ECE 537H1S - Random Processes, Fall 2014

Synopsis: Introduction to the principles and properties of random processes, with applications to communications, control systems, and computer science.

Prerequisites: Introductory probability (ECE 302), linear systems.

Required textbook:
A. Leon-Garcia, *Probability and Random Processes for Electrical Engineering*, Third Edition, Addison Wesley, 2008.

Recommended references:
A. Papoulis and S. U. Pillai, *Probability, Random Variables and Stochastic Processes*, Fourth Edition, McGraw-Hill, 2002.
S. I. Resnick, *Adventures in Stochastic Processes*, Birkhauser, 1992.

Instructor:
Ben Liang (BA 4122; http://www.comm.utoronto.ca/~liang)
Office hours: Mondays 4 – 5 pm

Teaching assistants:
Jaya Prakash Champati (champati <a t> comm.utoronto.ca)

Lectures: Mondays 5 – 6 pm (WB 119)**;** Thursdays 1 – 3 pm (GB 220)

Tutorials: Mondays 2 – 3 pm (BA 2145); Wednesdays 2 – 3 pm (BA 2145)

Syllabus:

Week 1. Sigma algebra, probability axioms, combined experiments
Week 2. Random variables, joint moments, conditional expectation
Week 3. Random vectors, independence, transformation, Gaussian random vector
Week 4. Convergence of random sequences, Laws of Large Numbers, Central Limit Theorem
Week 5. Random processes, specifying random processes, discrete-time processes
Week 6. Poisson process, shot noise, Gaussian processes
Week 7. Stationarity, mean square continuity, derivatives and integrals, ergodicity,
Week 8. Power spectrum, linear systems with stochastic input
Week 9. Mean square estimation, orthogonality principle, Wiener filtering
Week 10. Discrete-time Markov chains, limiting and steady-state distributions, irreducibility
Week 11. Recurrence, ergodicity, absorption probability, time to absorption
Week 12. Continuous-time Markov chains, steady-state distribution, birth-death processes
Week 13. Markovian queues, time reversibility, balance equations

Evaluation scheme: Weekly homework, 10%; midterm exam, 40%; final exam, 50%. Homework will be graded solely on the basis of effort, not correctness. Solution to the homework problems will be discussed during tutorials. Undergraduate and graduate students complete the same course work but are evaluated on separate scales.

Planned Schedule:

Lectures 1 - 3	Course Introduction, Subtlety of Probability, Probability Definitions	Probability Space, Probability over Real Line	(review) Conditional Probability, Total Probability, Bayes Rule, Combined Experiments, Bernoulli Trials
Lectures 4 - 6	(review) Random Variables, CDF, PDF, PMF, Poisson Theorem	(review) Function of RV, Expected Value, Moments, Characteristic Function, Moment Generating Function, Complex RVs	(review) Two RVs, Independence, Correlation, Orthogonality, Conditional Density, Conditional Expectation
Lectures 7 - 9	Random Vectors, Independence, Group/Pairwise/Linear Independence, Correlation Matrix	Transformation of Random Vectors	Gaussian Vectors
Lectures 10 - 12	Convergence of Random Sequence: Sure, Almost Sure, in Probability	Convergence of Random Sequence: in Distribution, in Mean Square Sense, Cauchy Criterion	Revisiting LLN and CLT
Lectures 13 - 15	Random Processes, Statistics of Random Processes, Multiple Random Processes	IID Processes, Sum Processes	Poisson Process
Lectures 16 - 18	Random Telegraph Process, Shot Noise, Gaussian Process, Wiener Process	Stationarity, Wide-Sense Stationarity	Continuity, Derivatives, Integrals
Lectures 19 - 21	Time Averages, Ergodicity	MS Periodicity, Fourier Series	Karhunen-Loeve Expansion
Lectures 22 - 24	Midterm Exam	Midterm Exam	Power Spectral Density, Wiener-Khinchin Theorem
Lectures 25 - 27	Jointly WSS processes, Sum of Random Processes, LTI Systems	LTI Systems with WSS Inputs	Brownian Motion, Amplitude Modulations
Lectures 28 - 30	MS Estimation	Linear MS Estimation, Orthogonality Principle	Prediction, Interpolation, Smoothing, Wiener Filtering
Lectures 31 - 33	Markov Chains, Motivating Example	D-T MC, Chapman-Kolmogorov Equation, Steady State Distributions	Irreducibility, Recurrence, Periodicity, Ergodicity
Lectures 34 - 36	Limiting Distributions, Reducible MCs	Absorption Probability, Mean Time to Absorption	C-T MC, State Sojourn Time, Construction, Transition Densities
Lectures 37 - 39	Transition Densities, Kolmogorov Equations, Limiting and Steady State Distributions	Birth-Death Processes, Markovian Queues	Time Reversibility, Balance Equations