AME 521 Engineering Vibrations II

Fall 2017
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	Monday 10:30 am -12 noon; Wednesday 10:30 am -12 noon

TA	TBD Office: Phone: Email:
Office Hour	

Text Book: William J. Bottega, 2014, Engineering Vibrations, CRC Press, 2nd ed.,
ISBN 9781498723664
Class notes (downloadable from the AME521 website)

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

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

[3] Daniel J. Inman, 2014, Engineering Vibration, Pearson, 4th edition

Grading:

Three One-Hour Midterm Exams	45%
Final Exam	40%
Project	15%
Total	100 %

Homework: Weekly non-credit homework assigned. Solutions provided afterwards.
It is the student's responsibility to do homework problems timely.

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

AME 521 Website

AME521 website is managed by Desire2Learn (http://courses.uscden.net). All the course materials of AME 521 are downloadable from this website. Once you log on, click "**CONTENT**" from the manual bar, to get access to all documents, including this syllabus, class lecture notes, handouts, project description and homework assignments.

If you have problems logging on or seeing your courses, please contact DEN@Viterbi Technical Support Center office at dentsc@usc.edu or 213-740-9356.

Topics

- Review of single-degree-of-freedom systems– 1 week
- Establishment of equations of motion – 1 week
  - Newton's laws
  - Lagrange's equations
  - Small oscillation and linearization (two methods)
- Multi-degree-of-freedom systems– 3 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
  - Use of MATLAB in vibration analysis
- State equations and transfer function formulation – 1 week
  - State equations and solution via eigenvector expansion and numerical integration
  - Transfer function formulation and convolution integral
  - Transient response via inverse Laplace transform
- Distributed vibrating systems – 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
- Approximate methods for distributed systems – 2 weeks
  - Rayleigh Ritz method
  - Finite element method
- Applications
  - Moving load problem
  - Moving oscillator problem

Course Schedule

Important Dates:

09/20/2017 Midterm Exam 1

10/18/2017 Midterm Exam 2

11/15/2017 Midterm Exam 3

12/04/2017 Project report due

12/06/2017 Final Exam

Week	Date	Materials Covered/Exams	Assignments
1	8/23	Review of single-degree-of-freedom systems	HW 1
2	8/30	Newtonian and Lagrangian Approaches	HW 2
3	9/6	Multi-degree-of-freedom systems: eigenvalue problems	HW 3
4	9/13	M-DOF systems: Modal analysis, free vibration	HW 4
5	9/20	**Midterm Exam 1,** M-DOF systems: Forced vibration	HW 5
6	9/27	M-DOF systems: Damped vibrating systems	HW 6, Project description
7	10/4	Distributed systems: Hamilton's principle, strings and beams	HW 7
8	10/11	Distributed systems: Eigenvalue problem	HW 8
9	10/18	**Midterm Exam 2,** Distributed systems: Modal analysis	
10	10/25	Distributed systems: Modal analysis, damped systems	HW 9
11	11/1	Approximate solutions Rayleigh-Ritz Method	HW 10
12	11/8	Applications: vehicle dynamics, coupled vehicle-bridge systems	HW 11
13	11/15	**Midterm Exam 3**, 2D continua: membranes & plates	HW 12
14	11/22	**Thanksgiving -- No class**	
15	11/29	Finite element method, course review	
	12/4	**Project report due by 5 pm (Monday)**	
	12/6	**Final Exam: 7-9 pm**	