ECE 153. Probability and Random Processes for Engineers

Spring 2024

(Last updated April 14, 2024) Updates shown in blue.

Contents

1 Course Overview

Lectures: Tuesdays and Thursdays, 5:00–6:20pm.
Location: FAH 1450.

Discussion: Wednesdays, 2:00–2:50pm.
Location: FAH 1101.

Instructor: Parinaz Naghizadeh
Email: parinaz@ucsd.edu (please use my email. I do not check the Canvas inbox.)
Office hours: Tuesdays 12-1pm and Thursdays 3:30-4:30pm, or by appointment (please email me at least 2 days in advance so we can find a time).
Location: Jacobs Hall 6403.

TA: Daniel Ochoa Tamayo
Email: dochoatamayo@ucsd.edu
Office hours: Mondays 2-3pm and Fridays 10-11am.
Location: FAH 5101C. Note: First two weeks will be on Zoom; see Canvas for Zoom link.

Catalog description: Random processes. Stationary processes: correlation, power spectral density. Gaussian processes and linear transformation of Gaussian processes. Point processes. Random noise in linear systems. Prerequisites: ECE 109 with a grade of C– or better.

Informal description: This course is mainly about the fundamentals of random processes: how to model and analyze them (e.g., their expectation, autocorrelation, etc.). Probability and random processes are widely applied in many fields, including communication systems, machine learning and data analytics, finance, microeconomics, operations research, control theory, and biology. While we learn about

probability and random processes in this course through a formal/theoretical approach, I will attempt to provide motivations from these application areas as often as possible. The broad set of topics to be covered in this course are:

- Review of probability: random variables, expected values, conditional/joint distribution/expectation.
- Sequences of random variables; random vectors
- Error estimation; convergence and limit theorems
- Random processes: definitions and basic properties
- Discrete time random processes
- Gaussian processes
- Stationary random processes

See the "Course Outline" section for a tentative schedule of topics to be covered in each lecture.

Prerequisites: Working knowledge of calculus and linear algebra is a must. Prior exposure to probability and statistics (at the level of ECE 109) is also assumed and required; we will have review lectures on these topics in the first few weeks of lectures and discussions, but these are to serve as a refresher, and will not be a substitute to the prerequisite.

2 Textbooks, Readings, and Course Technologies

Readings and reference books: There are no required textbooks for this course. Lecture slides will be posted on Canvas. These are intended to provide an overview of all topics covered in each lecture, but will not be a substitute to lectures, as they may not include all details such as some of the discussions or examples from class.

In case you would like to read more, some recommended references for the topics covered in the course are:

- "Probability and Random Processes for Electrical Engineers" by John A. Gubner
- "Random Processes for Engineers" by Bruce Hajek
- "Introduction to Probability Models" by Sheldon M. Ross
- "Stochastic Processes: Theory for Applications" by R. G. Gallager
- "Probability and Random Processes for Electrical Engineering" by A. Leon-Garcia

Some of these references are available online on the publisher or authors' webpages. They are also available through the library.

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.

Course technologies: Canvas will be used for announcements and to distribute course material. You will also upload your homework solutions and take quizzes on Canvas. To submit your homework, you will upload either a digital solution (typed or 'written') or a photo of your on-paper written solutions. For the latter option, you will need access to a camera (e.g., a phone camera). You do not need to use a scanner or anything fancy; any method that produces a legible file will do.

In-class review quizzes will be through Kahoot. If you would prefer not using a digital device in class to access Kahoot, you are welcome to write your answers on paper and hand them to me.

3 Grading

Grading: 30% Homework and Quizzes, 30% Midterm Exam, 35% Final Exam, and 5% Class Participation. Letter grades are expected to follow the standard scheme ($A+ \geq 97\%, A \geq 93\%, A- \geq 90\%, B+ \geq 87\%, \ldots$).

- **Homework and quizzes:** Our weekly assignment will be either a homework (x4) or a quiz (x2) – each week's assignment will determine 5% of the final grade. Homework will be posted one week in advance of its due date, and will be due by 5pm PT on Tuesdays (right before lecture). The two quizzes will be online (through Canvas). You can think of them as "mini"-homework (so they are open note/book, etc.), but (likely) timed and collaboration is not permitted on them. They will be posted at least 3 days in advance, and will be due by 5pm PT on Tuesdays (right before lecture). The tentative dates on which homework and quizzes will be due are given in the lecture outline.
- **Late homework policy:** Late homework or quizzes will be accepted only if there is a documented reason or unexpected circumstances (verifiable by the university). *No exceptions will be made; late assignments beyond this will not be accepted and will get a grade of zero.*
- **Midterm exam:** There will be an in-class midterm exam on Tuesday, 5/7/2024. It will be based on topics covered up to and including lecture 9. This will be a proctored exam.
- **Final exam:** There will a comprehensive final exam on Thursday, 6/13/2024, from 7:00-9:59PM. Location TBD. This will be a proctored exam.
- **Class participation:** This will be assessed through Kahoot review quizzes at the beginning of the lectures. I will randomly check the roster on these at the end of the quarter, and assign attendance credit accordingly. Discussion section attendance may be assessed as well. Please let me know in advance if and why you may be missing a lecture. Absences for any sincerely held religious belief, observance, or practice will be accommodated where reasonable. (See the University's Academic Regulations and Policies for more details.)

The above are subject to change. Please refer to the course announcements on Canvas to stay notified of any updates to this syllabus, including updates to homework or exam(s) assignment and/or due dates, as well as clarifications/corrections to assignment questions.

Collaboration policy: Students are welcome (and encouraged) to work together on homework and on general discussion of course material. Keep in mind however that all solutions handed in by the students must be written solely by them and reflect their independent understanding of the material. No collaboration, discussions, or use of any online resources, is permitted for the quizzes, midterm, and/or final exams.

4 Course Outline

Table 1: Lecture outline (subject to change)

Lecture	Date	Topics covered
1	4/2	Introduction: motivation, course logistics
1.5	4/3	Discussion: review of basic probability theory (covered by Parinaz)
2	4/4	Probability review, continued: random variables
3	4/9	Probability review, continued: two random variables
	4/9	**Homework 1 due**
4	4/11	Probability review, continued: (conditional) expectation (I)
5	4/16	Probability review, continued: (conditional) expectation (II)
	4/16	**Quiz 1 due**
6	4/18	Minimum mean square error estimation (I)
7	4/23	Minimum mean square error estimation (II)
	4/23	**Homework 2 due**
8	4/25	Random vectors (I)
9	4/30	Random vectors (II)
10	5/2	Convergence and limit theorems
11	5/7	**In-Class Midterm Exam**
12	5/9	Random processes: introduction and basics
13	5/14	Discrete time random processes (I)
	5/14	**Homework 3 due**
14	5/16	Discrete time random processes (II)
15	5/21	Gaussian processes (I)
	XX	**Quiz 2 due**
16	5/23	Gaussian processes (II)
17	5/28	Stationary processes (I)
	5/28	**Homework 4 due**
18	5/30	Stationary processes (II)
19	6/4	Review through an application
20	6/6	Course review
		Final exam (Thursday, June 13th, 7:00-9:59PM)

5 Other Course Policies

UC San Diego Principles of Community: The University of California, San Diego is dedicated to learning, teaching, and serving society through education, research, and public service. Our international reputation for excellence is due in large part to the cooperative and entrepreneurial nature of the UC San Diego community. UC San Diego faculty, staff, and students are encouraged to be creative and are rewarded for individual as well as collaborative achievements.

To foster the best possible working and learning environment, UC San Diego strives to maintain a climate of fairness, cooperation, and professionalism. These principles of community are vital to the success of the University and the well being of its constituents. UC San Diego faculty, staff, and students are expected to practice these basic principles as individuals and in groups. The complete UC San Diego Principles of Community in English and Spanish can be found here: `https://ucsd.edu/about/principles.html`.

Academic Integrity: Academic Integrity is expected of everyone at UC San Diego. This means that you must be honest, fair, responsible, respectful, and trustworthy in all of your actions. Lying, cheating or any other forms of dishonesty will not be tolerated because they undermine learning and the University's ability to certify students' knowledge and abilities. Thus, any attempt to get, or help another get, a grade by dishonesty will be reported to the Academic Integrity Office and will result in sanctions. Sanctions can include an F in this class and suspension or dismissal from the University. So, think carefully before you act by asking yourself:

a) is what I'm about to do or submit for credit an honest, fair, respectful, responsible and trustworthy representation of my knowledge and abilities at this time and,

b) would my instructor approve of my action?

You are ultimately the only person responsible for your behavior. So, if you are unsure, don't ask a friend—ask your instructor, instructional assistant, or the Academic Integrity Office. You can learn more about academic integrity at `http://academicintegrity.ucsd.edu`.

Nondiscrimination and Harassment: The University of California, in accordance with applicable federal and state laws and university policies, does not discriminate on the basis of race, color, national origin, religion, sex, gender, gender identity, gender expression, pregnancy (including pregnancy, childbirth, and medical conditions related to pregnancy or childbirth), physical or mental disability, medical condition, genetic information, ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services (including membership, application for membership, performance of service, application for service, or obligation for service in the uniformed services). The university also prohibits harassment based on these protected categories, including sexual harassment, as well as sexual assault, domestic violence, dating violence, and stalking. The nondiscrimination policy covers admission, access, and treatment in university programs and activities. If students have questions about student-related nondiscrimination policies or concerns about possible discrimination or harassment, they should contact the Office for the Prevention of Harassment & Discrimination (OPHD) at (858) 534-8298, ophd@ucsd.edu, or `http://reportbias.ucsd.edu`. Campus policies provide for a prompt and effective response to student complaints. This response may include alternative resolution procedures or formal investigation. Students will be informed about complaint resolution options. A student who chooses not to report may still contact CARE at the Sexual Assault Resource Center for more information, emotional support, individual and group counseling, and/or assistance with obtaining a medical exam. For off-campus support services, a student may contact the Center for Community Solutions. Other confidential resources on campus include Counseling and Psychological Services, Office of the Ombuds, and Student Health Services.

CARE at the Sexual Assault Resource Center
858.534.5793 — sarc@ucsd.edu — `https://care.ucsd.edu`

Counseling and Psychological Services (CAPS)
858.534.3755 — https://caps.ucsd.edu

Your Mental Health: As a student you may experience a range of issues that can cause barriers to your learning, such as increased anxiety, feeling down, difficulty concentrating, and/or lack of motivation. The University offers services to assist you with addressing these and other concerns you may be experiencing. If you find yourself feeling isolated, anxious, or overwhelmed, please know that there are resources to help: CAPS Student Health and Well-Being provides services like confidential counseling and consultations for psychiatric services and mental health programming https://wellness.ucsd.edu/caps/. Please feel free to let me know if there are circumstances affecting your ability to participate in class.

Accessibility Accommodations: I ask that students requesting accommodations for this course due to a disability provide a current Authorization for Accommodation (AFA) letter issued by the Office for Students with Disabilities (OSD) which is located in University Center 202 behind Center Hall. Students are required to present their AFA letters to Faculty (please make arrangements to contact me privately) and to the OSD Liaison in the department in advance so that accommodations may be arranged.
Office for Students with Disabilities (OSD)
Documents student disabilities, provides accessibility resources, and reasonable accommodations
858.534.4382 — osd@ucsd.edu — https://disabilities.ucsd.edu/