

# CEE 6511 – Random Vibrations Spring 2017

4:35 - 5:55 pm TTh, Mason 2117

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**Course Description:** This course introduces concepts of random processes for modeling dynamic structural behavior under time-dependent excitations. Numerical tools will be provided for assessing the reliability of structural systems subject to uncertain dynamic loads. Both single and multiple degree-of-freedom structures will be studied. The course also presents experimental modal analysis of structures with random vibration data.

## Prerequisites:

- CEE 6510 – Structural Dynamics or equivalence
- Undergraduate degree in civil, mechanical or aerospace engineering
- Experience with MATLAB is recommended

## Course References

Complete course notes will be handed out. Although no formal textbook is required, following books are good references.

- *Random Vibrations: Analysis of Structural and Mechanical Systems*, by L.D. Lutes and S. Sarkani.
- *Random Vibrations, Theory and Practice*, by P. H. Wirsching, T. L. Paez, and K. Ortiz.
- *Probability, Statistics, and Random Processes for Electrical Engineering*, by Alberto Leon-Garcia.

## Course Requirements:

- Homework assignments (approximately 6 assignments): you are allowed to work in groups on all homework and out of class assignments, but any work you turn in must be completed by yourself.
- Midterm exam
- Final project: modal analysis and model updating of a four-story shear-frame structure.

**Grading:** Five homework assignments (30%), midterm (40%), final project (30%)

## Outline

Week 1	Introduction; review of basic probability theory – sample space, probability axioms and basic laws, conditional probability and Bayes rule
Week 2	Independence, discrete and continuous random variables, functions of a random variable <b>Homework 1</b> assigned
Week 3	Two random variables, joint, marginal, and conditional distributions; functions of two random variables, expectation, moments <b>Homework 1</b> due, <b>Homework 2</b> assigned
Week 4	Covariance, correlation, conditional expectation, iterated expectation
Week 5	Mean square error estimation, linear estimation, jointly Gaussian random variables <b>Homework 2</b> due, <b>Homework 3</b> assigned
Week 6	Random vectors, joint, marginal, and conditional CDF, PDF, PMF, mean and covariance matrix, Gaussian random vectors
Week 7	Random processes, IID processes, random walk, Markov processes, Gauss-Markov process <b>Homework 3</b> due, <b>Homework 4</b> assigned
Week 8	Mean and autocorrelation functions, Gaussian random processes, stationary random processes, strong and weak stationarity <b>Lab Demo</b> - Acceleration measurement of a laboratory MDOF structure using wireless sensors
Week 9	<b>Midterm</b> Autocorrelation functions, power spectral density
Week 10	Response of LTI system to WSS process input, output mean, autocorrelation, and PSD <b>Homework 4</b> due, <b>Homework 5</b> assigned
Week 11	Random vibrations of SDOF systems, white noise excitations
Week 12	Random vibrations of MDOF systems, proportional and non-proportional damping <b>Homework 5</b> due, <b>Homework 6</b> assigned
Week 13	Threshold crossings, reliability by first passage time, envelop process, distribution of extrema
Week 14	Experimental modal analysis: natural excitation technique (NExT) and eigen-system realization (ERA) <b>Homework 6</b> due
Week 15	Recursive estimation, posterior PDF, condition PDFs for Gaussians, information interpretation
Week 16	Kalman filter, LTI system with sensor noise, Lyapunov recursion, measurement update, time update, steady-state Kalman filter <b>Final project</b> due