

EE 512: Stochastic Processes (Spring 2020)

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Lectures: Tuesday and Thursday 12:30-1:50pm, OHE 132

Discussion: F 12-12:50, OHE 132

Class website: <https://piazza.com/usc/spring2020/ee512/home>

Summary: The course is an exploration of the theory and applications of stochastic processes with a special focus on computation. This entails a rigorous mastery of the underlying probability theory and statistics as well as familiarity with a programming language (Python or R recommended). There will be two midterms and a final exam.

Prerequisites: EE 503 and (one of 441 or 510 or 518), and EE 441

Textbooks: There is no required textbook for this class. But the following textbooks are highly recommended. They are listed in order of priority for this course:

Gubner, J. A., *Probability and Random Processes for Electrical and Computer Engineers*, Cambridge University Press, 2006.

Ross, S. M. *Stochastic Processes*.

Hsu, H. P. *Schaum's outline of theory and problems of probability, random variables, and random processes*. 2nd Ed. McGraw-Hill, 2014.

Glasserman, P. *Monte Carlo methods in financial engineering*. Springer, 2013.

Ross, S. M. *Simulation*. Academic Press, 2013.

Durrett, R., *Essentials of Stochastic Processes*. Springer, 2016.

Grading: 15% homework, 45% midterms, 40% final
Your lowest homework score will be thrown out before computing final grades.
No late homework will be accepted. No make-up exams will be given.
You are encouraged to discuss homework problems among yourselves, but each person must do their own work. **Copying or turning in identical homework sets is cheating.**
You have *one week* from the date that a graded paper is returned to dispute the scoring of a problem, by submitting a request in writing to me.

Outline: (each item roughly corresponds to one week's material)

1. *Overview of probability:* Probability spaces, random variables, distribution functions, moment generating functions, expectation, conditional probability and expectation, probability inequalities, examples
2. *Stochastic processes:* Examples, notions of convergence, definition of a stochastic process, independence, zero-one laws, laws of large numbers, central limit theorems, stable laws
3. *The Poisson process:* Definition, conditional distribution of the arrival times, non-homogeneous Poisson process, compound Poisson random variables and processes
4. *Renewal theory:* Limit theorems, Wald's identity, key renewal theorem, branching processes, regenerative processes, stationary point processes
5. *Discrete-time Markov chains:* Examples in communication systems, Chapman-Kolmogorov equations, limit theorems, time-reversible Markov chains, semi-Markov processes

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6. *Continuous-time Markov chains*: Examples, birth-death processes, Kolmogorov differential equations, limiting probabilities, time reversibility, uniformization, application to queueing theory, hidden Markov models and the Baum-Welch algorithm

Midterm exam 1 In class (date TBA — February 20??)

7. *Martingales*: Definition, martingale differences, level crossings, stopping times, Azuma's maximal inequality, sub-martingales, super-martingales, and the martingale convergence theorem
8. *Random walks*: Definition, duality in random walks, exchangeable random variables, analysis using martingales, ruin problems, application in queueing systems
9. *Brownian motion and other Markov processes*: Definition, continuity and non-differentiability of paths, hitting times, maximum variable and arc sin laws
10. *Variations on Brownian motion*: Examples of diffusions, backward and forward diffusion equations, Markov shot noise process, scale functions, speed measures, calculation of functionals of measures

Midterm exam 2 In class (date TBA — March 26??)

11. *Stochastic integration*: Definition of Itô integral, Itô lemma, Chain rule of differentiation, Stratonovich integral, connection to Riemann and Riemann-Stieltjes integral
12. * *Stochastic differential equations and finance applications*: Itô stochastic differential equations, solution by the Itô lemma and the Stratonovich calculus, Girsanov's change of measure technique, Black-Scholes formula
13. ** *Simulation*: General techniques for simulating continuous random variables, simulating stochastic point processes, variance reduction techniques, sample complexity bounds, generating from the stationary distribution of a Markov chain, Markov Chain Monte Carlo

Final exam Wednesday, May 14, 2-4pm <http://classes.usc.edu/term-20201/finals/>

Important:

Any form of cheating or plagiarism will lead to a severe penalty which is an F in the class. Assisting or facilitating cheating will also lead to an F in the class.

If you find the course difficult with a high risk to a grade you would not like to get, you may consider dropping the class or see me early in the semester to review your progress and help you out with understanding the material better.

After the class is over nothing can be done to change grades based on personal constraints or any other excuse. If you encounter an emergency that prevents you from studying and doing well, let me know right away.

Statement on Academic Integrity:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: <http://www.usc.edu/dept/publications/SCAMPUS/gov/>. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: <http://www.usc.edu/student-affairs/SJACS/>.

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards <https://policy.usc.edu/student/scampus/>. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, <https://policy.usc.edu/scientific-misconduct/>.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity <https://equity.usc.edu/> or to the Department of Public Safety <http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us>. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. Relationship and Sexual Violence Prevention and Services provides 24/7 confidential support, and the sexual assault resource center webpage <https://studenthealth.usc.edu/sexual-assault/> describes reporting options and other resources.

Statement for Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Support Systems:

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute <https://ali.usc.edu/>, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs <https://dsp.usc.edu/> provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information <https://emergency.usc.edu/> will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.