EE 512: Evolution Theory of Stochastic Processes (Fall 2014)

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office hours: MW 2:30-3:30 cafe between EEB & RTH

Lectures: Tuesday and Thursday 11-12:20pm, OHE 132
Discussion: F 2-2:50, OHE 132
Class website: https://blackboard.usc.edu

Overview: This course provides a rigorous introduction to probability theory and stochastic processes and is geared towards first- and second-year graduate students in electrical engineering and to students in the financial engineering program, as well as computer science, industrial and systems engineering and other departments. The course will do a quick overview of basic concepts of probability theory including probability spaces, random variables, expectation, and related convergence concepts. It will then introduce stochastic processes, and key limit theorems. Other topics to be covered include Poisson processes, renewal theory, discrete- and continuous-time Markov chains, martingale theory, random walks, Brownian motion, stationary and Gaussian processes. The later part of the course will also provide an introduction to stochastic integration and stochastic differential equations, and cover applications in queueing theory, simulation and finance.

Prerequisites: EE 465 or 464 or 503, and EE 441

Intended audience: The course is primarily intended for MS and PhD students in Engineering who like to specialize in Financial Engineering, Communications, Controls, Networks and Signal Processing and other relevant areas in Electrical Engineering, Industrial and Systems Engineering, Computer Science, etc.

Textbooks: Primary text: Sheldon M. Ross, “Stochastic Processes” (2nd edition), 1996
Robert Gallagher, “Stochastic Processes”, 2013
Thomas Mikosch, “Elementary Stochastic Processes With Finance in View”, 1999

Grading: 15% homework, 35% midterm 1, 50% 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
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
7. *Martingales:* Definition, martingale differences, level crossings, stopping times, Azuma's maximal inequality, sub-martingales, super-martingales, and the martingale convergence theorem

Midterm exam In class

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
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 Tuesday, Dec. 16, 8-10am http://classes.usc.edu/term-20143/finals/

Important:

All students are expected to follow the rules for each exam. 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/.

Statement regarding Plagiarism/Copying:

Plagiarism or copying of home-works is strictly forbidden, and will result in penalties. Repeat plagiarism/copying by a student will be reported to Student Judicial Affairs and Community Standards for possible probation. Specifically, all the homeworks/exams must be written by students, individually. No part of the homework should be copied from any other document including the solutions from books, other student's homework, etc.

Make sure to review the "Behavior Violating University Standards and Appropriate Sanctions" section of the SCampus Student Guidebook.
http://web-app.usc.edu/scampus/1100-behavior-violating-university-standards-and-appropriate-sanctions/

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 as early in the semester as possible. Your letter must be specific as to the nature of any accommodations granted. DSP is located in STU 301 and is open 8:30 am to 5:30 pm, Monday through Friday. The telephone number for DSP is (213) 740-0776.