ECE 250. Random Processes

Fall 2024

(Last updated October 7, 2024. Updates shown in blue.

Contents

1	Course Overview	1
2	Textbooks, Readings, and Course Technologies	2
3	Grading	3
4	Course Outline	4
5	Other Course Policies	5

1 Course Overview

Lectures: Tuesdays and Thursdays, 11:00am–12:20pm. Location: CSB 001.

Discussion: Mondays, 2:00–2:50pm. Location: WLH 2005.

Instructor: Parinaz Naghizadeh

Email: parinaz@ucsd.edu (please use my email. I do not check the Canvas inbox.) Office hours: Tuesdays 4-5pm and Thursdays 9:30-10:30am, or by appointment (please email me at least 2 days in advance so we can find a time). Location: Jacobs Hall 6403.

TA: Sai Ashish Somayajula Email: ssomayaj@ucsd.edu Office hours: Wednesdays 10-11pm and Fridays 10-11am. Location: In person, location TBA.

Reader: Geetika Agrawal Email: geagrawal@ucsd.edu

Catalog description: Random variables, probability distributions and densities, characteristic functions. Convergence in probability and in quadratic mean, Stochastic processes, stationarity. Processes with orthogonal and independent increments. Power spectrum and power spectral density. Stochastic integrals and derivatives. Spectral representation of wide sense stationary processes, harmonizable processes, moving average representations. Recommended preparation: ECE 153. **Informal description:** This course is mainly about the fundamentals of random processes: how to model and analyze them. 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. We will learn about random processes with a formal/theoretical approach; example application areas are mentioned for motivation. The broad set of topics to be covered in this course are:

- Review of probability; foundations of probability theory
- Sequences of random variables; random vectors; random processes
- Convergence of sequences of random variables; limit theorems
- Estimation theory; minimum mean square error estimation
- Discrete-time random processes; Markov chains
- Continuous-time random processes; stationary random processes
- Random processes through linear systems
- Martingale theory

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

Prerequisites: The formal prerequisite is graduate standing. That said, prior exposure to probability and statistics, and some familiarity with random processes (at the level of ECE 153) is assumed and is a must; 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: This course will be delivered through lecture slides, which will be posted on Canvas. These are intended to provide an overview of all topics covered in each lecture, but will not necessarily be a substitute to lectures, as they may not include all details such as some of the discussions or examples from class. I will also make references to content from "Random Processes for Engineers" by Bruce Hajek (available online), throughout the course, for additional readings. In case you would like to read more, some recommended references for the topics covered in the course are:

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

Some of these references are available online on the publisher's or authors' webpages, as well. 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/or 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.

3 Grading

Grading: 30% Homework, 30% Midterm Exam, 40% Final Exam. Letter grades are expected to follow the standard scheme $(A + \ge 97\%, A \ge 93\%, A - \ge 90\%, B + \ge 87\%, \ldots)$. There will be a 3% bonus for Class Participation; more details below.

- Homework: We will have 6 homework sets. Each homework will determine 5% of the final grade. Homework will be posted about one week in advance of its due date, and will be due by 11:59pm PT on Tuesdays. Homework may be either "spot-graded" (i.e., only a random subset of questions will be graded), or graded on a discrete scale (0: very bad; 1: bad; 2: average, 3: good; 4: very good; 5: outstanding). The tentative dates on which homework will be due are given in the lecture outline.
- Late homework policy: Late homework 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, 10/29/2024. 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 Wednesday 12/11/2024, 11:30am-2:29pm. Location TBD. This will be a proctored exam.
- Class participation: This component is for bonus points. It will be assessed through in-class short quizzes at the beginning of a few randomly selected lectures. Participating in them can earn you up to a 3% bonus, based on your performance in them.

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 any quizzes, midterm, and/or final exams.

4 Course Outline

Lecture	Date	Topics covered
1	9/26	Introduction: motivation, course logistics
2	10/1	Probability basics/theory (I)
	10/1	(voluntary) review homework 0
3	10/3	Probability basics/theory (II)
4	10/8	Random vectors (I)
	10/8	Homework 1 due
5	10/10	Random vectors (II)
6	10/15	Estimation (I)
	10/15	Homework 2 due
7	10/17	Estimation (II)
8	10/22	Convergence and limit theorems (I)
	10/22	Homework 3 due
9	10/24	Convergence and limit theorems (II)
10	10/29	In-Class Midterm Exam
11	10/31	Basics of random processes
12	11/5	Markov chains (I)
13	11/7	Markov chains (II)
14	11/12	Markov chains (III)
	11/12	Homework 4 due
15	11/14	Markov chains (IV)
16	11/19	Stationary random processes (I)
	11/19	Homework 5 due
17	11/21	Stationary random processes (II)
18	11/26	Random Processes in Linear Systems (I)
	11/26	Homework 6 due
19	12/3	Random Processes in Linear Systems (II)
20	12/5	Martingales
		Final exam (Wednesday 12/11/2024, 11:30am-2:29pm)

Table 1: Lecture outline (subject to change)

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/