ECE 340
Probabilistic Methods in Engineering

Summer 2008 instructor: Dr. Ogla Lavrova
Spring 2009 Instructor: Professor Majeed Hayat (course coordinator)

Description:
This course is intended to introduce the student to basic theoretical concepts and computational tools in probability and statistics with emphasis on their role in solving engineering problems. Topics include two sub-areas:

(i) Discrete processes, random variables and applications;
(ii) Continuous processes, random variables and applications.

Goal: To introduce the student to basic theoretical concepts and computational tools in probability and statistics with emphasis on their role in solving engineering problems.

Main objectives for this class are:

- Students will learn basic concepts of describing engineering processes and phenomena using statistics and probability definitions;
- Students will learn to distinguish between discrete, continuous variables, pairs and vector independent and dependant variables and how to calculate values associated with them;
- Students will learn about probability, probability density and cumulative distribution functions, and how to calculate values associated with them;
- Students will also get a preview of random processes and chains of events, and methods that are applicable to description of such processes;
- Students will learn elements of statistical inference
- Students will exercise solving a variety of practical problems using acquired in class theoretical knowledge.
- Apply their knowledge to solve a practical engineering problem in a group project
- This knowledge will be used as a pre-requisite for higher-level engineering classes;

Course Catalog Description: Introduction to probability, random variables and random processes. Distributions and density functions, expectations and correlation, autocorrelation functions and power spectral densities for wide-sense stationary processes; confidence intervals; transmission of random signals through linear systems.

Prerequisites: ECE314.

Table I: Objectives, Implementation, and Assessment

Objectives		Implementation	Assessment	A	B	C	D	E	F	G	H	I	J	K
O_1	Understand statistical and/or random nature of engineering processes and the nature of random/statistical events in engineering measurements.	3 hrs. lecture in 1st week	All homeworks, exams and a project	X	X			X						X
O_2	Understand Events, Sample Spaces, Sets and Subsets, Axioms of Probability, Conditional Probability	3 hrs. lecture in 2nd and 3rd weeks	All homeworks, exams and a project	X	X			X						X
O_3	Understand discrete and continuous random variables. Be able to calculate typical values (probability, expected value, moments) for a single variable and multiple variables. Be able to establish of the variables are independent or conditional.	15 hrs. lecture in weeks 3 through 7	HW 1, Exam I, project, quizzes	X	X			X						
O_4	Understand functions of variables, independence, joint probability functions, marginal probability functions, Covariance, Correlation of variables, conditional probability, conditional expected values	6 hrs. lecture in weeks 9-10	HW 2, Exam I, project, quizzes	X	X			X						
O_5	Understand Samples and calculation of probability values as applicable to samples, confidence levels as applicable to engineering tasks	6 hrs. lecture in weeks 11-12	HW 3, Exam I, project, quizzes	X	X			X						X
O_6	Understand Random Processes, calculation of expected value and moments associated with processes, chains	6 hrs. lecture in weeks 12-11	Project, midterm exam	X	X			X						
O_7	Use acquired knowledge to solve a real-life engineering problem using statistics and probability concepts	Project assignment	Project	X	X			X						X

Table II: Expectation and Assessment Outcome
Summer 2008, Dr. Olga Lavrova

General expectations:
Homeworks:
Homework generally involved two components:

1. Overall understanding of an engineering (or daily life) problem
2. Quantifying such understanding into statistical and probability terms, and solve for a required answer

For (1), expect that all of the students will be able to answer 100% of the problems assigned.
For (2), Expect 75% of the students to score 80% or better on the problems assigned

Midterm Exam: Expect 75% of the students to score 80% or better on the exam.

Final project:
Final Project – Requires analysis of a problem and different ways to solve it, identifying a correct and the most efficient way to a solution. Expect 85% of the students to score 80% or better on the Final Project.

Objectives		Assessment	Outcome measurement
O_1	Understand statistical and/or random nature of engineering processes and the nature of random/statistical events in engineering measurements.	All homeworks, exams and a project	√ Δ Homework #1: 6% of students receive ≥80% grade √ Δ Quiz 1: 6% of students receive ≥80% grade √ Homework #2: 70% of students receive ≥80% grade √ Quiz 2: 50% of students receive ≥50% grade √ Homework #3: 52% of students receive ≥80% grade √ Midterm exam: 52% of students receive ≥80% grade √ Final Project: 76% of students receive ≥80% grade
O_2	Understand Events, Sample Spaces, Sets and Subsets, Axioms of Probability, Conditional Probability	All homeworks, exams and a project	√ Δ Homework #1: 6% of students receive ≥80% grade √ Δ Quiz 1: 6% of students receive ≥80% grade √ Homework #2: 70% of students receive ≥80% grade √ Quiz 2: 50% of students receive ≥50% grade √ Homework #3: 52% of students receive ≥80% grade √ Midterm exam: 52% of students receive ≥80% grade √ Final Project: 76% of students receive ≥80% grade
O_3	Understand discrete and continuous random variables. Be able to calculate typical values (probability, expected value, moments) for a single variable and multiple variables. Be able to establish of the variables are independent or conditional.	HW 1, Exam I, project, quizzes	√ Δ Homework #1: 6% of students receive ≥80% grade √ Δ Quiz 1: 6% of students receive ≥80% grade √ Midterm exam: 52% of students receive ≥80% grade √ Final Project: 76% of students receive ≥80% grade
O_4	Understand functions of variables, independence, joint probability functions, marginal probability functions, Covariance, Correlation of variables, conditional probability, conditional expected values	HW 2, Exam I, project, quizzes	√ Homework #2: 70% of students receive ≥80% grade √ Quiz 2: 50% of students receive ≥50% grade √ Midterm exam: 52% of students receive ≥80% grade √ Final Project: 76% of students receive ≥80% grade

O_5	Understand Samples and calculation of probability values as applicable to samples, confidence levels as applicable to engineering tasks	HW 3, Exam I, project, quizzes	√ Homework #3: 52% of students receive ≥80% grade √ Midterm exam: 52% of students receive ≥80% grade √ Final Project: 76% of students receive ≥80% grade
O_6	Understand Random Processes, calculation of expected value and moments associated with processes, chains	Project, Midterm exam	√ Midterm exam: 52% of students receive ≥80% grade √ Final Project: 76% of students receive ≥80% grade
O_7	Use acquired knowledge to solve a real-life engineering problem using statistics and probability concepts	Project	√ Final Project: 76% of students receive ≥80% grade

√ means passing expectation
Δ means needing improvement

Δ Homework #1, Quiz #1: Students did not use detailed enough mathematical descriptions and answers to statistical problems. This will be stressed for future assignments.

Required Textbook: *Probability and Random Processes for Electrical Engineering*, 3rd edition
Alberto Leon-Garcia, Addison Wesley, 2008.
ISBN 978-13-601641-0

Sample Course Schedule

Spring 2009 Schedule

Week 1 (01/21):	Introduction to engineering problems that require the use of phenomena from statistics and probability theory. Motivating examples (from electrical and computer engineering).
Week 2 (01/28):	experiments, sample spaces and outcomes, events, some set theory, axioms of probability, independence of events, examples, notion of random variable
Week 3 (02/04):	Counting principles (permutations and combinations, etc), repeated experiments. binomial multinomial laws, calculation of probability in combinatoric problems
Week 4 (02/11):	Conditional probability, law of total probability, and Bayes formula; applications and examples
Week 5 (02/18):	Distinction between discrete and continuous random variables; discrete random variables and their distribution functions, probability density and mass functions (Bernoulli, Geometric, Binomial, Poisson).
Week 6 (02/25):	Calculating expected values, variance, standard deviation, and moments for random Variables; characteristic functions Exam 1
Week 7 (03/03):	Continuous random variables, probability distribution and density functions, major continuous random variables (uniform, exponential, Gaussian, Gamma, Rayleigh, Laplacian).
Week 8 (03/10):	Calculating expected values, variance, standard deviation, and moments for continuous Random, variables, characteristic functions; more on Gaussian distribution Exam 1
Week 9 (03/24):	Functions of random variables, sums of independent random variables, random vectors, joint and marginal probability density and mass functions
Week 10 (03/31):	Covariance, Correlation of variables, conditional probability, conditional expectations, Chebychev's inequality
Week 11 (04/07):	Sample mean and sample variance, estimating distributions from data, confidence interval, central limit theorem, weak law of large numbers Exam 2
Week 12 (04/14):	Random Processes, calculation of expected value and moments associated with processes
Week 13 (04/21):	Wide sense stationarity, autocorrelation and autocovariance functions, white noise, power spectral density
Week 14 (04/28):	Response of LTI systems to random inputs, white noise, power
Week 15 (05/05):	Project presentations
Week 16 (05/12):	Project presentations, Final Exam