them numerically

You will apply your knowledge on numerous datasets gathered from practical problems



Laurent El Ghaoui, instructor

Professor, EECS/IEOR

Office: 421 Sutardja Dai Hall

elghaoui@berkeley.edu

OH: 2:00-3:00pm Tu/Th

After class on weeks of teaching

Interesting fact:

Laurent would like to play the “hang” one day.



Alexandre Bayen, instructor

Professor, EECS/CEE

Office: 109 McLaughlin Hall

bayen@berkeley.edu

OH: 2:00-3:00pm Tu/Th

After class on weeks of teaching

Interesting fact:

Alex likes to play the piano and improvise in the style of Liszt and ask people which pieces of Liszt they recognize.



Patricia Hidalgo-Gonzalez, Head GSI

5th year PhD candidate at ERG/EECS

Office: 425 Sutardja Dai Hall

patricia.hidalgo.g@berkeley.edu

OH: Tuesdays 10am - 11am, Cory 212 (on Sept
11th: Cory 400)

Interesting fact:

Once a year, I go to a silent meditation retreat
where we meditate 10 hours/day for 10
days. One of my life goals is to do this for
a full year... someday haha.



Romain Lopez, GSI

PhD student Y3 EECS

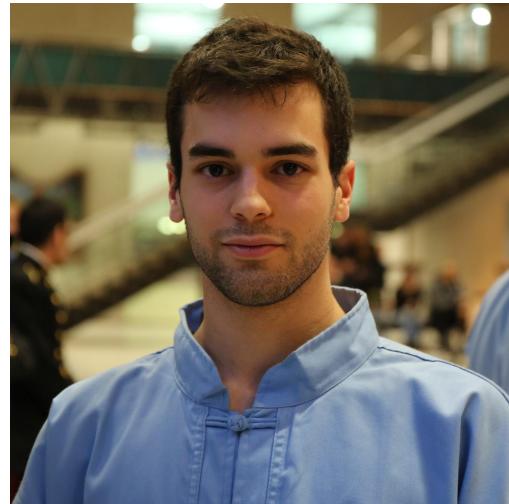
Office: 378 Stanley Hall

romain_lopez@berkeley.edu

OH: M: 2.30pm - 3.30pm, Cory 258

Interesting fact:

Judo Black Belt since 10 years, interned in
Tokyo for a summer in 2016 to regularly
train with policemen (they were strong...).



Nilesh Tripuraneni, GSI

Third-year PhD student in CS

Office: Soda 465H (back of the RISELab)

nilesh_tripuraneni@berkeley.edu

OH: Monday 10am-12pm (Soda-Alcove-341A)

Interesting fact:

In my (limited) free time I enjoy lifting weights
and hope to pick up the guitar again. Some
of my research focuses on optimization so
am happy to be TAing for EE127/227A!



Larry Yang, GSI

5th Year Masters in CS

larrywyang@berkeley.edu

OH: Friday 3pm - 4pm Soda 651

Interesting fact: I can't work or read with the television on in the background but love listening to music instead.

Mong H. Ng (CK), uGSI

Third Year CS Undergraduate Student

monghim.ng@berkeley.edu

OH: Friday 10-11am Soda Room 651

Interesting fact:

I am currently a yellow-green belt holder in Taekwondo. But don't be intimidated, because yellow-green is one of the lowest of the lowest rank. Aye, 'tis my dream to get a black belt after years and years of arduous training.



Helen Yang, uGSI

Fourth Year EECS Undergraduate Student

helenlyang@berkeley.edu

Interesting fact:

I once ate three pounds of ice cream in under
ten minutes! Would not recommend to
others...



Aurelia Guy, uGSI

Senior CS Undergraduate Student

[lia@berkeley.edu](mailto:aia@berkeley.edu)

Interesting fact:

I enjoy writing and once wrote a novel. In my free time I like to exercise, and enjoy outdoor activities including hiking and swimming.



Shikhar Bahl, uGSI

4th Year CS and Applied Math Student

shikharbahl@berkeley.edu



Interesting fact: It took me a month to come up
with an interesting fact about myself.

Tanya Veeravalli, uGSI

Senior CS and Economics Student

tveeravalli19@berkeley.edu

Interesting fact: I'm very interested in magic, especially card tricks :) I also have an extremely sweet tooth, and have had exactly 1 cup of coffee. I enjoy sports, especially soccer and badminton.



Jason Wang, reader

Senior CS/AppMath Undergrad student

zhanshi_wang@berkeley.edu

Interesting fact:

This is an Interesting Fact

I used to eat five times a day and gained 20 more pounds.



Yiran Jia, reader

Third Year CS Undergraduate Student

yiranjia@berkeley.edu



Interesting fact:

I'm from Shanghai and I've lived briefly in Lyon and Montreal. In my free time, I enjoy hiking, playing music, traveling, and watching Grey's Anatomy.

Wenxin Li, reader

Senior CS/Stats Undergraduate Student

wenxin_li@berkeley.edu

Interesting fact:

In my free time I like reading Japanese comics.

My favorite series is One Piece and the story is as old as I am.



Andrew Li, reader

Junior EECS Student

andrewyli@berkeley.edu

Interesting fact: I'm a classical singer, and have done solos and private chorus for seven years!



Material at your disposal to learn

This class comes with an integrated set of material

- Book [For broader context, superset of slides]
- Set of slides [The reference for exams]. We will outline in the slides what is required for the exams.

The spectral theorem

Any symmetric matrix is orthogonally similar to a diagonal matrix. This is stated in the following so-called *spectral theorem* for symmetric matrices.

Theorem 1 (Spectral Theorem)

Let $A \in \mathbb{R}^{n,n}$ be symmetric, let $\lambda_i \in \mathbb{R}$, $i = 1, \dots, n$, be the eigenvalues of A (counting multiplicities). Then, there exist a set of orthonormal vectors $u_i \in \mathbb{R}^n$, $i = 1, \dots, n$, such that $Au_i = \lambda_i u_i$. Equivalently, there exist an orthogonal matrix $U = [u_1 \cdots u_n]$ (i.e., $UU^\top = U^\top U = I_n$) such that

$$A = U\Lambda U^\top = \sum_{i=1}^n \lambda_i u_i u_i^\top, \quad \Lambda = \text{diag}(\lambda_1, \dots, \lambda_n).$$

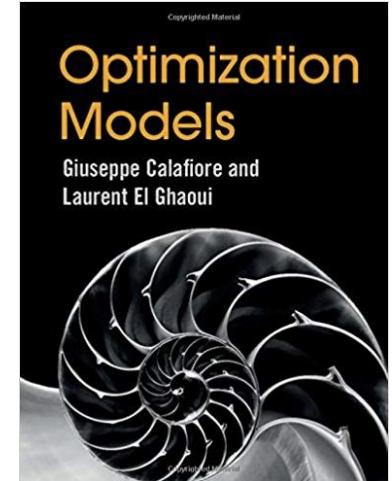
Theorems

Sometimes, examples, proofs

Material at your disposal to learn

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- **Book [For broader context, superset of slides]**



Optimization Models, G.C. Calafiore and L. El Ghaoui, Cambridge University Press , October 2014

Material at your disposal to learn

This class comes with an integrated set of material

- Book [For broader context, superset of slides]
- Set of slides [The reference for exams]
- “Livebook”
 - Hypertext where users can post comments / ask questions
 - Available at
<http://livebooklabs.com/keepies/c5a5868ce26b81>
 - Simplified version of Book, Slides



The screenshot shows a livebook interface titled "Optimization Models and Applications" by Laurent El Ghaoui. The page includes a navigation sidebar with links to Home, Introduction, Linear Algebra, Convex Models, Duality, Case Studies, and Appendix. The main content area features a title slide with the book's name, author, and a brief description. Below the title is a thumbnail image of a grayscale house. At the bottom, there is a note about citation and a BibTeX entry.

LiveBook Lab Optimization Models and Applications

Laurent El Ghaoui

EECS Department, UC Berkeley

Optimization Models and Applications

Spring 2017

This livebook offers an introduction to optimization models and their applications, with emphasis on numerically tractable problems, such as linear or constrained least-squares optimization. The livebook platform allows users to post comments and ask questions. As an author, I will not guarantee answers, but I will do my best!

This work elaborates on an earlier [hypertextbook](#), which is no longer maintained. It provides a less complete, shorter view of the recently published book "[Optimization Models](#)", by Calafiori and El Ghaoui, Cambridge University Press, 2014.

The image on the left is taken from an application of optimization to image denoising (J. Matas, F. Bach, J. Ponce, G. Sapiro and A. Zisserman, [Non-Local Sparse Models for Image Restoration](#), International Conference on Computer Vision (ICCV), 2009).

Note: if you wish to cite this livebook, here is a BibTeX entry:

```
@misc{elghaouilivebookopt2018,  
key={ElG},  
}
```

Material at your disposal to learn

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- Book [For broader context, superset of slides]
- Set of slides [The reference for exams]
- Livebook [For additional material]
- **Reading material for the discussion sessions**

Exercise 3 (Inner product) Let $x, y \in \mathbb{R}^n$. Under which condition on $\alpha \in \mathbb{R}^n$ does the function

$$f(x, y) = \sum_{k=1}^n \alpha_k x_k y_k$$

define an inner product on \mathbb{R}^n ?

Exercise 4 (Orthogonality) Let $x, y \in \mathbb{R}^n$ be two unit-norm vectors, that is, such that $\|x\|_2 = \|y\|_2 = 1$. Show that the vectors $x - y$ and $x + y$ are orthogonal. Use this to find an orthogonal basis for the subspace spanned by x and y .

Exercise 5 (Extrema of inner product over a ball) Let $y \in \mathbb{R}^n$ be a given non-null vector, and let $\mathcal{X} = \{x \in \mathbb{R}^n : \|x\|_2 \leq r\}$, where r is some given positive number.

1. Determine the optimal value p_1^* and the optimal set (i.e., the set of *all* optimal solutions) of the problem $\min_{x \in \mathcal{X}} |y^T x|$.
2. Determine the optimal value p_2^* and the optimal set of the problem $\max_{x \in \mathcal{X}} |y^T x|$.
3. Determine the optimal value p_3^* and the optimal set of the problem $\min_{x \in \mathcal{X}} y^T x$.
4. Determine the optimal value p_4^* and the optimal set of the problem $\max_{x \in \mathcal{X}} y^T x$.

Exercise 6 (Gradient of log-sum-exp function) The log-sum-exp function $\text{lse} : \mathbb{R}^n \rightarrow \mathbb{R}$ is defined as

$$\text{lse}(x) = \ln \left(\sum_{i=1}^n e^{x_i} \right).$$

Determine the gradient of this function at x .

Problem sets to be solved in discussion session so you can absorb the material better.

Solutions will be available

Material at your disposal to learn

This class comes with an integrated set of material

- Book [For broader context, superset of slides]
- Set of slides [The reference for exams]
- Livebook [For additional material]
- Reading material for the discussion
- Homework aligned with material taught in class

Problem sets you have to turn
in
electronically.

EECS 127 / 227AT
A. Bayen, L. El Ghaoui 8/23/18

Homework Assignment #1

Due date: 9/6/18, before class. Please L^AT_EX or handwrite your homework solution and submit an electronic version.

Exercise 1 (About general optimization) In this exercise, we test your understanding of the general framework of optimization and its language. We consider an optimization problem in standard form:

$$p^* = \min_{x \in \mathbb{R}^n} f_0(x) : f_i(x) \leq 0, \quad i = 1, \dots, m.$$

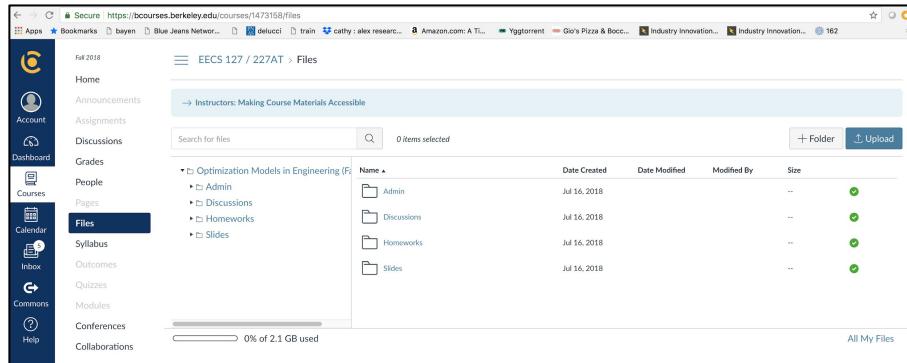
In the following we denote by \mathcal{X} the feasible set. For the following statements, provide a proof or counter-example.

1. Any optimization problem can be expressed as one with a linear objective.
2. Any optimization problem can be expressed as one without any constraints.
3. Any optimization problem can be recast as a linear program, provided one allows for an infinite number of constraints.
4. If there are strict inequalities we can always replace them with non-strict ones. *Note:* you are not required to provide a formal justification.
5. If one inequality is strict at the optimum, then we can remove it from the original problem and obtain the same solution.
6. If the problem involves the minimization of an objective function of the form $f_0(x) = \min_y F_0(x, y)$,

Material at your disposal to learn

This class comes with an integrated set of material

- Book [For broader context, superset of slides]
- Set of slides [The reference for exams]
- Livebook [For additional material]
- Reading material for the discussion
- Homework aligned with material taught in class
- bCourse site with all other material (hwk, sols etc.)



Homework policies

For completing the class you need to turn in homeworks
— 6 homeworks total

	A	B	C	D	E	F	G	H	I	J	K
1	Week	Lecture #	Date	Instructor	Part	Lecture	Reading (book)	Reading (livebook)	Hw given	Hw due	Hw Topic
2	1	1	8/23/18	AB & LEG	Linear algebra	Introduction	Ch. 1	Sec. 1	Hw1		Vectors, matrices, scalar products
3	2	2	8/28/18	AB		Vectors and functions	Ch. 2	Sec. 2.1			
4	2	3	8/30/18	AB		Matrices and linear maps	Ch. 3, except sec. 3.3, 3.4.9, 3.7	Sec. 2.2, except 2.5			
5	3	4	9/4/18	LEG		Quiz and mini-review / extra topic					
6	3	5	9/6/18	LEG		Symmetric matrices and their eigenvalues	Ch. 4	Sec. 2.5	Hw2	Hw1	SVD, PCA, covariance matrices
7	4	6	9/11/18	LEG		Singular value decomposition	Ch. 5	Sec. 2.6			
8	4	7	9/13/18	LEG		Linear equations	Ch. 6, except 6.5	Sec. 2.3			
9	5	8	9/18/18	AB		Least-squares and variants	Ch. 6, except 6.5	Sec. 2.4			
10	5	9	9/20/18	AB		Review				Hw2	
11	6		9/25/18			MIDTERM					
12	6	10	9/27/18	AB	Conic optimization	Linear optimization	Ch. 9, sec. 9.3	Sec. 3.2	Hw3		LP, QP, SOCP, LS
13	7	11	10/2/18	AB		Quadratic optimization	Ch. 9, all sections except 9.7	Sec. 3.2			
14	7	12	10/4/18	AB		Second-order cone optimization	Ch. 10, sections 10.1 and 10.2	Sec. 3.3			
15	8	13	10/9/18	AB		Robust optimization	Ch. 10, section 10.3	Sec. 3.4			
16	8	14	10/11/18	AB		Review			Hw4	Hw3	Convexity, robust optimization
17	9		10/16/18	AB		Quiz and extra topic TBD					
18	9	16	10/18/18	LEG	Convex optimization	Convexity	Ch. 8, sections 8.1, 8.2	Sec. 3.1.1, 3.1.2			
19	10	17	10/23/18	LEG		Convex optimization problems	Ch. 8, sections 8.3, 8.4	Sec. 3.1.3			
20	10	18	10/25/18	LEG		Weak duality	Ch. 8, section 8.5	Sec. 3.1.5	Hw5	Hw4	Duality
21	11	19	10/30/18	LEG		Strong duality	Ch. 8, section 8.5	Sec. 3.1.5			
22	11	20	11/1/18	LEG		Applications of duality					
23	12		11/6/18			MIDTERM					
24	12	21	11/8/18	LEG		Overview of algorithms	Ch. 12	Sec. 3.1.4	Hw6	Hw5	Applications
25	13	22	11/13/18	AB / LEG TBD	Applications	Machine learning	Ch. 13	Sec. 3.2.5, 3.4.4			
26	13	23	11/15/18	AB / LEG TBD		Engineering design	Ch. 16	Sec. 3.5			
27	14	24	11/20/18	LEG		Finance	Ch. 14	Sec. 5.5			
28	15	25	11/27/18	AB		Control applications	Ch. 15	Sec. 2.6, 5.1,		Hw6	
29	15	26	11/29/18	AB		Review					
30	16		12/4/18	RRR		RRR					
31	16		12/6/18	RRR		RRR					
32			12/14/18			FINAL (8-11am)					

Homework policies

For completing the class you need to turn in homeworks

- 6 homeworks total
- HWKs are for working on assignments, which are out on the day outlined in the xls file (and posted on bCourses), at 5:00pm, and due 5:00pm the day outlined in the xls file (and posted on bCourses)
- There will be a grace period until 7:00pm, this avoids problems of ‘upload traffic jam’ at 4:59pm. If you have this problem at 6:59pm, you are responsible for it.
- **To be clear: HW IS DUE AT 5:00PM, NOT 7:00PM**
- The submission procedure is very simple, explained in the next slide

Homework submission process

For completing the class you need to turn in homeworks through gradescope: <https://www.gradescope.com>

- Once you make an account, click “Add a course”
- Our course entry code is: **9DJ885**

This screenshot shows the 'Student Courses' page on Gradescope. It displays a list of courses for 'Fall 2017', including 'CS 162: Operating Systems and Systems Programming'. A teal button at the bottom left indicates '3 assignments'. On the right side, there is a large red rectangular box highlighting the '+ Add a course' button.

1

This screenshot shows the 'Your Courses' page. It lists 'Fall 2017' and 'Test121: Test Course for CS121'. Below the course list, a red box highlights the 'Assignment' link under the 'Test121' course entry.

2

This screenshot shows the 'Test121 | Fall 2017' assignment page. It displays basic assignment details like name, status, and due date. A red box highlights the 'Test Assignment' link.

3

This screenshot shows the 'Submit Assignment' page for the 'Test Assignment'. It provides instructions for submission and features two prominent red boxes highlighting the 'SUBMIT IMAGES' and 'SUBMIT PDF' buttons.

Homework parties

- There will be one homework party per homework
- On Mondays or Tuesdays depending on the HW#
- uGSIs will run the parties
- Parties' schedule:
 - HW # 1: Tuesday Sept 4th, 6pm - 7.30pm, Soda 306 HP
 - HW # 2: Monday Sept 17th, 6pm - 8pm, Soda 306 HP
 - HW # 3: Tuesday Oct 9th, **5pm - 7pm, Cory 540AB**
 - HW # 4: Monday Oct 22nd, 6pm - 8pm, Soda 306 HP
 - HW # 5: Tuesday Nov 6th, 6pm - 8pm, Soda 306 HP
 - HW # 6: Tuesday Nov 20th, 6pm - 8pm, Soda 306 HP

Homework cycle process: 7 weeks cycle

The homework process is as follows, to ensure quality, fairness and relevance to the class



With 250 students we need to treat this like a production line process, no exceptions!

Homework cycle process: 7 weeks cycle

The homework process is as follows, to ensure quality, fairness and relevance to the class

- Week n-3: Homework m created by blue team, solutions created by blue team.
- Week n-2: Homework m tested by red team without solutions, homework modified by red team without solutions, solutions modified by red team, new homework and solutions delivered to instructors
- Week n-1: Instructors final check for homework and solutions
- Week n: Homework released
- Week n+2: Homework due (5pm), grading starts
- Week n+3: Homework back to the students, solutions posted, grades posted and available to the students, one week regrade period for homework starts, regrade requests received and addressed
- Week n+4: Regrade period for homework stops (5pm), new grade is posted and final, request is returned by once completed

With 250 students we need to treat this like a production line process, no exceptions!

Homework and midterms regrade process

In order to be considered, your regrade request needs to comply with the following guidelines

- Request must be submitted within the one week following release of grades
- Request needs to be submitted to eeecs127requests@gmail.com
- Request needs to submit a single pdf containing (1) typed nature of the request and explanations of the request, (2) original scanned / graded homework/midterm
- Be aware that **your grade can go up or down**

With 250 students we need to treat this like a production line process, no exceptions!

Homework and midterms regrade process

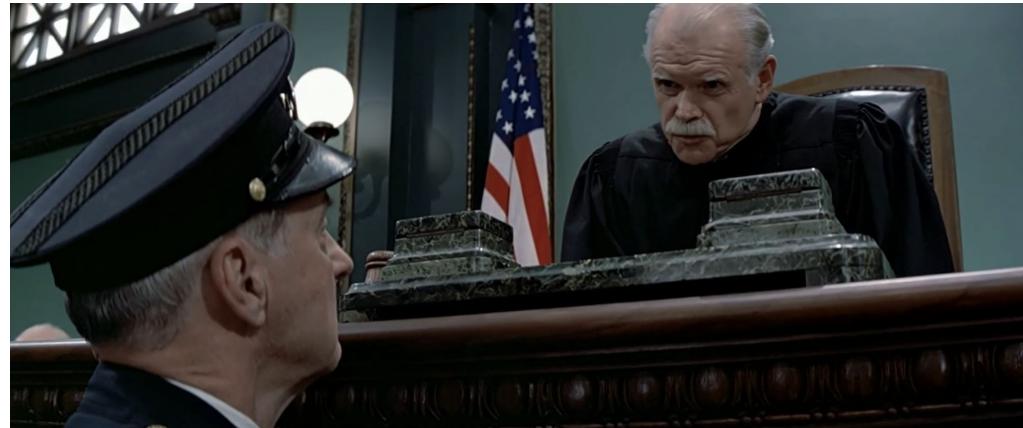
Only request regrades when needed, when legit, when fair



With 250 students we need to treat this like a production line process, no exceptions!

Homework and midterms regrade process

Only request regrades when needed, when legit, when fair



With 250 students we need to treat this like a production line process, no exceptions!

Lectures, Discussions, Office Hours, Hwk parties

You will have lectures on TuTh 12:30-2:00

- Lectures are mandatory, we do not check, but you will be responsible for knowing the material covered in the lectures. Lectures are not videotaped, it is your responsibility to either attend or have a way to access the material covered in class on the board.
- There might be supplemental sections to cover
 - Either not critical path material
 - Review for the exams

These are not mandatory.
- In general, lecture is given by the instructors
- Instructor in charge of the lecture is responsible for the corresponding OH (the same week).

Office hours

When are office hours?

- Instructor office hours are held by instructor teaching that week
 - Bayen: Tu/Th 2-3pm 109 McLaughlin
 - El Ghaoui: Tu/Th 2-3pm 421 SDH
- GSI office hours are
 - PHG - set on Tuesday 10am - 11am, Cory 212 (09/11: Cory 400)
 - CK - set on Friday 10am - 11am, Soda 651
 - RL - set on Monday 2.30pm - 3.30pm, Cory 258
 - LY - set on Friday 3pm - 4pm, Soda 651
 - NT - set on Monday 10am - 12pm, Soda-Alcove-341A

Discussions

Discussions sections are on (start next week):

W: 5 - 6pm, Stanley 106

Th: 5 - 6pm, LeConte 4

- Choose one of those time slots (same content W and Th)**
- Discussion sections are not mandatory, but encouraged**
- They help you see things in a less formal setting**
- They are taught by the Head GSI and they are more interactive**
- They reinforce what you see in lecture**
- Problems to be solved will be posted on Wednesday's morning**

Lectures, Discussions, Office Hours, Hwk parties

Office hours and homework parties recommended topics

- Instructor office hours:
 - Material seen in class
 - Other topics related to the class
- Head GSI / GSI
 - Material seen in class
 - Discussion material, hwk
- uGSIs / homework parties
 - Hwk material
 - Material seen in class when in the context of hwk

We will adjust these for the exam weeks

Email

Ex. of appropriate use of email with instructors

1. Emergency (“need to go to funeral”, “in hospital cannot come to exam”, “held outside of the US by immigration”)
2. Personal issues that cannot be solved by rest of the team

Ex. of not appropriate use of email with instructor

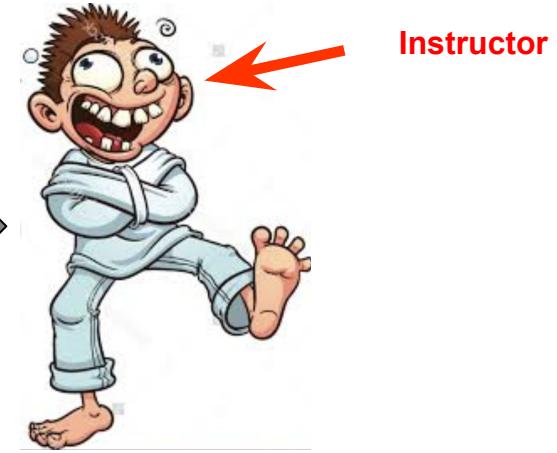
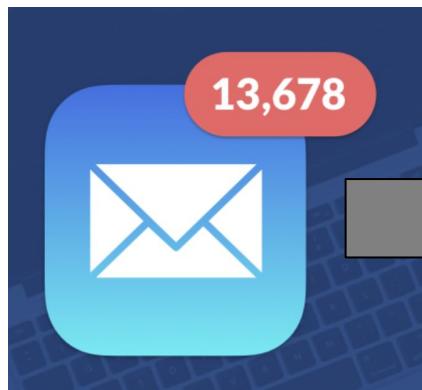
1. “Equation (4) on p. 3 should have a minus sign”
2. Will the Hessian be on the final?
3. Do you think I should go to Stanford for my PhD? Is that a good school?

We will not answer email unless appropriate. Use your judgement to communicate with us.

To communicate with us

To communicate with the teaching team

1. In class, in session, in hwk party
2. In office hours
3. On piazza
4. With the appropriate email channels
5. For personal cases or emergency, by email, otherwise: please consider this



Instructor

Disabled Students Program

If you are in this situation

- You need to have the DSP send us your letter as soon as possible.
- Without the letter from the DSP we cannot help you, because we do not know what you need (and we cannot do it legally).
- With the letter from the DSP, we know exactly what to do, and we can ask for the resources to do it. **IT WORKS WELL.**
- Talk to us ahead of time.
- Share your concerns.
- We will do everything we can to help, tell us how to help you.

Other personal needs (please remember previous slide)

- Let us know
 - In person in OH
 - In email
 - After class, in the lab, make special appointment if needed.

Exam policies

There will be 2 midterms (held in-class) and 1 final.

- Each midterm will be approximately 80 minutes.
- The final will be a standard 3 hour written final in the appointed exam time slot (12/14/18 8-11am).
- We will allow each student one, double-sided (handwritten) cheatsheet of notes for each exam.
- **There will be no make-up exams, except for medical emergencies.**
- Regrade policy for exam problems is identical to HWK regrade policy.

Extra Credit

The following activities will receive extra credit:

- Scribing (next slide)**
- Top five students posting correct answers on Piazza**
- Bonus problems in some homeworks**

Scribing

This year we will be having several scribes produce high-quality Latex notes for each lecture.

- You will receive extra-credit for this!
- Please see <https://github.com/nileshtrip/EE127Notes> for detailed instructions (in instructions.pdf) scribes are required to follow.
- Link also contains a Google doc sign-up sheet.
- Scribes should follow the example template in Lecture0 to produce their notes.

Grading system: we value consistency

Grade breakdown is as follows.

- Homework: 40%
- Midterm Exam: 20%
- Final: 40%

Specifics on grading.

- We will drop the lowest of the two midterms: two midterm exams, the highest grade counts for 20%
- We will drop the lowest hwk grade through the semester.
- The quiz does not count. The quiz is for you to be in an exam situation, see how you do, and learn from not knowing how to solve a question. Use it as practice for the exams.

This is not a grading scale

This is not a grading scale, ceci n'est pas une pipe

- A : 93 – 100%
- A-: 90 – 93%
- B+: 87 – 90%
- B : 83 – 87%
- B-: 80 – 83%
- C+: 77 – 80%
- C : 73 – 77%
- C-: 70 – 73%
- D+: 67 – 70%
- D : 63 – 67%
- D-: 60 – 63%
- F : < 60%



Ceci n'est pas une pipe.



This is not a hammer.

Cheating

Throughout the semester, you are encouraged to collaborate with other students in the class. However, directly copying from your peers' assignments will not be tolerated. Here we give our formal definition of cheating in this course.

CHEATING:

Turning in work done by another person as if were your own.



Topics covered in lecture

A	B	C	D	E	F	G	H
Week	Lecture #	Date	Instructor	Part	Lecture	Reading (book)	Reading (livebook)
1	1	8/23/18	AB & LEG	<i>Linear algebra</i>	Introduction	Ch. 1	Sec. 1
2	2	8/28/18	AB		Vectors and functions	Ch. 2	Sec. 2.1
2	3	8/30/18	AB		Matrices and linear maps	Ch 3, except sec. 3.3, 3.4.9, 3.7	Sec. 2.2, except 2.5
3	4	9/4/18	LEG		Quiz and mini-review / extra topic		
3	5	9/6/18	LEG		Symmetric matrices and their eigenvalues	Ch. 4	Sec. 2.5
4	6	9/11/18	LEG		Singular value decomposition	Ch. 5	Sec. 2.6
4	7	9/13/18	LEG		Linear equations	Ch. 6, except 6.5	Sec. 2.3
5	8	9/18/18	AB		Least-squares and variants	Ch. 6, except 6.5	Sec. 2.4
5	9	9/20/18	AB		Review		
6		9/25/18			MIDTERM		
6	10	9/27/18	AB	<i>Conic optimization</i>	Linear optimization	Ch. 9, sec. 9.3	Sec. 3.2
7	11	10/2/18	AB		Quadratic optimization	Ch. 9, all sections except 9.7	Sec. 3.2
7	12	10/4/18	AB		Second-order cone optimization	Ch. 10, sections 10.1 and 10.2	Sec. 3.3
8	13	10/9/18	AB		Robust optimization	Ch. 10, section 10.3	Sec. 3.4
8	14	10/11/18	AB		Review		
9		10/16/18	AB		Quiz and extra topic TBD		
9	16	10/18/18	LEG	<i>Convex optimization</i>	Convexity	Ch. 8, sections 8.1, 8.2	Sec. 3.1.1, 3.1.2
10	17	10/23/18	LEG		Convex optimization problems	Ch. 8, sections 8.3, 8.4	Sec. 3.1.3
10	18	10/25/18	LEG		Weak duality	Ch. 8, section 8.5	Sec. 3.1.5
11	19	10/30/18	LEG		Strong duality	Ch. 8, section 8.5	Sec. 3.1.5
11	20	11/1/18	LEG		Applications of duality		
12		11/6/18			MIDTERM		
12	21	11/8/18	LEG		Overview of algorithms	Ch. 12	Sec. 3.1.4
13	22	11/13/18	AB / LEG TBD	<i>Applications</i>	Machine learning	Ch. 13	Sec. 3.2.5, 3.4.4
13	23	11/15/18	AB / LEG TBD		Engineering design	Ch. 16	Sec. 3.5
14	24	11/20/18	LEG		Finance	Ch. 14	Sec. 5.5
15	25	11/27/18	AB		Control applications	Ch. 15	Sec. 2.6, 5.1,
15	26	11/29/18	AB		Review		
16		12/4/18	RRR		RRR		
16		12/6/18	RRR		RRR		
		12/14/18			FINAL (8-11am)		