University Of California, Berkeley
Department of Mechanical Engineering

ME 277 - Nonlinear and Random Vibrations (3 units)

Graduate Course

Syllabus

CATALOG DESCRIPTION

Oscillations in nonlinear systems having one or two degrees of freedom. Graphical, iteration, perturbation, and asymptotic methods. Self-excited oscillations and limit cycles. Random variables and random processes. Analysis of linear and nonlinear, discrete and continuous, mechanical systems under stationary and non-stationary excitations.

COURSE PREREQUISITES

ME 104 and ME 133 or their equivalent.

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

H. Benaroya, S. M. Han and M. Nagurka, *Probabilistic Models for Dynamical Systems*, 2*nd* ed., CRC Press, Boca Raton, Florida, 2013.

D. W. Jordan and P. Smith, *Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers,* 4*th ed.,* Oxford University Press, New York, 2007.

COURSE OBJECTIVES

To give a compact, consistent, and reasonably connected account of the theory of nonlinear vibrations and uncertainty analysis at the advanced level. A secondary purpose is to survey some topics of contemporary research.

DESIRED COURSE OUTCOMES

Acquired necessary knowledge and scientific maturity to begin research in nonlinear vibrations and uncertainty analysis.

TOPICS COVERED

See weekly schedule.

CLASS/LABORATORY SCHEDULE

3 hours of lecture and 0-1 hour of discussion (variable)

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

This course covers time-honored materials in nonlinear and stochastic dynamics. It is an essential and the only graduate course involving nonlinear vibrations and uncertainty analysis.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

30% Homework
30% midterm
40% final examination

SAMPLE OF WEEKLY AGENDA

The following topics are covered:
Week 1: Linearity, piecewise linear systems, time-varying systems, nonlinear springs.
Week 2: Form of equations of motion, exact methods, Duffing's equation.
Week 3: Graphical methods, phase plane, equilibrium points, limit cycles, van der Pol oscillator.
Week 4: Stability analysis, classification of equilibrium points, Liapunov methods.
Week 5: Hysteresis, Coulomb damping, structural damping, equivalent linearization.
Week 6: Perturbation, iterative methods, jump phenomenon.
Week 7: Self-excited oscillations, mechanical chatter, parametric excitation, Mathieu equation.
Week 8: Floquet theory, chaos, attractor, Poincare map.
Week 9: Probability, random variables, mathematical expectation.
Week 10: Stochastic processes, correlation functions, Gaussian processes, stochastic calculus.
Week 11: Linear stochastic systems in time domain, stationary excitation, ergodic excitation.
Week 12: Linear stochastic systems in frequency domain, input and output relationship, white noise.
Week 13: Generation of random numbers, Monte Carlo simulation, variance reduction techniques.
Week 14: Nonlinear random vibration, statistical equivalent linearization, Markov processes.
Week 15: Diffusion equations, stationary probabilities, parametric effects.

PERSON(S) WHO PREPARED THIS DESCRIPTION
Professor Fai Ma
2/27/18

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): NONLINEAR & RAN VIB
TIE CODE: LECT
GRADING: Letter
SEMESTER OFFERED: Fall and/or Spring
COURSES THAT WILL RESTRICT CREDIT: ME 274
INSTRUCTORS: Ma
DURATION OF COURSE: 15 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 9
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None