ME/BE 788: Soft Tissue Biomechanics

Fall 2010
MW 2-4pm, PSY B55

Course Description

This course will introduce students to the mechanics of soft biological tissue. In particular, the response of the heart, vasculature, and tissue scaffolds to mechanical loads from the perspective of nonlinear solid mechanics will be studied. Constitutive models for hyperelastic materials will be adapted to biomaterials to handle mechanical characteristics such as nonlinearity, viscoelasticity, and orthotropy. Basic experimental methods, and anatomy and physiology of particular tissue types will also be introduced. Emphasis is placed on integrating the basic analytical, experimental, and computational methods for a more complete understanding of the underlying mechanobiology.

Prereq: Vectors and tensors, kinematics, stress/strain tensors, mechanics of rigid bodies; ME 521, ME 580, or equivalent with consent of instructor

Instructor

Dr. Katherine Yanhang Zhang
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Office Hours

MW 4-5pm. In addition to the regularly scheduled hours, the instructor is also available by appointment.

Textbooks

Cardiovascular Solid Mechanics: cells, tissues, and organs, Jay D. Humphrey. Springer-Verlag, 2002. ISBN 0-387-95168-7.

Reference

Biomechanics: mechanical properties of living tissues, Y. C. Fung. Springer-Verlag, 1993. ISBN 0-387-97947-6.
Nonlinear Solid Mechanics: a continuum approach for engineering, Gerhard A. Holzapfel. John Wiley & Sons, 2001. ISBN 978-0471-82319-3.

Grading

Your grade in this course will be assessed by homework, project, exams, attendance and class participation.

Homework	20%
Midterm exam	40%
Term Project	30%
Class participation	10%

Total: 100%

Attendance and class participation

You are required to attend the class and are responsible for all materials and announcements in the class. Make-up class is only available in very special circumstances, such as illness. You are also required to participate in class discussions, analyzing and discussing reading assignments. Reading assignments, usually journal articles will be assigned weekly starting a few weeks after the class begins. For each reading assignment, a lead reader will also be assigned who will lead the discussion.

Homework

Homework will be assigned bi-weekly. Discussions on the homework are encouraged. However, copying other people's homework will result in no credit.

Term project*

Every student is required to complete a term project. The objective of the project is that each student understands the theory and the biological mechanisms, and applies these understandings to analyze and solve problems. Shortly after the course begins, students will be asked to choose research problems that interest them and are related to the course subject, which may or may not be related to work you are actually doing in the laboratory. A short review paper describing basic problems and approaches in the area will be due towards the midpoint of the semester. Students will then use this background to prepare a research proposal, which will be due two weeks before the end of the semester. In addition to receiving a grade from the instructor, each proposal will be distributed to two classmates who will be responsible for reviewing the proposal according to NSF merit criteria. These reviews will be due at the end of the semester and will be graded by the instructor and shared with the author of the proposal. At the last week of the semester, each student will give an oral presentation of the term project.

Due dates:

October 27: short review
December 1: research proposal
December 8: reviews on proposals from classmates

*More details about the term project will be forthcoming.

SYLLABUS FOR Fall 2010

Week		Topics	Suggested readings		
			Fung	Humphrey	SM
1		No class			
2	9/8	Introduction and Mathematical preliminaries	Ch. 1	Ch. 1-2	
3	9/13	Continuum mechanics	Ch. 2	Ch. 3	
	9/15	Tensor Analysis Continuum mechanics			
4	9/20	Finite elasticity	Ch. 7.1q	Ch. 4	
	9/22				
5	9/27	Experimental methods and	--	Ch. 5	SM
	9/29	structure/function/properties for native and engineered soft tissues			
		Discussion on reading assignment			
6	10/4	Vascular mechanics of normal	Ch 8	Ch. 4,7-9	SM
	10/6	vasculature and vascular disorders Lab tour of MSTBL on 10/6			
		Discusson on readaing assignment			
7	10/12	Constitutive models			
	10/13				
		Discusson on readaing assignment			
8	10/18	Constitutive models			
	10/20	Cardiac mechanics of normal heart	Ch. 10	Ch. 10	
		Discusson on readaing assignment			
9	10/25	Cardiac mechanics of normal heart			
	10/27	Viscoelasticity			
10	11/1	Linear models	Ch. 2.11	--	SM
		Quasilinear viscoelasticity	Ch. 7.6	--	SM
	11/3	***Midterm exam***			
11	11/8	Engineered tissue scaffolds	--	--	SM
	11/10				
12	11/15	Mechanotransduction	--	--	SM
	11/17	Electrochemical effects on tissue properties			
		Discussion on reading assignment			
13	11/22		Ch. 11	--	SM
	11/24	***Fall break***			
		Discusson on readaing assignment			
14	11/29	Growth biomechanics (depending on	--	9.1	SM
	12/1	time)			
15	12/6	Student Project Presentation			
	12/8				