University Of California, Berkeley
Department of Mechanical Engineering

ME 120: Computational Biomechanics Across Multiple Scales (3 units)

Undergraduate Elective

Syllabus

CATALOG DESCRIPTION

This course applies the methods of computational modeling and continuum mechanics to biomedical phenomena spanning various length scales ranging from molecular to cellular to tissue and organ levels. The course is intended for upper level undergraduate students who have been exposed to undergraduate continuum mechanics (statics and strength of materials).

COURSE PREREQUISITES

ME C85

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Course Reader

COURSE OBJECTIVES

To offer a hands-on training in computational modeling of biomechanical phenomena ranging from cellular to tissue to organ scales

DESIRED COURSE OUTCOMES

The students will develop insight, skills and hands-on experience in computational modeling of diverse biomechanical systems and topics, spanning various scales from cellular to tissue and organ levels.

TOPICS COVERED

- Computational modeling
- Material properties and strength of materials
- Theories of viscoelasticity
- Biosolid mechanics
- Biofluid mechanics
- Cell, Tissue, and Organ Biomechanics

CLASS/LABORATORY SCHEDULE

2 hours of lecture plus 3 hours of lab section. For more details, please see the sample weekly topics.

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

The course will equip the students with computational modeling skills that guide the design of biomedical devices and help the understanding of biological/medical phenomena in health and disease.

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

(a) an ability to apply knowledge of mathematics, science, and engineering
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(g) an ability to communicate effectively
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

ME 120 is taught using a combination of weekly lectures and hands-on computer labs, with liberal use of class examples and demonstrations to link the course material with various biological and biomedical issues. Readings will be drawn from different medical and biological sources as indicated in the lecture schedule. Problems will be assigned each week to be handed in and graded. There will be one midterm exam, and a project term paper and poster presentation due at the end of the term.

Grading:	Homework and lab assignments	20%
	Midterm	40%
	Term paper and poster presentation	40%

<u>HOMEWORK PROBLEM SETS.</u> Exercises on lecture material to reinforce engineering principles to prepare the student for exams. The problem sets will be assigned most weeks to be handed in and graded. Homework grading is intended to show you how well you are progressing in learning the course material. 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.

<u>WEEKLY LAB SESSIONS</u>. Hands-on training in computational modeling labs will be held each week through the 10^{h} week, preparing the students for term project. At the end of each lab, the students will submit their results via the course website. Lab sections will continue beyond the 10th week, except that the students will be working on their term projects.

- Lab 1 – Introduction to Computational Modeling with COMSOL
- Lab 2 – Computational Modeling of Hip Replacement
- Lab 3 - Stress Distribution in Atheroslerotic Arterial Models
- Lab 4 – Computational Modeling of Angioplasty
- Lab 5 – Blood Flow in Stenotic Carotid Bifurcation
- Lab 6 – Blood Flow in a Coronary Artery
- Lab 7- Truss/tensegrity Model for the cell
- Lab 8- Micropipette Aspiration of a Cell or Nucleus
- Lab 9- Viscoelastic Model of a Cell under Shear Forces
- Lab 10- Mobile Analysis of Tumor Cells in Brain ECM

- Lab 11- Neuron Twist in Traumatic Brain Injury
- Lab 12- Finite Element Biomechanical Analysis of Biomolecules

TERM PAPER. A computational project and term paper will be assigned that will require the students to delve deeply into one of the topics of the course. The project can be devoted to a design or analysis effort related to a biomechanics problem abundant in biology and medicine. Additional information concerning the project and term paper will be provided at a later date.

Term projects require a 6-page concise write-up in scientific format consisting of a description of biological or clinical relevance of the work undertaken, technical analysis and discussion, conclusions and future work. The projects will be presented as posters. Students will work in groups of 2-3.

TOPICS COVERED IN LECTURES

Week 1	Introduction to Biomechanics A Historical Overview of Biomechanics Logistics and Course Introduction
Week 2	Introduction to Finite Element Method for Computational Modeling Introduction to COMSOL
Week 3	Introduction to Tissue and Organ Biomechanics
Week 4	Introduction to Cell Biomechanics
Week 5	Review of Solid Mechanics Principles (Statics and Strength of Materials)
Week 6 & 7	Review of Fluid Mechanics Principles (Conservation of Mass, Momentum, and Navier-Stokes Eqs.)
Week 8 & 9	Time-dependent mechanical behavior of materials (theories of viscoelasticity)

Midterm

Week 10	Computational Models of Tissue and Organ Biomechanics

Preliminary review of term projects
1-page abstracts are due in class

Week 11& 12	Computational Models of Cell Biomechanics
Week 13	Multiscale Computational Models in Biomechanics
Week 14	Open Questions in Multiscale Biomechanics
Week 15	Course wrap-up, reflections and review
Week 16	(RRR) Computational Biomechanics minisymposium: Term project poster presentations

PERSON(S) WHO PREPARED THIS DESCRIPTION
Mohammad R. K. Mofrad, 10 November 2011

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): Comp Bio Acr Scls
TIE CODE: LECT
GRADING: Letter
SEMESTER OFFERED: Fall and Spring
COURSES THAT WILL RESTRICT CREDIT: None
INSTRUCTORS: Mofrad
DURATION OF COURSE: 14 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 9
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None