University of New Mexico, Albuquerque
Department of Electrical & Computer Engineering
ECE-541-001: Probability Theory & Stochastic Processes
Fall Semester 2020, 3 Credit Hours

COURSE INFORMATION:

Course Instructor	Prof. Balu Santhanam
Office Location	Room 326A, ECE Bldg.
Contact Info	Email: bsanthan@unm.edu
	Tel: (505) 277-2436 , Fax: (505) 277-8298
Prerequisite	ECE-314, ECE-340, knowledge of MATLAB
Location	ECE-310
Lectures	TR: 12:30 - 1:45 PM
Textbook	H. Starks and J. W. Woods, "Probability and Random Processes with Applications to Signal Processing," Fourth Edition, Prentice Hall Inc, Upper Saddle River, New Jersey, 2002.
Office Hours	TR: 2:30 - 3:30 PM or by appointment

GRADING SCHEME:

Problem Sets/Computer Projects : 30%
Midterm Exam : 35%
Final Project : 35%: Thurs, Dec. 10, 10:00 - 12:00 AM

REFERENCES:

1. Sheldon Ross, "A First Course in Probability," Third edition, Macmillan Publishing Company, New York, 1988.
2. Athanasios Papoulis, "Probability, Random Variables, and Stochastic Processes," Second edition, McGraw-Hill Publications, New York, 1984.
3. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling," John Wiley & Sons Inc, New York 1996.
4. G. Casella and R. L. Berger, "Statistical Inference," Duxbury Press, New York, 1990.
5. A. V. Oppenheim, R. W. Schafer, J. R. Buck, "Discrete-Time Signal Processing," Prentice Hall Inc., Upper Saddle River, New Jersey, 1999.
6. K. S. Shanmugam and A. M. Breipohl, "Random Signals: Detection, Estimation and Data Analysis," John Wiley & Sons, New York, 1988.
7. Gilbert Strang, "Linear Algebra and Its Applications," Third Edition, Harcourt Brace Jovanovich Inc., New York, 1988.

Topical Outline:

This is intended to be a first graduate course on stochastic processes. The fundamental concepts in this course pertain to the study of random processes (signals), classification of stochastic processes and processing of these signals for purposes of information extraction and/or detection. In particular, we will dealing with the concepts of probability theory, Hilbert spaces, stochastic calculus, correlation functions, power spectra, and optimal linear filtering, linear prediction of random signals, and methods for extracting information from random processes. We will also look at specific applications of these concepts in signal modeling, digital communications, detection and estimation, adaptive filtering, diversity signaling and several other areas of signal processing and communication system design. MATLAB exercises pertaining to applications will be given to augment and complement the lecture material.

- **Review of Random Variables**[1]: notion of probability, Borrel Field, sigma algebra, measurable space, concept of measure, notion of a random variable, Moments of a random variable, conditional distribution of a random variable, functions of a random variable, jointly distributed random variables, joint PDF, CDF and conditional distributions, transformations of random variables, characteristic functions of random variables, Markov/Chebyshev inequalities, central limit theorem.

- **Random Processes**: definitions, notation, and classifications of random signals, stationarity, WSS processes, stochastic continuity, mean-square calculus, cyclostationary random processes, pulse amplitude modulation, ergodicity, correlation, covariance, power spectrum, cyclic autocorrelation and cyclic power spectral density, white noise and related random process, random walk, Wiener process, Markov process, Markov chains, predictable and unpredictable random processes, Wolds decomposition, filltering of random processes through LTI systems, multirate systems with random inputs, innovations representation of random processes, power spectral factorization of random processes, Gaussian random processes, Rice representation for bandpass random processes, Karhunen–Loeve expansion, convergence of random sequences, notion of entropy as a measure of information.

- **Processing**: sampling and quantization of random signals, matched filtering, mean square estimation, optimal FIR and IIR Wiener filtering, linear prediction and the Levinson–Durbin recursion, linear regression and least-squares estimation, Kalman innovations, optimum nonlinear estimation, consistency and efficiency of estimators.

- **Applications**: channel equalization, MAP detection for AWGN channels, diversity signaling for flat fading channels, digital modulation and demodulation, co-channel signal separation, DMT touch-tone system design, applications to queuing theory and several other applications as time permits.

[1] It is assumed that you understand that you are expected to know most of this material from the prerequisites and towards this end PS # 0.0 has been posted for your convenience.

Additional Information Course Webpage

The webpage for the course is located at ece-research.unm.edu/bsanthan/courses under ECE-541. Information regarding homework, homework solutions, MATLAB assignments, MATLAB resources, problem sessions etc, will be posted here so please check there often.

Library and Computer Resources

There will be a folder for ECE-541 at the centennial science and engineering library (CSEL) reserve desk. I will also be putting some of the reference material on reserve so that they can be checked out for a limited period of 2 hours. In regards to the computing resources, you should obtain a ECE computer account if you do not already have one. There is an online application form that you need to fill in and submit once you are in the ECE network this will give you access to the ECE Unix and Windows machines that have MATLAB x.x loaded on them. These will come in handy during the MATLAB assignments.

Exams and Tests

The final exam for the course will be take-home type exams. You will be given 24 hours to complete the exam. These exams are open book open notes mode exams. For example, if the final exam is on May 11, Thursday and therefore the take-home exam will be posted on May 10, Wed around 5:00 PM and will be due back the next day. Please note that I do not entertain students taking the exam out of order, i.e., neither before or after the exam date unless it is really extraneous circumstances (health reasons).

Policies and Assumptions

Homework and Office Hours

Homework assignments are meant to strengthen your conceptual understanding in the course. They are not intended to be a masochistic ritual. I also recommend that you use my office hours properly and judiciously. If you have not had related material before, this material takes a while to sink in. This is not a "easy" course by any definition and if you have not had exposure to these concepts before then I suggest you do extra problems from the references to strengthen your concepts.

Attendance Policy

It is assumed that the students are aware of and understand the university attendance policy. In any case if you do not attend class, honestly I don't care, because you are assumed to be adults and it is your money going down the drain.

Cheating and Academic Honesty

It is also assumed that you are familiar with the UNM academic honesty policy. You are allowed to discuss material in homework exercises with other colleagues with the understanding that it still needs to be your own work. You are not allowed to collaborate with anyone else in the exams. Needless to say that academic dishonesty will be dealt with seriously

Make-up Exam Policy

I do not give make-up exams. If you need to take the exam ahead of time then it is your responsibility to arrange a alternative date/time with me and this will be only under extraneous circumstances.

Prerequisites

I am assuming that you are familiar with the computing software, MATLAB. If you need some review or introduction I can direct you to reference material. I will also go through the review material from ECE-314 and ECE-340 in a very brief fashion. So if you feel that your knowledge of this material is inadequate then

you should probably register for the undergraduate courses instead. I also have some notes from the ECE-340 course if you need a quick review of the material. The course ECE-439, i.e., the undergraduate DSP course is recommended for students who feel a need to review DSP concepts. Needless to say that it is the responsibility of the student to make sure that they have the prerequisite knowledge needed for the course and not the instructors.

Academic Fairness

There will also be a file containing all my homework and tests from previous years placed in a dropbox site which students can download. This is an effort to equalize the "playing field" and provide everyone equal access to old material.