

Overview: This course is a graduate level probability and random processes course. We will begin with an overview of probability and develop limit theorems. We will then discuss models for random processes, with applications in communications, networks, control and computer systems.

Pre-requisites: EE 351K (undergraduate level Probability, Statistics and Random Processes) or equivalent.

Textbooks: 1. *An Exploration of Random Processes for Engineers*, by B. Hajek. Available on the web at <http://www.ifp.uiuc.edu/~hajek/Papers/randomprocesses.html>

2. *Markov Chains: Gibbs Fields, Monte Carlo Simulation and Queues*, P. Bremaud, Springer-Verlag, 1998.

Class Hours: Class will be held on **Monday and Wednesday, 9:30 - 11:00 am** in **ENS 115**. Office hours will be decided on the first day of class.

Course Policy: Attendance is expected. You are responsible for material covered in the reading assignments (even if not covered in class) as well as material covered in class that is not in the book. Homework will be assigned roughly every ten days. Late homeworks **will not be accepted**.

You may discuss homework problems with other students, but you are not allowed to copy from others. University disciplinary procedures will be invoked if any form of cheating is detected. Course and instructor evaluations will occur the last day of class.

“The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities.” For more information, contact the Office of the Dean of Students at 471-6259, 471-4241 TDD or the College of Engineering Director of Students with Disabilities at 471-4321.

Web-based, password-protected class sites are associated with all academic courses taught at The University. Syllabi, handouts, assignments and other resources are types of information that may be available within these sites. Site activities could include exchanging e-mail, engaging in class discussions and chats, and exchanging files. In addition, electronic class rosters will be a component of these sites. Students who do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar, Main Building, Room 1.

Grading:

- (i) Class Participation: 5%
- (ii) Homework: 15%
- (iii) Midterm Exam 1: 20%
- (iv) Midterm Exam 2: 20%
- (v) Final Exam: 40%

Syllabus

1. **Introduction:** sigma algebra, probability axioms, independence, random variables, expectation, pdf, cdf, moments, MGF
 2. **Convergence and Limit Theorems:** Convergence of random variables – almost sure, mean-square, convergence in probability, convergence in distribution; Borel-Cantelli Lemma; Limit theorems – strong law of large numbers, central limit theorem; convex functions and Jensen's inequality; Chernoff bound and large deviations
 3. **Mean Square Estimation:** The orthogonality principle, Gaussian random vectors, Minimum Mean Square and Linear Mean Square Estimators (MMSE, LMSE)
 4. **Markov Chains I:** Discrete Time Markov Chains (DTMC), Structural properties (communication classes, periodicity, irreducibility), Stationary distribution, Positive/null recurrence, Transience, Tests for positive recurrence/transience, Foster's Theorem
 5. **Markov Chains II:** Strong Markov property and stopping times, Ergodic theorem for DTMC, Reversibility, Markov chains on graphs, Spectral properties of Markov Chains (Perron-Frobenius Theorem, convergence rate, Geometric bounds)
 6. **Random Processes:** Random walk, independent increment processes, Brownian motion, Poisson process, Stationarity
 7. **Martingales:** Definition, filtration, stopping times, optional stopping theorem, Azuma-Hoeffding inequality, Doob's backward martingale, martingale convergence theorem
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Reference

- (i) Probability and Random Processes, G. R. Grimmett and D. R. Stirzaker, Oxford University Press, 3rd edition, 2001.
- (ii) Probability and Computing - Randomized Algorithms and Probabilistic Analysis, M. Mitzenmacher and E. Upfal, Cambridge University Press, 2005.
- (ii) Probability and Random Processes with Applications to Signal Processing, H. Stark and J. Woods, 3rd edition, 2002.