ENEE 324H –ENGINEERING PROBABILITY, Spring 2018, Tu Th, 9:30-10:45 am in EGR 3111; Discussion W 2:00 pm in ATL 0201. Instructor: P. S. Krishnaprasad (krishna@umd.edu; 301-405-6843). Office is in A.V. Williams Building – room 2233. Office Hours: Tu 12:00 pm – 2:00 pm & 5:15 – 7:15 pm
Graduate Teaching Assistant: Dipankar Maity dmaity@terpmail.umd.edu; Office Hours: W 3:00 – 5:00 pm
Course website - http://www.ece.umd.edu/class/enee324h.S2018/

Contents in Brief: Axioms of probability; conditional probability and Bayes' rule; random variables, probability distribution and densities; functions of random variables; weak law of large numbers and central limit theorem; Introduction to random processes; correlation functions, spectral densities, and linear systems. Applications to noise in electrical systems, filtering of signals from noise, estimation, and digital communications

Course Goals: The principal goal of this course is to introduce students to the basic concepts of probability, random variables, and stochastic processes so that they will have an understanding of how to deal with random phenomena (e.g. additive noise) while designing and analyzing systems. The concept of a probability space and the fundamental axioms of probability will be presented first, illustrated by discrete settings. This will be extended to *conditional* probability. Then the concept of a (real-valued) random variable will be introduced, followed by *cumulative distribution function* (cdf) and probability *mass* and *density* functions (pmf and pdf). Multi-dimensional random variables and joint distributions and densities will be discussed. Methods for finding probability density functions of functions of random variables will be derived. The concept of expected value will be presented, and means, variances, covariances and moment generating functions and methods to estimate them will be examined. The concept of a random (or stochastic) process will be introduced and specialized to the analysis of linear time-invariant systems with random inputs (Gauss-Markov process). The Nyquist-Johnson noise model will be used to illustrate the role of stochastic processes in electrical engineering. Markov chains and related concepts (e.g. steady state probability distribution) will be discussed. Concepts from *statistical analysis* – estimation of parameters and testing of hypotheses, will be introduced and applied to various examples. (See next page for course structure.)

Course Prerequisite: ENEE 322 (Signals and System Theory) and completion of all lower-division technical courses in the ECE curriculum. **Topic Prerequisite**: Calculus (including multiple integrals); Laplace and Fourier transforms; linear time-invariant systems.
Required Textbook: Geoffrey Grimmett and David Stirzaker **- Probability and Random Processes** , Third Edition, Oxford University Press, 2001, (reprinted in 2004 with corrections) ISBN 0 19 857222 0 (paperback). I expect to cover chapters 1-5 entirely, parts of chapters 6, 7, 8 and 9 selectively.

Grading: There will be regular homework assignments and two midterm examinations (Thursday, February 22, and Thursday, April 5) and a final examination (Monday, May 14, 8:00 am -10:00 am). The grades will be assigned on the basis of the breakdown – homework sets 10%, each midterm 25%, and final 40%. All examinations are of the closed book kind. There will also be a strong emphasis on reading assignments from the textbook.

Policy on Classroom Environment

It is of utmost importance to maintain a classroom environment conducive to focus on and attention to instruction. **Hence usage of electronic devices (music equipment, cell phones, text messaging devices and computers) is disallowed during regular class hours.**

Course Structure

1. **Basic Concepts of Probability** (5 classes)
(a) Review of set operations; (b) sample space; (c) axioms of probability; (d) permutations and combinations; (e) applications to discrete sample spaces; (f) conditional probability and Bayes rule; (g) statistical independence; (h) Bernoulli trials and the binomial distribution
2. **Random Variables** (4 classes)
(a) Definition of a random variable and indicator random variables; (b) cumulative distribution function (cdf); (c) probability mass function (pmf); (d) probability density function (pdf); (e) examples of discrete and continuous random variables; (f) function of a random variable and methods for finding cdf or pdf of a function
3. **Multiple Random Variables** (4 classes)
(a) Joint cdf and pdf; (b) independent random variables; (c) conditional density of one random variable given another; (d) jointly Gaussian random variables; (e) functions of two or more random variables and the transformation theorem (change of variables formula)
4. **Expected Values** (5 classes)
(a) Definition of the expected value of a random variable; (b) mean, variance, standard deviation and other moments; (c) covariance and correlation coefficient; (d) expected value of function of random variables; (e) estimating probabilities via inequalities; (f) characteristic function (Fourier transform) and moment generating function (Laplace transform) and their applications to computing moments etc; (g) random variables without moments
5. **Sums of Random Variables** (3 classes)
(a) Sample mean and variance; (b) Weak Law of Large Numbers; (c) Central Limit Theorem
6. **Random Processes** (6 classes)
(a) Definition of a random process; (b) nth order statistics; (c) autocorrelation function; (d) sine wave with random phase, the random telegraph wave, the binary random wave; (e) strict-sense and wide-sense stationary random processes; (f) power spectral density; (g) wide-sense stationary random process and linear, time-invariant systems – how to find output power spectral densities and autocorrelation functions; (h) Markov Chains; (i) statistical estimation and testing

Comment: This course will provide a solid theoretical base to treat uncertainty and randomness. Key concepts and techniques for calculations will be illustrated via engineering applications. This course will have four pillars: (a) Bayes' theorem; (b) Limit theorems; (c) Change of variables; (d) Dynamic stochastic models. By the end of the semester these pillars should have been built and should be in good shape to support further study of science and engineering, with an appreciation for the role of uncertainty and randomness.