Course number and name: ECE 321 Random Signals & Noise
Credits: 3
Contact hours: 3
Name of instructor or course coordinator: Ali N. Akansu

Instructional Materials:

Textbook:
Peyton Z. Peebles, *Probability, Random Variables and Random Signal Principles*. 4th Edition, McGraw Hill, 2001.
Supplementary Material:
MATLAB Student Edition.
Course notes distributed whenever needed.
Relevant articles distributed for self-study.

Specific course information (Brief description of the content of the course (catalog description)):

Random processes occurring in electrical and computer engineering. An introduction to probability and random variables is followed by stochastic processes and noise. Topics include auto- and cross-correlation functions, power spectral density, response of linear systems to random signals, and noise figure calculations.

Prerequisite:
ECE232 Circuits and Systems II
Corequisite:
ECE333 Systems and Signals

Educational objectives for the course (e.g. The student will be able to explain the significance of current research about a particular topic.):

The concepts of randomness, fundamentals of random signals and statistical signal processing are introduced in this course. The probability theory is presented and engineering applications dealing with random signals are highlighted. The mathematical methods and tools to represent random signals and randomness are thoroughly discussed to build the theoretical basis widely used to handle natural phenomena and real-world problems. The *MATLAB* use is a *requirement* for the course project and some HWs. Students are strongly encouraged to download the Statistics and Machine Learning Toolbox and practice with the available examples, in particular the first three subjects, given at the link https://www.mathworks.com/help/stats/index.html .

List of topics covered:

Weeks 1 & 2: Probability, Joint & Conditional Probability, Independent Events, Combined Experiments, Bernoulli Trials (Ch. 1)

Weeks 3 & 4: The Random Variable (RV), Probability Distribution Function (PDF), Probability Density Function (pdf), Gaussian RV, other pdf types, Conditional Distribution and Density Function (Ch. 2)

Week 5: Operations on One random variable, Expectation, Moments, Moment Functions, Transformation of a RV (Ch. 3)

Week 6: Multiple Random Variables, Statistical Independence, and Central Limit Theorem (Ch. 4)

Weeks 7 & 8: Quiz #1, Operations on Multiple Random Variables (Ch. 5)

Week 9: Random Processes, Stationarity and Statistical Independence, Correlation Functions (Ch. 6)

Week 10: Gaussian Random Processes, Poisson Random Process (Ch. 6)

Weeks 11 & 12: Quiz #2, Spectral Characteristic of Random Processes (Ch. 7)

Weeks 13: Linear Systems with Random Inputs (Ch. 8)

Week 14: Optimum Linear Systems, Maximization of Signal-to-Noise Ratio (SNR), Minimization of Mean Square Error (MSE), Wiener Filters (Ch. 9). Some applications (Ch. 10).

Course Assignments: Weekly homework assignments. Submission is mandatory.

Course Project: MATLAB implementation of one real world problem using measured data samples and the concepts learned in the course. Project submission is mandatory.

Educational objectives for the course (e.g. The student will be able to explain the significance of current research about a particular topic.):

1. The student will be able to clearly understand the concepts of an experiment and its sample space or spaces and map them to probability measurements.
2. The student will be able to use probability measurements and map them in the resulting probability distribution function (PDF) and its first derivative function as probability density function (pdf).
3. The student will learn the function types spanning from Gaussian to Rayleigh that analytically model randomness and are widely used in many engineering applications.
4. The students will learn the concept of random variable and random vector process through the theoretical as well as applications emphasis. They will be able to relate real world data science and big data problems to mathematical tools introduced and used them. Homework assignments guide students to use computational tools like MATLAB to better understand and appreciate the content of the course.
5. The statistical metrics like mean, variance, higher order moments, skewness and others are introduced, and their practical meanings and purposes are introduced in the course.
6. The student will learn the concepts of auto- and cross-correlations along with covariance of random vector processes (stochastic processes). The power spectral density (PSD) is introduced.
7. The student will learn the input-output relationship of linear time invariant (LTI) systems for a random input. This knowledge helps students to understand how randomness is reshaped through the use of deterministic system (LTI) with random input as in contrast to deterministic input case that they learn in ECE232 Circuits and Systems II course. Several engineering applications benefit from this knowledge base are highlighted.