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.

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

<table>
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<tr>
<th>Week 1</th>
<th>Introduction; review of basic probability theory – sample space, probability axioms and basic laws, conditional probability and Bayes rule</th>
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| Week 2 | Independence, discrete and continuous random variables, functions of a random variable  
**Homework 1** assigned |
| Week 3 | Two random variables, joint, marginal, and conditional distributions; functions of two random variables, expectation, moments  
**Homework 1** due, **Homework 2** assigned |
| Week 4 | Covariance, correlation, conditional expectation, iterated expectation |
| Week 5 | Mean square error estimation, linear estimation, jointly Gaussian random variables  
**Homework 2** due, **Homework 3** 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  
**Homework 3** due, **Homework 4** assigned |
| Week 8 | Mean and autocorrelation functions, Gaussian random processes, stationary random processes, strong and weak stationarity  
**Lab Demo** - Acceleration measurement of a laboratory MDOF structure using wireless sensors |
| Week 9 | **Midterm**  
Autocorrelation functions, power spectral density |
| Week 10 | Response of LTI system to WSS process input, output mean, autocorrelation, and PSD  
**Homework 4** due, **Homework 5** assigned |
| Week 11 | Random vibrations of SDOF systems, white noise excitations |
| Week 12 | Random vibrations of MDOF systems, proportional and non-proportional damping  
**Homework 5** due, **Homework 6** 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)  
**Homework 6** 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  
**Final project** due |