



Shahid Chamran University of Ahvaz
**Faculty of civil engineering
and architecture**

Syllabus and presentation process

Random vibrations

Lecturer:

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Vibrations of engineering systems are analyzed using random vibration theory considering the excitation as stochastic process. The course is focused on practical engineering problems and is designed to develop the students' appreciation for application of peak responses that often govern the design. Specifically, students will learn what are the Ergodic processes and temporal statistics; how to model the wind and earthquake excitations as stochastic excitations; how to evaluate the parameters of the probability distribution for the up crossing and first passage problems; how to assess the peak response of single- and multi-degree-of freedom systems and their incorporation in design code; The students will also learn simple techniques to assess non stationary responses and nonlinear random vibrations. The general topics are Stochastic processes: definition, interpretation, representation in frequency domain and power spectra density function; Modeling of wind and earthquake excitations: characteristics of commonly used power spectral density functions for wind and earthquake; Peak response of single-degree-of-freedom linear elastic system: time domain versus frequency domain approach, power spectral density of the response, introduction to up crossing problem and first passage problem, assessment of peak response; Peak response of multi-degree-of-freedom linear elastic system: power spectra density function of the response; peak response, practical combination rules;

Codification and peak responses: discuss how the peak responses and combination rules are implemented or used in design codes; Non stationary and/or nonlinear responses: an introduction to the Priestley's representation of non stationary processes, assessment of probability distribution of peak responses with uncertain structural properties, use of stochastic Newmark's method and stochastic central difference method in solving structural vibration problem.

Book to be read:

Random Vibrations, Spectral and Wavelet Analysis

D.E Newland

Third edition

I. CONTENTS

1 Introduction to probability distributions and averages

Probability density function
Gaussian distribution
Calculation of averages
Probability distribution function

2 Joint probability distributions, ensemble averages

Second-order probability functions
Second-order averages
Conditional probability
Second-order Gaussian distribution
Ensemble averaging

3 Correlation

Autocorrelation
Cross-correlation

4 Fourier analysis

Fourier integral
Complex form of the Fourier transform

5 Spectral density

Narrow band and broad band processes
Spectral density of a derived process
Cross-spectral density
Note on the units of spectral density

Excitation – response relations for linear systems

Classical approach

Frequency response method

Impulse response method

Relationship between the frequency response and impulse response functions

Calculation of response to an arbitrary input

Transmission of random vibration

Mean level

Autocorrelation

Spectral density

Mean square response

Cross-correlation

Cross-spectral density

Probability distributions

Statistics of narrow band processes

Crossing analysis

Distribution of peaks

Frequency of maxima

Accuracy of measurements

Analogue spectrum analysis

Variance of the measurement

Analysis of finite length records

Confidence limits

Digital spectral analysis I: Discrete Fourier transforms

Discrete Fourier transforms
Fourier transforms of periodic functions
Aliasing
Calculation of spectral estimates

Digital spectral analysis II: Windows and smoothing

Relationship between linear and circular correlation
Fourier transform of a train of aperiodic functions
Basic lag and spectral windows
Smoothing spectral estimates
Extending record length by adding zeros
Summary
Practical considerations

The fast Fourier transform

Basic theory
Sample calculation
 Programming flow charts
 Practical value of FFT
 Alternative algorithms

13 Pseudo random processes

Random binary process
Pseudo random binary signals
Random multi-level process
Spectrum of a multi-level process
Generation of random numbers
Synthesis of correlated noise sources

14 Application notes

Response of a resonant mode to broad band excitation
Fatigue and failure due to random vibration
Excitation by random surface irregularities
Simulation of random environments
Frequency response function and coherency measurements
Local spectral density calculations
Weibull distribution of peaks

15 Multi-dimensional spectral analysis

- Two-dimensional Fourier series
- Properties of the two-dimensional DFT
- Spectral density of a multi-dimensional random process
- Discrete spectral density and circular correlation functions for a two-dimensional random process
- Two-dimensional windows
- Two-dimensional smoothing
- Artificial generation of a two-dimensional random process
- Generation of an isotropic surface
- Cross-spectral density between parallel tracks across a random surface

16 Response of continuous linear systems to stationary random excitation

- Response to excitation applied at a point
- Response to distributed excitation
- Normal mode analysis
- Kinetic energy of a flat plate subjected to uncorrelated random excitation
- Single degree-of-freedom analogy

17 Discrete wavelet analysis

- Basic ideas
- Dilation equations

II. REFERENCES

II. a. Books

[1] Random Vibrations Analysis of Structural and Mechanical Systems

Book • 2004



Authors:
Loren D. Lutes and Shahram Sarkani

1st Edition

Random Vibration Mechanical, Structural, and Earthquake Engineering Applications

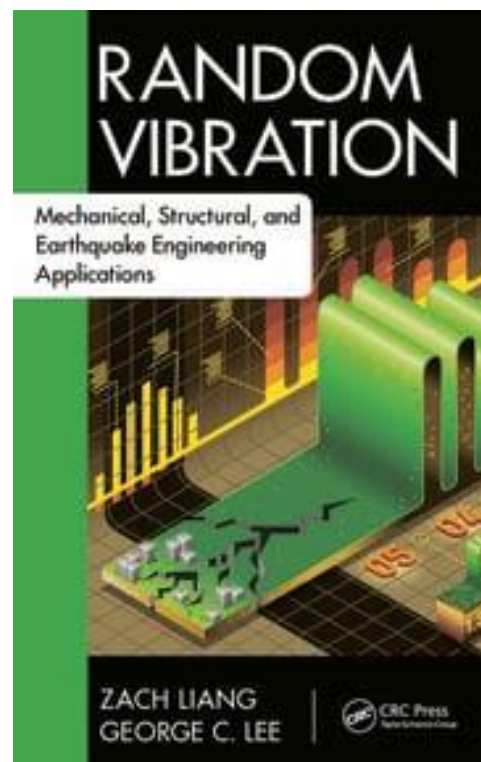
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Some Engineering Applications in Random Vibrations and Random Structures

Giora Maymon

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Earthquake Engineering
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Structural Dynamics

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International Association for
Earthquake Engineering

Book Reviews

[Free Access](#)

Random vibration of structures, by C. Y. Yang, John Wiley, New York, 1986. No. of pages: 295. Price: £46

[J. D. Robson](#)

First published: September/October 1986

<https://doi.org/10.1002/eqe.4290140509>

Citations: [1](#)

II. b. Journal Papers

- ✓ International Journal of Fatigue, Elsevier
- ✓ Mechanical Systems and Signal Processing, Elsevier
- ✓ Engineering Structures, Elsevier
- ✓ Sound and Vibration, Elsevier
- ✓ Earthquake Engineering & Structural Dynamics, Wiley
- ✓ The Structural Design of Tall and Special Buildings
- ✓ Journal of Structural Engineering, ASCE

III. EVALUATION

- Project: **8.0/20.0**
- Practice and Homework: **6.0/20.0**
- Final Exam: **6.0/20.0**

