University Of California, Berkeley
Department of Mechanical Engineering

ME 133 – Mechanical Vibrations (3 units)

Undergraduate Elective

Syllabus

CATALOG DESCRIPTION

An introduction to the theory of mechanical vibrations including topics of harmonic motion, resonance, transient and random excitation, applications of Fourier analysis and convolution methods. Multidegree of freedom discrete systems including principal mode, principal coordinates and Rayleigh's principle.

COURSE PREREQUISITES

ME 104

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Textbooks such as

S. S. Rao, *Mechanical Vibrations*, 5*th* ed., Prentice Hall, Upper Saddle River, New Jersey, 2011.

Or

D. J. Inman, *Engineering Vibration*, 4^{th} ed. Prentice Hall, Upper Saddle River, New Jersey, 2013.

COURSE OBJECTIVES

Introduce basic aspects of vibrational analysis, considering both single and multi-degree-of-freedom systems. Discuss the use of exact and approximate methods in the analysis of complex systems. Familiarize students with the use of MATLAB as directed toward vibration problems.

DESIRED COURSE OUTCOMES

Upon completion of the course students shall be able to: Derive the equations of motion for vibratory systems. Linearize nonlinear systems so as to allow a linear vibrational analysis. Compute the natural frequency (or frequencies) of vibratory systems and determine the system's modal response. Determine the overall response based upon the initial conditions and/or steady forcing input. Design a passive vibration absorber to ameliorate vibrations in a forced system.

TOPICS COVERED

Single DOF vibrations - free and forced. Periodic, Non-sinusoidal signals. Multi DOF vibrations - free and forced. Continuous systems - free and forced.

CLASS/LABORATORY SCHEDULE

Three hours of lecture per week (15 Weeks), 5 hours of lecture per week (10 Weeks)

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

This course contributes primarily to the students' knowledge of engineering topics and does not provide hands-on design experience. There is a component of experimentation through individual simple spring-mass experiments. These are explicative in nature though and do not involve synthesis.

Manufacturability and health and safety issues are considered throughout the course as they apply to the topics addressed.

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

The grade for the course will be based on homework, two midterms and a final exam. Homework is typicallyt assigned on a weekly basis. While the distribution of grading is at the discretion of the instructor, a sample distribution is Homework (15%), Midterm 1 (20%), Midterm 2 (25%) and Final Exam (40%).

SAMPLE OF WEEKLY AGENDA

A sample weekly agenda includes 3 hours of lectures and 1 hour of discussion (lead by the Graduate Student Instructor) if the Course is offered during the Fall or Spring Semesters. During the 10 week summer session, the weekly schedule includes 5 hours of lecture per week and a pair of 1 hour Discussion Session lead by the Graduate Student Instructor.

The course outline is listed below in terms of 50 minute lectures so the correlation of the Summer Sessions Course to a Semester-long course is apparent.

Lectures 1-3: Linearity, discrete systems, time-varying systems, discussion of applications
Lectures 4-6: Prototype SDOF LTI system, energy methods
Lectures 7-9: Viscously damped free vibration, forced vibration in time domain, applications
Lectures 10-12: Laplace transform, impulse response, convolution integral, vibration testing,
Lectures 13-15: Harmonically excited vibration, response to periodic excitation, Fourier series
Lectures 16-18: Forced vibration in frequency domain, Fourier integrals,
Lectures 19-21: Analytical formulation, Lagrange's equations, form of the equations of motion

Lectures 22-24: Configuration-space analysis of MDOF systems, stability, coordinate coupling
Lectures 25-27: Conservative free vibration, natural frequencies and mode shapes
Lectures 28-30: Orthogonality of modes, modal analysis,
Lectures 31-33: Modal equations for damped systems, proportional damping, classical damping
Lectures 34-36: Decoupling approximations, complex modal analysis, synchronization,
Lectures 37-39: Semidefinite systems, Rayleigh's principle, Historical comments on Rayleigh's contributions
Lectures 40-42: Transverse vibration of strings, wave equation, separation of variables
Lectures 43-45: Modal expansion of response, orthogonality of eigenfunctions, forced vibration

PERSON(S) WHO PREPARED THIS DESCRIPTION
Oliver M. O'Reilly - Monday, January 11, 2016

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): MECH VIBR
TIE CODE: LECT
GRADING: Letter
SEMESTER OFFERED: Fall, Spring or Summer
COURSES THAT WILL RESTRICT CREDIT: None
INSTRUCTORS: Staff
DURATION OF COURSE: 15 Weeks, 10 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: Varies
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None