AME 521 Engineering Vibrations II

Fall 2014
Department of Mechanical Engineering
University of Southern California

Description: 3 units.
Multi-degree of freedom systems; modal analysis; Rayleigh's quotient; continuous systems; modal analysis; beams, rods, membranes; Galerkin, Rayleigh Ritz methods; finite elements.

Prerequisite: AME 420

Instructor	Professor Ben Yang Office: OHE 430 Phone: (213) 740-7082; Email: bingen@usc.edu
Class Meeting	Wednesday 6:40-9:20 pm, OHE100C
Office Hour	TBD

Text Book: Daniel J. Inman, 2014, Engineering Vibration, Pearson, 4th edition
ISBN-13: 978-0-13-287169-3

References:

[1] S. Graham Kelly, 2006, Advanced Vibration Analysis, CRC.

[2] Leonard Meirovitch, 2002, *Fundamentals of Vibrations*, McGraw-Hill.

[3] William J. Bottega, 2006, Engineering Vibrations, CRC Press

Grading:

Midterm Exam	20%
Final Exam	40%
Homework	30%
Project	10%
Total	100 %

Homework: Weekly homework assigned, and due the following week.
Late homework receives **NO** credits.

Project: A project requesting software MATLAB will be assigned.
A final report will be due at the end of the semester.

Topics and Reading Assignments:

- Review of single-degree-of-freedom systems (Chapter 3 of the textbook) – 1 week
- Establishment of equations of motion (Chapter 2) – 1 week
    - Newton's laws
    - Lagrange's equations
    - Small oscillation and linearization (two methods)
- Multi-degree-of-freedom systems (Chapter 3 and handouts) – 4 weeks
    - Spring-mass-damper systems
    - Methods of influence coefficients for linear systems
    - Natural modes of vibration
    - Eigenvalue problems and solutions
    - Rayleigh's quotient
    - Steady-state response to harmonic excitations
    - Vibration absorbers
    - Transient response via modal analysis
    - Damping in vibrating systems
    - Gyroscopic systems
    - Use of MATLAB in vibration analysis
- State equations and transfer function formulation (Handouts) – 1 week
    - State equations and solution via eigenvector expansion and numerical integration
    - Transfer function formulation and convolution integral
    - Transient response via inverse Laplace transform for general mechanical systems described by $M\ddot{x} + (D+G)\dot{x} + Kx = f$.
- Distributed vibrating systems (Chapter 7) – 4 weeks
    - Boundary-initial value problems of strings, rods, shafts and beams
    - Hamilton's principles and equations of motion
    - Solution of eigenvalue problems
    - Natural normal modes and eigenfunction expansion
    - Systems with lumped end masses
    - Damping in distributed systems
    - Self-adjoint and non-self-adjoint systems
    - Green's function formulation
    - Vibration of membranes
- Approximate methods for distributed systems (Chapters 5 and 8) – 2 weeks
    - Rayleigh's quotient
    - Galerkin's method
    - Rayleigh Ritz method
    - Finite element method

Course Schedule:

Week	Date	Materials Covered/Exams	Assignments
1		Review of single-degree-of-freedom systems	HW 1
2		Methods for establishing equations of motion	HW 2
3		Multi-degree-of-freedom (M-DOF) systems	HW 3
4		M-DOF systems	HW 4
5		M-DOF systems	HW 5
6		M-DOF systems	HW 6
7		M-DOF systems	HW 7, Project description
8		Distributed vibrating systems: Hamilton's principle	HW 8
9		**Midterm Exam**	
10		Distributed systems: eigenvalue problem	HW 9
11		Distributed systems: Eigenfunction expansion	HW 10
12		Distributed Transfer Function Method	HW 11
13		Approximate solutions: Rayleigh quotient, Rayleigh-Ritz Method	HW12
14		**Thanksgiving -- No class**	
15		Finite element method, course review	
		Project report due (before or at the final exam)	
		Final Exam: 7-9 pm	