

ELE201: INFORMATION SIGNALS

Spring 2020

Instructor:	Yuxin Chen	Time:	Tue & Thu, 9:30am - 10:50am
Email:	yuxin.chen@princeton.edu	Location:	Friend Center 004

Course Description. Signals that carry information play a central role in technology and engineering, ranging from sound and images to MRI, communication, radar, multimedia interaction, and robotic control. This course teaches mathematical tools to analyze, manipulate, dissect, and preserve information signals. A major focus of the course is transforms — in particular, the Fourier, Laplace, and Z transforms — which reveal the frequency spectrum of signals and can make them easier to manipulate. We also study sampling, the process of converting a signal from continuous to digital, and which transforms to use depending on the waveform. Additional topics covered include linear time-invariant systems, modulation, quantization, and stability. Lab design projects will use MATLAB.

Instructor. Yuxin Chen, C330 Equad (email: yuxin.chen@princeton.edu). Office hours: Tue & Thu 11am-12pm, or by appointment.

Teaching assistants.

- **Graduate head TA:** Anirudh Sridhar (email: anirudhs@princeton.edu). Office hours: Tue 3-4pm (Equad J323), Wed 3-4:30pm (Equad F115, during lab).
- Graduate TA: Di Jia Su (email: dsu@princeton.edu). Office hours: Thu 3:30-4:30pm (Equad J323), and Wed 8:30-10pm (Equad F115, during lab).
- Graduate TA: Ting-Han Fan (email: tinghanf@princeton.edu). Office hours: Mon 3-4:30pm (Equad F115, during lab).
- **Undergraduate head TA:** Joe Zhang (email: zhaoz@princeton.edu). Lab section: 2nd half of Mon and 2nd half of Wed afternoon (Equad F115).
- Undergraduate TA: Clare Cook (email: cbcook@princeton.edu). Lab section: 1st half of Mon and 1st half of Wed afternoon (Equad F115).
- Undergraduate TA: Sonia Gu (email: soniagu@princeton.edu). Lab section: Wed evening (Equad F115).

Prerequisites. Students should have knowledge of elementary calculus.

Piazza. The main mode of electronic communication between students and staff, as well as amongst students, will be through <http://www.piazza.com/>. It is intended for general questions about the course, clarifications about assignments, student questions to each other, discussions about material, and so on. We strongly encourage students to participate in discussion, ask and answer questions through this site. The course staff will monitor discussions closely.

Lab attendance. Lab attendance is not necessary to complete the labs, but the TAs will be available in Equad F115 during lab hours to help with any questions about the lab or the course in general. You are also allowed to go to any of the lab sections during the week (i.e., you are not tied to the section you signed up for on TigerHub).

Required textbook. Signals and Systems (Second Edition), by Oppenheim and Willsky.

Tentative topics.

- Unit 1: Signals and systems (Chapters 1.0-1.6)
 - Continuous-time and discrete-time signals, periodic signals, even and odd signals, exponential and sinusoidal signals
 - Impulse and unit step functions
 - Continuous-time and discrete-time systems
 - System properties: linear, time-invariant, causal, stable, others
- Unit 2: Linear time-invariant (LTI) systems (Chapters 2.1-2.4)
 - Discrete-time impulse response, convolution for discrete-time LTI systems
 - Continuous-time impulse response, convolution for continuous-time LTI systems; properties: commutative, distributive, associative, invertibility, stability, other
 - Difference / differential equations for discrete-time LTI systems
- Unit 3: Fourier series (Chapters 3.2-3.8)
 - Response of LTI systems to complex exponentials
 - Fourier series for continuous-time periodic signals, sinusoidal and exponential representations
 - Properties of continuous time Fourier series
 - Fourier series for discrete-time periodic signals
 - Properties of discrete-time Fourier series
- Unit 4: Continuous time Fourier transform (CTFT) (Chapters 4.1-4.7)
 - The continuous-time Fourier transform (CTFT)
 - Linearity and time shifting properties of the CTFT
 - Other CTFT properties: differentiation, integration
 - Fourier transform table; Frequency response of a continuous-time LTI system
 - Fourier transform solution to differential equations
- Unit 5: Discrete time Fourier transform (DTFT) (Chapters 5.1, 5.3-5.8)
 - The discrete-time Fourier transform (DTFT)
 - Periodicity, linearity, time shifting, and frequency shifting
 - The DTFT convolution and multiplication property, Fourier transform table;
 - Frequency response of a discrete-time LTI system
- Unit 6: Sampling and communication systems (Chapters 7.1-7.4, 8.1-8.3)
 - Sampling (Shannon-Nyquist's) Theorem
 - Impulse-train sampling
 - Undersampling and aliasing;
 - Discrete-time processing of continuous time signals
 - Amplitude modulation, FDM
- Unit 7: Laplace transform (Chapters 9.1-9.8)
 - The Laplace transform
 - Region of convergence
 - The inverse transform

- Properties; Laplace transform pairs
- LTI systems and Laplace transform, LTI systems described by differential equations, Block diagrams, Butterworth filters
- Unit 8: Z transform (Chapters 10.1-10.3, 10.5-10.8)
 - The z-transform
 - Region of convergence
 - The inverse transform, properties
 - LTI systems and z-transform

Evaluation. This class will have four types of evaluations:

- *Problem sets (30%).* There will be (approximately) seven problem sets. These will generally be released before the last week in which a unit is covered and due one week later. They must be submitted as a hardcopy to the course mailbox. Late submissions will be accepted for three days, with points deducted for each day late.

In addition, there will be attendance quizzes for the second half of the semester. All the quizzes together will add up to one homework grade and essentially count as the eighth problem set. It is possible to miss three quizzes and still get full score for the quiz grade.

You are allowed to *drop 1 problem in each problem set* without penalty. In addition, the lowest homework grade will be dropped. If the total quiz grade is lower than any of the homeworks, it will be dropped instead.

- *In-class midterm exam (20%).* There will be one midterm exam. It will be administered on Thursday, March 12. The exam will be closed book and closed notes, with the exception of a double-sided formula sheet on an 8.5×11 sheet of paper that you can create for yourself.
- *Labs (20%).* There will be three graded labs, each of which will use MATLAB extensively. You are allowed to work in groups of two and submit one write-up together. All of the labs will be two weeks in duration. Generally speaking, the writeup will be due at the end of the second week of the lab. The submission must be in hardcopy form to the course mailbox. All parts of the lab which ask for a demonstration to the TA should be submitted as part of the writeup.

In addition, you will be allowed 3 free late days to use whenever you want (i.e., you can use them all on one lab, spread them out between the three labs, or not use them at all). You do not have to state that you are using your late days, we will manage all of the bookkeeping on our end. Once you have consumed your 3 free late days, a 20% per day penalty will be assessed to your lab write-up.

- *Final exam (30%).* The final exam will be comprehensive, covering all materials taught during this semester. The questions will be of similar style to the midterm. You are permitted to bring two double-sided formula sheet of paper that you can create for yourself.

Collaboration policy. We encourage you to work on homework problems in study groups. However, each of you must write up and submit your own solutions and code without reading or copying the solutions of other students or other online resources.

Administrative assistant. Lisa Lewis, B325 Equad (email: ll2@princeton.edu).

Grading policy and procedures. Grading in this class will be performed in accordance with the policies set forth by the Office of the Dean of the College (ODOC). The teaching staff will take responsibility for ensuring that each assessment — problem sets, labs, and exams — is marked in a manner that constitutes “substantive feedback to give students clear information about the quality of their work.”

Note also that there are no exact numerical ranges associated with how letter grades will be allocated. For this reason, the instructors reserve the right to institute curves, both on individual assessments and on the final grades, as they see fit. Both upward and downward curves are possible, though the former is more likely if at all. That being said, students can also expect that their final letter grades will not deviate too substantially far from what would be expected on a traditional scale.