

## **Syllabus: CE 130N - Mechanics of Structures**

Instructor: Shaofan Li; Classroom: 390 Hearst Mining; MW 1-2 pm  
Office: 783 Davis Hall; Email: li@ce.berkeley.edu, Tel: (510)-642-5362

Lab One: GSI: Benjamin Worsfold Butler; Classroom: 345 DAVIS HALL; M 2:00-5:00 pm;  
Office Hour (504 Davis Hall): M & Thur. 9:30 am -11:00 am 504 Davis Hall,  
Email: benjamin\_worsfold@berkeley.edu

Lab Two: GSI: Yuxi Xie; Classroom: 345 DAVIS HALL; Tuesday 2-5pm  
Office Hour: : Tu: 4:00pm-5:30pm & W: 2:30 pm 4:00 pm (504 Davis Hall),  
Email: yuxi\_xie@berkeley.edu

Lab Three: GSI: Mikols Zoller; Classroom: 345 DAVIS HALL; Thursday 2:00-5:00 pm  
Office Hour: M: 11:30am-1:00pm & W: 2:30 pm-4:00pm (504 Davis Hall),  
Email: zollermi@berkeley.edu

Reader: Mr. Chao Wang; Email: chao\_wang@berkeley.edu

Grading: HW 25 %, Lab Report 30 % Midterm 20 % Final Project 25%

My Office Hour: MWF. 3:00pm-4:00 pm (783 Davis Hall)

Homework will be assigned on each Friday, and due on the following Friday. Assignments will be paper and pencil and computer-based. Lab assignments will mostly be required to be completed in the lab but some may extend over a longer period and be part of the weekly homework.

Lab: Mandatory M 2-5, Tu. 2-5, Thu. 2-5 in 345 Davis Hall. If you do not have access to the computer lab. Please follow the instructions on the department website. Note, there will be no labs the last week of the semester. Labs will begin January 26. You must go to your assigned lab section.

Software: MATLAB is used extensively in the course so it is recommended that you have you have a copy on your own computer. You can obtain a free license from the campus; see <https://software.berkeley.edu/matlab>

Web Page: Please see bCourses. bCourses will be used extensively for the course. You can download the course reader there, the syllabus, assignments, here.

Prerequisites: CE30/ME85 and (CE60 or E45)

Description: Elastic deformation analysis of bars, shafts, beams, and columns using energy and variational methods and their generalization to related areas of engineering science; stability analysis of structures;

computer-aided mathematical techniques for solution of engineering problems and modular computer programming methods.

Textbook: The text for the course can be downloaded from bCourses: Govindjee, S. (2015). A First Course on Variational Methods in Structural Mechanics and Engineering.

There will be one midterm exams and a final project. The in-class midterm exam are scheduled for March 14th (Wednesday). The final examination will be held on Tuesday, May 8th, 2018, 8am-11am.

Limited collaboration is permitted on homework assignments. You may discuss the homework with each other but may not show your written work or computer code to others. Similarly, the use of solution keys or solution sets of any type is expressly forbidden. All cases of misconduct on homework will be reported to the Student Conduct Office in addition to the assignment of a zero for the entire homework portion of the course grade. Misconduct on examinations will likewise be reported to the Student Conduct Office and result in a failing grade for the course.

### **Topic Outline**

1. Review of one dimensional models for basic elastic structural elements, tension-compression bars, torsion bars, beams

- (a) Differential equation representations,
- (b) Static indeterminacy.

2. One dimensional elements in two and three spatial dimensions

- (a) Direct assembly of truss systems, determinate and indeterminate systems.

3. Energy methods

- (a) Review of conservation of energy, conservative forces, conservative systems,
- (b) Potential energy of a system,
- (c) Stationary potential energy and Castigliano's 1st Theorem,
- (d) Trusses revisited using stationary potential energy,
- (e) Approximate energy solutions: Ritz,
- (f) Buckling problem via potential energy method.

4. Variational Methods

- (a) Virtual work (virtual displacement) method,
- (b) Virtual force method,
- (c) Castigalian's 2nd theorem,
- (c) Variational derivative.

## Detailed lecture-by-lecture topics and lab scheduling

### 1. Week 1

- (a) Introduction, overview, recall 1-D bar from CE C30;
  - (b) Review: Tension-Compression bar as a second order differential equation.
- No Lab

### 2. Week 2

- (a) Review: Torsion of a circular bar as a second order differential equation;
  - (b) Review: Beam bending as a fourth order differential equation.
- (Lab 1) BVP4c in Matlab applied to tension-compression bars.

### 3. Week 3

- (a) Equilibrium of Trusses: Introduction;
  - (b) Equilibrium matrix & Compatibility matrix.
- (Lab 2) BVP4c in Matlab applied to beams

### 4. Week 4

- (a) Truss Stiffness Matrix;
  - (b) Energy Definitions: Power, Work, Conservative Forces, Conservative Systems.
- (Lab 3) Construction of compatibility matrix for truss program.

### 5. Week 5

- (a) Energy conservation: trusses and expressions for torsion and bending;
  - (b) Energy conservation: examples.
- (Lab 4) Static condensation and solution for nodal displacements.

### 6. Week 6

- (a) Energy conservation example; Potential Energy;
  - (b) Potential energy example, potential energy truss.
- (Lab 5) Utilization of truss program from Lab 4 to analyze a truss.  
(Monday lab is out of phase due to holiday).

### 7. Week 7

- (a) Potential energy truss, Approximate potential energy;
  - (b) Approximate potential energy, the method of Ritz.
- (Lab 6) Visualization lab for potential energy in 1 and 2 degree of freedom systems.

### 8. Week 8

- Approximate potential energy, the method of Ritz worked example with program.
- (Lab 7) Potential energy solution with hat functions: mini- FEA code

9. Week 9

(a) Midterm Exam (a) Revisit rigid buckling with potential energy;

(b) Revisit beam buckling with potential energy;

Monday lab meets; no labs TuTh

10. Week 10

Spring Break Week: No lectures or labs

11. Week 11

(a) Buckling with supports and distributed loads;

(b) Response of beams with axial compression; intro to virtual work (bars).

(Lab 8) Buckling lab with rigid bars.

12. Week 12

Bars Virtual Work; Principle of V.W.; approximate V.W.

(a) Virtual Work expressions for torsion and bending.

(Lab 9) Buckling of beams using polynomial and trigonometric expansions with potential energy approximations

13. Week 13

(a) Virtual force method,

(b) Variational derivative

(Lab 10) Virtual work solutions of beam problems using Hermite polynomials: mini-FEA code

14. Week 14

(a) Castigliano's 2nd theorem,

(b) Review

(Lab 11) Finite element solution for buckling of cantilever column.