

# EE 512: Stochastic Processes

## Spring 2019

Time: Tuesday and Thursday 12:30PM-1:50 PM  
Location: OHE 132  
Instructor: Ashutosh Nayyar  
Discussion: OHE 132, Friday 12:00-12:50 PM  
TA: Shiva Navabi

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**Prerequisites:** EE 503

### Course Overview:

This course provides a rigorous introduction to stochastic processes for graduate students in electrical engineering, financial engineering, 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. The course will then cover various topics including Poisson processes, renewal theory, discrete and continuous-time Markov chains, martingale theory, random walks, Brownian motion and Ito diffusions.

### Intended Audience:

The course is intended for MS and PhD students in Communications, Controls, Networks and Signal Processing Areas of Electrical Engineering, MS students in the Financial Engineering program, and should also be of interest to graduate students in Industrial and Systems Engineering and Computer Science.

### Suggested Texts:

Primary:

- \* Stochastic Processes, second edition, by S. Ross, J. Wiley & Sons, 1996.
- \* Essentials of Stochastic Processes, by Rick Durrett, 2011 (available online).

Supplementary:

- (i) Stochastic Processes, Robert Gallager, Cambridge, 2013.
- (ii) Probability and Random Processes for Electrical and Computer Engineers by J. Gubner, Cambridge University Press, 2006.
- (iii) Introduction to Probability Models by S. Ross, 10th edition.
- (iv) Schaum's outline of theory and problems of probability, random variables, *and random processes*, by H. P. Hsu, 2<sup>nd</sup> Edition McGraw-Hill, 2014.
- (v) Monte Carlo methods in financial engineering, by P. Glasserman, Springer 2013.

**Grading:**

1. *Home Works* 15%
2. *Mid-terms*: 20% + 20%
3. *Final*: 45%. **On May 8th, 2-4PM**

**TOPICS:**

1. *Overview of Probability*: Probability spaces, random variables, distribution functions, moment generating functions, expectation, conditional probability and expectation, probability inequalities.
2. *Stochastic processes*: Examples, Notions of convergence, Definition of a stochastic process, Independence, Zero-one laws, Laws of large numbers, Central limit theorems.
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.
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.
7. *Martingales*: Definition, Martingale differences, Level crossings, Stopping times, Azuma's maximal inequality, Sub-martingales, Supermartingales, and the Martingale convergence theorem.
8. *Brownian motion and Ito diffusions*: Definition, Hitting times, maximum variable and arc sine laws, Geometric Brownian motion, Ornstein-Uhlenbeck process, backward and forward diffusion equations.

If time permits, we will look at additional topics such as: Markov chain Monte Carlo methods, Stochastic integrals, Girsanov change of measure and Black-Scholes model.

**Statement on Academic Conduct and Support Systems****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://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/>. Other forms of academic dishonesty are equally unacceptable. See additional

information in *SCampus* and university policies on scientific misconduct, <http://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* <http://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 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. *The Center for Women and Men* <http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage [sarc@usc.edu](mailto:sarc@usc.edu) describes reporting options and other resources.

### **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* <http://dornsife.usc.edu/ali>, which sponsors courses and workshops specifically for international graduate students. The *Office of Disability Services and Programs* [http://sait.usc.edu/academicsupport/centerprograms/dsp/home\\_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html) 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* <http://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.