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:
Class notes (downloadable from the AME521 website)

References:

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

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