UNIVERSITY OF CALIFORNIA AT BERKELEY
Department of Civil Engineering and Environmental
Structural Engineering, Mechanics and Materials

CE 232 Structural Mechanics
Course information

Location and time:

122 Latimer, TTh 9:30-11am.

Instructor:

Francisco Armero
713 Davis Hall
Phone: (510) 643-0813 (Office)
e-mail address: armero@ce.berkeley.edu
Web page: http://www.ce.berkeley.edu/~armero
Office hours: To be announced
plus by appointment (please use e-mail preferably).

Homework:

Homework will be assigned along the week. The problems assigned in one week will be due the Thursday class of the following week. No late homeworks will be accepted.

Solution sets, class handouts and different announcements will be posted in my Web home page (http://www.ce.berkeley.edu/~armero).

Grading system:

Grades will be based on homework, one midterm and a final exam. The exams are planned to be take-home.

Course outline

PART I: NONLINEAR MECHANICS OF SOLIDS (2D/3D continua)

0. Mathematical Preliminaries (CE231)

1. Nonlinear Kinematics

1.1 Deformations and strains.
1.2 Motion.

2. Theory of Stresses

2.1. Cauchy's theorem (CE231).
2.2. Piola-Kirchhoff stresses.
2.3. Equilibrium (revisited).

3. Constitutive Theory

3.1. Frame indifference (invariance).
3.2. Finite Elasticity.

PART II: WORK AND ENERGY PRINCIPLES

4. Energy Principles

4.1. Principle of virtual work.
4.2. Potential energy.
4.3. Complementary energy.

5. Stability Theory

5.1. Euler method.
5.2. Non-conservative systems.

PART III: THEORIES OF STRUCTURAL MECHANICS (Directed continua)

6. Review of Classical Beam Theories

6.1. Euler-Bernoulli and Timoshenko beam theories.
6.2. Energy methods.
6.3. Large deflections (beam-columns).
6.4. Stability (planar and lateral buckling).

7. Classical Plate Theories

7.1. Kirchhoff and Reissner-Mindlin plate theories.
7.2. Solution methods.
7.3. Energy methods.
7.4. Large-deflection theories (von Karman equations).
7.5. Stability (buckling).

8. Introduction to Invariant Theories of Rods and Shells

8.1. Introduction to Cosserat continua.

Expanded Course Description

The goal of this course is to give an advanced view of different theories of structural mechanics in the framework of nonlinear solid mechanics. To that purpose, the course is divided in three parts:

1. The first part of the course will concentrate on some specific aspects of finite strain theories of solids. Concepts like nonlinear measures of strain and Piola-Kirchhoff stresses will be introduced to arrive at the fundamental concept of *invariance* in mechanics. Finite elasticity will be taken as a model theory with this property. (No prior knowledge of nonlinear solid mechanics is required. Only a prior contact with the concepts of infinitesimal strain and stress tensors and equilibrium equations will be assumed.)

2. Next, energy principles will be discussed in detail, starting with the infinitesimal range. Concepts like the *principle of virtual work* as well as *potential* and *complementary energies* in the elastic case will be studied. Extensions to the finite strain elastic theories described in Part 1 will be undertaken next. The linearization of the nonlinear energy principles thus developed will give the general setting for the classical theory of *elastic stability.*

3. The concepts developed above will be applied to the understanding of classical theories of structural mechanics. Linear classical *beam theories* (Euler-Bernoulli and Timoshenko beams) will be derived from the 3D equilibrium equations as well as from energy principles via the introduction of the appropriate kinematic assumptions. Large-deflection theories of beam-columns will be similarly developed, leading to the study of buckling of such members. Extensions including torsional and lateral buckling will be addressed. The same program will be followed for plate theory. First, classical linear *plate theories* (Kirchhoff and Reissner-Mindlin plates) will be derived from equilibrium and energy considerations. Solution methods will be discussed, including approximate solutions via energy methods. Large-deflection theories (von Karman equations) will be presented, and plate buckling examples will be solved. Finally, an introduction will be presented of *invariant theories* of rods and shells, thus connecting with the general geometric framework of nonlinear mechanics. The fundamental concepts behind Cosserat continua will be introduced for the interested student to pursue as a research topic in the future.