Course Description

Review of matrix force and displacement methods of structural analysis; virtual work theorem, virtual forces, and displacements; Maxwell-Betti theorems, effects of approximations, introduction to finite element analysis.

Textbook
Note: This book is out-of-print. UCLA Bookstore sells e- and hard-copies.

References
Materials that are posted on the class web page.
Hibbeler RC, Structural Analysis, Prentice Hall, 2007 (recommended)

Prerequisites
cee135a: Elementary Structural Analysis
cee135b: Intermediate Structural Analysis

Course Schedule
Check the CCLE regularly for new posted material

Instructor
Professor Ertugrul Taciroglu
5731K Boelter Hall, Phone: (310) 267-4655, Email: etacir@ucla.edu.
Office Hours [Sec80]: by appointment (email questions at all times are welcome).

Teaching Assistants
Barbaros Cetiner
bacetiner@ucla.edu, 3771 Boelter
Office Hours [ZOOM]: Wednesday 4:00 to 6:00 PM, and Saturdays 9:00 to 11:00 AM

Course Website
https://ccle.ucla.edu/course/view/18F-CEE235A-80

Grading Basis

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>35%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>45%</td>
</tr>
</tbody>
</table>
Class Logistics

The class is designed to cover basic theory and demonstration of concepts during lectures. Solved example problems and homework assignments will reinforce the materials covered during lectures. The tentative list of topics to be covered is listed below and closely follows Chapters 1-7 in the textbook. The schedule is subject to change depending on time constraints. The course will occasionally utilize Matlab, when working on example problems and assignments. A basic primer on Matlab is available at the CourseWeb for downloads. Matlab access is provided through SEASnet to all enrolled students (note: If you wish to install Matlab on your own computer, there is a student version available for ~$100).

Handouts, assignments, homework solutions, etc., will be provided through the CourseWeb. Weekly homework problem sets will be assigned as shown below. These assignments are designed to cement your basic understanding of the principles covered in class. Due to limited lecture time, some ideas and applications may be introduced in the homework assignments. For exams, it is your responsibility to know the material covered not only in lectures, but in all assignments as well. Solutions are posted on the due date so no late homeworks are accepted.

You may make use of MASTAN2, which is the companion software for the textbook, to verify your manual solutions. Look for a narrated tutorial of MASTAN2 available at the CourseWeb. Also, visit www.mastan2.com for an online tutorial.

Course Topics

1. Introduction
2. Review of Statics
3. Matrix Analysis of Trusses
4. Matrix Analysis of Frames
5. Virtual Work Principles
6. Virtual Work Principles in Analysis of Frames

<table>
<thead>
<tr>
<th>#</th>
<th>Assignment Date</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thursday, Oct 4</td>
<td>Sunday, Oct 14</td>
</tr>
<tr>
<td>2</td>
<td>Thursday, Oct 11</td>
<td>Sunday, Oct 21</td>
</tr>
<tr>
<td>3</td>
<td>Thursday, Oct 18</td>
<td>Sunday, Oct 28</td>
</tr>
<tr>
<td>4</td>
<td>Thursday, Oct 25</td>
<td>Thursday, Nov 1</td>
</tr>
<tr>
<td></td>
<td>Midterm, Nov 4 (tentative)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Thursday, Nov 1</td>
<td>Sunday, Nov 11</td>
</tr>
<tr>
<td>6</td>
<td>Thursday, Nov 8</td>
<td>Sunday, Nov 18</td>
</tr>
<tr>
<td>7</td>
<td>Thursday, Nov 15</td>
<td>Sunday, Nov 25</td>
</tr>
<tr>
<td>8</td>
<td>Wednesday, Nov 21</td>
<td>Sunday, Dec 2</td>
</tr>
<tr>
<td>9</td>
<td>Wednesday, Nov 28 (optional bonus assignment)</td>
<td>Sunday, Dec 16</td>
</tr>
</tbody>
</table>
Tentative Schedule of Topics

Week 0
Syllabus and intro to structural analysis.

Week 1, Oct 1
Analysis of statically determinate structures: static equilibrium, free-body diagrams, static and kinematic indeterminacy, stability, linearity, principle of superposition [H3.1-3.2].

Week 2, Oct 8

Week 3, Oct 15

Week 4, Oct 22
Matlab Implementation. Frame Element (bending review): Bernoulli-Euler kinematic hypothesis, differential equations of equilibrium, strain-displacement, material response.

Saturday, Oct 27
Midterm Exam Sec 80 (tentative; check MSOL page for actual date/time).

Week 5, Oct 29
Frame Element (torsion review): St.-Venant’s kinematic hypothesis for torsion of circular shafts, differential equations of equilibrium, strain-displacement, material response.

Week 6, Nov 5
Matrix method of analysis for reticulated frame elements: Work & energy, Maxwell’s reciprocal theorem, flexibility-to-stiffness transformations [§4.1-4.4], derivation of the stiffness matrix [§4.5], flexibility equations [§4.5-4.7].

Week 7, Nov 12
Matrix method of analysis for reticulated frame elements: Coordinate transformations, global equations [§5.1], Loads between nodal points, initial and thermal strains [§5.2-5.3]. Matlab Implementation.

Week 8, Nov 19
Virtual work principles: Principle of virtual work for rigid and flexible bodies [§6.1-6.2]. Principle of Virtual Displacements (PVD): Internal and external work, construction of exact and approximate solutions [§6.3-6.4].

Week 9, Nov 26
Principle of Virtual Forces (PVF): Construction of analytical solutions [§6.5].

Week 10, Dec 3

Saturday, Dec 9
Final Exam Sec 80 (tentative; check MSOL page for actual date/time).

The marker “!” indicates that parts of this material are not available in the textbook, but will be posted on the Courseweb.

The marker “§” indicates a section of the course textbook by McGuirie, et al.

The marker “H” indicates a section of the textbook by Hibbeler. The purchase if this book is not required.
I. Review of fundamentals [Chapter 1, Mcguire, Chapters 1&2 Hibbeler]
A brief introduction to structural analysis
Typical framed structures; Structural idealization; Loads
Coordinate axes, sign conventions,
Degrees-of-freedom; Static equilibrium
Indeterminacy (kinematic and static) & stability,
Linearity and the principle of superposition

II. Analysis of statically determinate trusses [Chapter 3, Hibbeler]
Common types of trusses
Classification of co-planar trusses
The method of joints
Zero-force members
The method of sections

III. Axial force element [Chapter 2, McGuire]
Governing equations of equilibrium, strain-displacement, and material response
Initial stress and thermal effects?
Exact solutions of governing differential equations
Axial force, and displacement diagrams
Element stiffness & flexibility equations
Global stiffness equations

IV. Matrix method of analysis of statically indeterminate trusses [Chapter 3, McGuire]
Direct Stiffness Method - Basic equations & the general procedure
Texture & solution of the discrete algebraic equations: Symmetry, bandwidth, sparsity
A note on indeterminacy [Using Matlab?]

V. Energy Approaches [Chapter 4, McGuire]
Definitions of Work & Energy
Maxwell's Reciprocal Theorem
Castigliano’s Principles (axial members)
Stiffness-flexibility transformations
VI. The Frame Element [Chapter 4, McGuire]
St.-Venant’s torsion: Governing differential equations of equilibrium, strain-displacement, and material response
Flexure of the Timoshenko & Bernoulli-Euler Beams: Governing differential equations of equilibrium, strain-displacement, and material response
Element flexibility and stiffness matrices

VII. Analysis of statically indeterminate frames [Chapter 5, McGuire]
Coordinate transformations: Orthonormal matrices, degrees-of-freedom, and energy
Loads between nodes
Initial and thermal strains

VIII. Virtual Work Principles [Chapter 6, McGuire]
Principle of Virtual Displacement (PVD) for rigid and deformable bodies
Internal and external virtual work
Construction of analytical solutions using PVD
Construction of approximate solutions using PVD
Principle of Virtual Forces

IX. Virtual Work Principles in Analysis of Frames [Chapter 7, McGuire]
Kinematics (Shape functions)
Formulation of the element stiffness matrix using PVD
Non-prismatic members
Loads between nodal points
Initial strain effects
Formulation of the element flexibility matrix using PVF
Shear deformations
Curved Members