Course Syllabus

BioE102: Introduction to Biomechanics: Analysis and Design

FALL 2019

Instructor:

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208A Stanley Hall

(510) 643-8165

Office Hours: Tuesday/Thursday 5-6 PM

GSI:

Mohaddeseh Peyro (peyro@berkeley.edu)

Office Hours: Mondays 12-2PM, Stanley hall atrium level B1

Lectures:

Tues/Thursdays 11-12:30PM 106 Stanley

Discussions:

DIS 101 M 11:-Noon | 202 Wheeler

DIS 102 W 8-9AM | | 310 Hearst Mining

DIS 104 F 3-4PM | 182 Dwinelle

Course website: http://bcourses.berkeley.edu

CATALOG DESCRIPTION:

This course introduces, develops and applies the methods of continuum mechanics to biomechanical phenomena abundant in biology and medicine. It is intended for upper-level undergraduate students who have been exposed to vectors, differential equations, and undergraduate course(s) in physics and certain aspects of modern biology.

COURSE OBJECTIVES:

This course introduces, develops and applies scaling laws and the methods of continuum mechanics to biomechanical phenomena related to tissue or organ levels. It is intended for upper level undergraduate students who have been exposed to vectors, differential equations, and undergraduate course(s) in physics and certain aspects of modern biology.

Topics include:

- Biosolid mechanics
- Stress, strain, constitutive equation
- Vector and tensor math
- Equilibrium
- Extension, torsion, bending, buckling
- Material properties of tissues

Prerequisites: Math 54; Physics 7A

Grading: Letter

Estimated Number of student hours per week: 15

Core Specialization:

- Biomechanics, Biomaterials, Cell and Tissue Engineering

- Biomedical Systems Engineering

BioE Content: biological, design, clinical

Textbook:

An Introduction to Biomechanics: Solids and Fluids, Analysis and Design (Jay Humphrey and Sherry O'Rourke), Springer 2015

DESIRED COURSE OUTCOMES:

The students will develop insight, skills and tools in quantitative analysis of diverse biomechanical systems and topics, spanning various scales from cellular to tissue and organ levels.

CLASS SCHEDULE

3 hours of lecture plus a 1-hour discussion section each week

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

The course will equip the students with a deep understanding of principles of biomechanics. The intuitions gained in this course will help guide the analysis of design of biomedical devices and help the understanding of biological/medical phenomena in health and disease.

COURSE STRUCTURE AND ASSIGNMENTS:

BioE102 will be taught in lecture format, but with liberal use of class examples and demonstrations to link the course material with various biological and biomedical issues. Readings will be drawn from the text sources as indicated in the lecture schedule. Problems will be assigned each week to be submitted electronically. There will be a midterm test, a final exam, and a project term paper due at the end of the term (details to be described in class).

- **Grading:**
- Homework assignments 7%
- Class presentation and active participation 13%
- Midterm test 20%
- Final projects and term paper 20%
- Final exam 40%

MIDTERM TEST on October 15 in Class

All exams will be closed book. One standard (8.5"x11") note/equation sheet is allowed.

HOMEWORK PROBLEM SETS. Exercises on lecture material to reinforce engineering principles to prepare the student for exams. The problem sets will be assigned in most weeks. You are encouraged to seek advice or help from other students and/or to work in study groups. However, the work that is turned in must be your own. The homework exercise should be viewed as a learning experience, not a competition.

Late homework will not be accepted.

Class presentations. All students are required to present in the class once during the course of the semester (in addition to the final project presentation at the end of the

semester). The presentations will be done in groups of 3 students. There will be two 5-minute presentation slots during each class plus a 2-minute period for Q&A. The subject of the presentations should be closely related to the theme of the corresponding week. Grading of these presentations will be based on the creativity in the selection of the subject and the presentation itself. The presentations will be graded very carefully by the professor and the GSIs.

TERM PAPER. A final project and term paper will be assigned that will require the students to delve deeply into the topics of the course. More information later.

Topics covered

- Introduction to Biomechanics
- Role of Biomechanics in Biomedical Systems
- A Historical Overview of Biomechanics

- Introduction to Vector Calculus and Tensors

- Introduction to Solid Mechanics
- Concepts of Stress, Strain, and Constitutive Relations
- Mechanical Properties of Tissues
- Stress Transformations
- Principal Stresses and Maximum Shear
- Mechanical Properties of Tissues

- Equilibrium, Universal Solutions, and Inflation
- General Equilibrium Equations
- Axially Loaded Rods
- Pressurization and Extension of Thin-Walled Tubes
- Pressurization of Thin Spherical Structures
- Thick-Walled Cylinders
- Extension and Torsion
- Deformations due to Extension

- Shear Stress due to Torsion
- Principal Stresses and Strains in Torsion
- Angle of Twist due to Torque
- Combined Inflation, Extension and Twist

- Beam Bending and Column Buckling
- Shear Forces and Bending Moments
- Stresses and Deformations in Beams
- Principle of Superposition
- Buckling

- Advanced Topics and Applications (Biomechanics of Disease, Mechanotransduction, ...)