**AME 521 Engineering Vibrations II**

**Fall 2014**
Department of Mechanical Engineering
University of Southern California

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**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

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<tr>
<th>Instructor</th>
<th>Professor Ben Yang</th>
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<tr>
<td>Office</td>
<td>OHE 430</td>
</tr>
<tr>
<td>Phone</td>
<td>(213) 740-7082</td>
</tr>
<tr>
<td>Email</td>
<td><a href="mailto:bingen@usc.edu">bingen@usc.edu</a></td>
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**Class Meeting**
Wednesday 6:40-9:20 pm, OHE100C

**Office Hour**
TBD


**References:**

**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:

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