Electrical and Computer Engineering Course Syllabus

Instructor:	Prof. Henry Pfister	**E-mail:**	henry.pfister@duke.edu
Office:	Gross Hall 305	**Office Hour:**	TBD
Class Room:	Wilkinson 132	**Class Time:**	MW 1:25-2:40

Course Name:	**ECE 581**
Course Title:	**Random Signals and Noise**
Prerequisite(s):	Grad standing or UG prob (STA 130L/240L or Math 230/340 or ECE 380/555 or EGR 238L)
Required Text(s):	*Probability and Stochastic Processes: ...* (PSP), by Yates and Goodman, 3rd Ed. *Fundamentals of Applied Probability and Random Processes* (FAP), by Ibe, 2nd Ed.
Other Text(s):	*Undergraduate Probability I* (UPI), by Chamberland *Probability, Random Processes, and Statistical Analysis* (PRPSA), by Kobayashi and Turin

Course Objectives:

1. Review basic probability: counting principles, sample spaces, probability laws and random variables. Understand mathematical descriptions of random variables including probability mass functions, cumulative distribution functions and probability density functions. Review independence and conditional probabilities including the total probability theorem and Bayes' rule.
2. Review expectations and moments, including means and variances. Understand the Markov and Chebyshev inequalities.
3. Discuss special random variables and their distributions, such as Bernoulli, binomial, geometric, Poisson, exponential, uniform, normal, etc. Introduce the concept of conjugate pairs of variables.
4. Explore the properties of multiple random variables using joint probability mass functions and joint probability density functions. Understand correlation, covariance and the correlation coefficient. Discuss how these quantities relate to the independence of random variables.
5. Characterize the distributions of functions of random variables.
6. Understand descriptive statistics such as the the sample mean and standard deviation. Relate the distribution of a random variable to a histogram of independent samples. Apply Maximum Likelihood Estimation and Expectation Maximization algorithm to estimate the distribution parameters from observations.
7. Understand basic concepts of hypothesis testing, type I/II errors and significance level.
8. Understand the classification and characterization of random processes. Determine whether a random process is stationary/ergodic. Explore the definition and properties of power spectral density.
9. Understand the effect of linear systems on random processes. Explore optimum linear smoothing and predicting filters.
10. Discuss special random processes including the Bernoulli process, Poisson process, discrete-time Markov chains and Gaussian process.
11. Relate machine learning applications with the associated probability/random processes topics
12. Engage the students in active learning through problem solving, computational simulation and real-world applications. Encourage the students to become an independent learner and increase his/her awareness of available resources.

Rules and Guidelines:

The class shall follow all established policies of Duke University:
`https://dukecommunitystandard.students.duke.edu/policies/`.

Student Evaluation:

Homework / Quizzes	28%	8-10 assignments throughout the semester
Midterm Exams	50%	Two equally weighted midterm exams
Mini-Projects	22%	Use the tools acquired in this class to solve engineering problems

Course Topics and Hours:

Unit	Topics	Hours
1	Review: Basic Probability	3
2	Review: Expectations and Moments	3
3	Review: Special Random Variables	3
4	Multiple Random Variables	3
5	Functions of Random Variables	3
6	Descriptive Statistics (mean/variance)	1.5
7	Maximum Likelihood Estimation	3
8	Hypothesis Testing	1.5
9	Random Processes	4.5
10	Special Random Processes	6
11	Estimation, Filtering, and Smoothing	3
12	Review and Exams	6
	Total Hours	40.5

Course Outline

Date	Topic	Reading	Assignment	Slides
08/25/25	Basic Probability 1	Slides 1, PSP Ch. 1 (UPI Ch. 1-2),	ECE 586 Ch. 1, Logic/Set Theory Video	1
08/27/25	Basic Probability 2	Slides 2, PSP Ch. 2 (UPI Ch. 3-4)	Veritasium: AI Education Video	2
09/01/25	Labor Day Holiday	X	X	X
09/03/25	Discrete RVs 1	Slides 3, PSP Ch. 3 (UPI Ch. 5-6)	3Blue1Brown - Bayes Video	3
09/08/25	Discrete RVs 2	Slides 3, PSP Ch. 3 (UPI Ch. 5-6)		4
09/10/25	Catch-up		HW1 Due	5
09/15/25	Continuous RVs 1	Slides 4, PSP Ch. 4 (UPI Ch. 8)	3Blue1Brown - Continuous Video	6
09/17/25	Continuous RVs 2	Slides 4, PSP Ch. 4 (UPI Ch. 8)	HW2 Due 9/18	7
09/22/25	Multiple RVs 1	Slides 5-7, PSP Ch. 4 (UPI Ch. 7)		8
09/24/25	Multiple RVs 2	Slides 4, PSP Ch. 4 (UPI Ch. 11)	HW3 not graded	9
09/29/25	Review			X
10/01/25	Midterm 1			X
10/06/25	Inner Product Spaces 1	Handout on website		10
10/08/25	Inner Product Spaces 2	Handout on website	HW4 Due 10/20	11
10/10/25	Fall Break Holiday	X	X	X
10/15/25	Functions of RVs 1	Handout, PSP Ch. 4 (UPI Ch. 9)		12
10/20/25	Functions of RVs 2	Handout, PSP Ch. 4 (UPI Ch. 9)		13
10/22/25	Convergence 1	Handout on website	HW5 Due 11/03	14
10/27/25	Convergence 2	Handout on website		15
10/29/25	Markov Chains 1	Handout on website		16
11/03/25	Markov Chains 2	Handout on website		17
11/05/25	Statistics 1	Handout on website	HW6 not graded	18
11/10/25	Statistics 2	Handout on website		19
11/12/25	Review			X
11/17/25	Midterm 2			X
11/19/25	Gaussian Processes 1	Handout on website		20
11/24/25	cancel	Thanksgiving	HW 7	21
12/01/25	Gaussian Processes 2	Handout on website		22
12/03/25	Random Processes			23