Northwestern University

Department of Electrical Engineering and Computer Science

EECS 422: Random Processes in Communications and Control I Winter 2012

Information Sheet:

Instructor:
Prof. Randall Berry
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Office Hours: by appointment

Time and Place:
TuTh 3:30-4:50 pm, Room M166 Tech

Course Overview: Probability and random processes are central fields of mathematics and are widely applied in many areas including risk assessment, statistics, data networks, operations research, information theory, control theory, theoretical computer science, quantum theory, game theory, finance, and neurophysiology. This course will provide an introduction to mathematical probability and random process with a focus on techniques that are useful in studying communication and control systems as well in many other domains. We will begin with a thorough review of basic probability theory including random variables, transform methods, probabilistic inequalities, laws of large numbers, central limit theorems, Gaussian random variables and estimation. We then will introduce random processes and discuss both discrete and continuous time processes. Topics to be covered include ergodicity, stationary, Markov Chains, Gaussian processes, Poisson processes, filtering and spectral representations.

Prerequisites

- The official prerequisite is one undergraduate course in probability (e.g., EECS 302). If you have not had this, then you should discuss your background with the instructor. Some familiarity with linear systems and Fourier transforms is also helpful (e.g., EECS 222).

Text:

- Alberto Leon-Garcia, Probability, *Statistics and Random Processes for Electrical Engineering*, 3rd Edition, Prentice Hall, 2008.

  Note all problems will be assigned from the 3rd edition, these differ from those in earlier editions.

Reference Texts:

1. Dimitri Bertsekas and John Tsitsiklis, *Introduction to Probability,* 2nd Ed., Athena Scientific, 2008.

   This book is for an introductory course on probability and is a good reference for reviewing the prerequisite material.

2. Geoffrey Grimmett and David Stirzaker, *Probability and Random Processes*, 3rd Ed., Oxford University Press, 2001

   This is a bit more mathematical than the required text.

3. Robert Gallager, *Discrete Stochastic Processes*, available at http://www.rle.mit.edu/rgallager/notes.htm

   This book focuses on both discrete stochastic processes (e.g. Poisson Processes, Markov chains) as well as Gaussian processes.

4. Bruce Hajek, *An Exploration of Random Processes for Engineers*, available at http://www.ifp.illinois.edu/~hajek/Papers/randomprocesses.html

   Course notes from a somewhat more advanced course at UIUC.

5. Michael Mitzenmacher and Eli Upfal, *Probability and Computing: Randomized Algorithms and Probabilistic Analysis*, Cambridge University Press, 2005.

   This book provides some nice computer science applications of probability and random processes.

6. Sheldon Ross, *Stochastic Processes*, Wiley, 1996.

   This book focuses mainly on operation research applications.

Course Handouts:

Handouts not picked up during class and other announcements will be available on the course web site at http://www.eecs.northwestern.edu/~rberry/EECS422/

Studying:

A goal of this course is to understand of probability and random processes so that you can apply the ideas to problems in a variety of different research areas. Successfully doing this requires you to develop solid intuition and insight into random process, which does not come naturally to most people. This requires you to not simply do "plug and chug" calculations, but to instead spend time understanding the concepts and proofs behind the results. In particular, you are encouraged to not simply focus on completing the homework, but to also spend time reading over and thinking about the material.

Problem Sets:

Problem sets will be assigned on a quasi-weekly schedule. In making up the exams it will be assumed that you have worked all the problems. Working together in small groups on the problem sets is encouraged, however each person should be sure to understand and write up their own solution to hand in. The problem sets are intended to help you learn the material and whatever maximizes learning for you is desirable. Problem sets must be handed in by the end of the class in which they are due. Late problem sets will not be accepted.

Exams:

There will be a one midterm exam and one final exam. The midterm will be in class and the final will be a take home.

Course Grade:

Your final grade in the course is based upon our best assessment of your understanding of the material. The weightings used to determine the final grade are:

Midterm	35%
Final	40%
Problem Sets	25%

Syllabus (tentative):

- Probability spaces, events as sets, conditional probabilities, independence
- Random variables- expectation, conditional expectation, inequalities.
- Multiple Random variables – joint distributions, Gaussian random vectors
- Limit theorems – laws of large numbers, central limit theorems
- Estimation
- Random processes – definitions, properties, examples
- Markov chains – first passage time analysis
- Poisson Process
- Gaussian Processes
- Spectral properties – power spectral density, response of linear systems to random processes.