UNIVERSITY OF CALIFORNIA AT BERKELEY
Department of Civil & Environmental Engineering

Structural Engineering,
Mechanics & Materials
Instructor: Armen Der Kiureghian

SYLLABUS

CE 226: STOCHASTIC STRUCTURAL DYNAMICS
SPRING 2014, Tue/Thu 12:30-2PM, 534 Davis Hall

Prerequisites: Graduate Standing, CE225 (or equivalent).

Units: 3

Catalog Description: Introduction to the theory of probability and random processes. Correlation and power spectral density functions. Stochastic dynamic analysis of single- and multi-degree-of-freedom structures subjected to stationary and non-stationary random excitations. Time- and frequency-domain analyses; modal cross-correlations. Response to multi-support excitations. Level crossings, envelope process, first-excursion probability, and distributions of peaks and extremes. Introduction to nonlinear stochastic dynamic analysis. Applications in earthquake, wind and ocean engineering.

Course Objectives: Many loads affecting structures and other mechanical systems are uncertain and vary in time or space. Examples include earthquakes, wind and ocean waves. The dynamic response of structures subjected to such loads is also uncertain. This course introduces the topics of stochastic processes and random vibrations for modeling such loads and evaluating the corresponding structural response. The aim is to determine the statistical nature of the response, including the probability that the response will exceed specified safe thresholds. The course also provides the theoretical background for some commonly used and seemingly deterministic approximate dynamic analysis methods, such as response spectrum analysis for single- and multi-support excitations. Special attention is given to applications in earthquake engineering.

For Master's students, in addition to an introduction to stochastic methods, the course provides a deeper understanding of structural dynamics, including analysis in the frequency domain and the concepts of coherency of motion and modal cross-correlations. For doctoral students, the course additionally provides the introductory background to pursue research that employs the concepts of stochastic processes and random vibration theory.

Recommended Text:

Lutes, L.D., and S. Sarkani, *Random Vibrations: Analysis of Structural and Mechanical Systems*, Elsevier Butterworth-Heinemann, Burlington, Mass, 2004. ISBN 0-07506-7765-1.

Notes and papers on selected topics will be posted on the course website at bSpace.

Reference Texts:

Lin, Y.K., *Probabilistic Theory of Structural Dynamics*, McGraw-Hill, New York, NY, 1967 and Krieger Pub., Huntington, NY, 1976.

Lin, Y.K., and G.Q. Cai, *Probabilistic Structural Dynamics: Advanced Theory and Applications*, McGraw-Hill, New York, NY, 1995.

Newland, D.E., *An Introduction to Random Vibrations, Spectral & Wavelet Analysis: Third Edition*, Dover Publications, Mineola, NY, 2005.

Nigam, N.C., *Introduction to Random Vibrations*, MIT Press, Cambridge, MA, 1983.

Nigam, N.C., and S. Narayanan, *Applications of Random Vibrations*, Narosa Pub., New Delhi, India, 1994.

Roberts, J.B., and P.D. Spanos, *Random Vibration and Statistical Linearization*, John Wiley & Sons, New York, NY, 1990.

Soong, T.T., and M. Grigoriu, *Random Vibration of Mechanical and Structural Systems*, Prentice Hall, Englewood Cliffs, NJ, 1993.

Homework: Homework assignments, due dates and solutions will be posted on the course web-site at bSpace**.** The homework will be graded and returned. A solution set will be posted after the homework is collected. Students are encouraged to use MATLAB or MATHCAD to solve the assigned problems. However, they should be prepared to use hand derivations/calculations during the examination.

Examination: An examination is tentatively scheduled for Tuesday April 22, covering material taught until that time.

Term project: Each student is expected to work on a mini-project during the last five weeks of the semester. The student will work with the instructor to select a topic. Typically, the project will involve stochastic dynamic analysis of a structural system, though other applications are also possible with the instructor's approval. The project must involve some of the material taught during the last few weeks of the semester. Students will make oral presentations in a class symposium tentatively scheduled for Thursday May 15. Term project reports will be due the same day.

Grading: Homework 30%, Examination 40%, Term Project 30%.

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Course Topical Outline:

1.	Review of basic topics in probability theory	4 lectures
2.	Introduction to the theory of random processes Time- and frequency-domain characteristics Stationary and nonstationary processes Continuity, differentiation and integration Example processes (Poisson, Gaussian)	8 lectures
3.	Random vibration of linear structures Unit-impulse and frequency-response functions Time- and frequency-domain analysis Single- and multi-degree-of-freedom systems Stationary and nonstationary responses State-space formulation Modal cross-correlations Response to multi-support excitation, coherency function	10 lectures
4.	Crossings and reliability analysis Threshold crossings The envelope process First passage probability Distribution of local and extreme peaks	3 lectures
5.	Response spectrum methods Response spectrum methods (CQC, CQC3, MSRS) PSD consistent with response spectrum	2 lecture
6.	Brief introduction to nonlinear stochastic dynamic analysis Equivalent linearization Tail-equivalent linearization	1 lecture