Syllabus

Biomedical Engineering

Advanced topics in Cardiovascular Solid Biomechanics - (338402)

Winter semester 2021

(2.5 credits)

Description

This course discusses biomechanical models of living tissue with emphasis on problems in the cardiovascular system. The first part of the course is dedicated to studying general viscoelastic and hyper-elastic models and examining their application in biomechanics. The second part of the course, is dedicated to bio-mechanics of cells with focus on blood cells including: red blood cells and endothelial cells. The topics of modeling cell adhesion under flow and biomechanical aspect of thrombosis will be presented as well.
Throughout the course, a strong emphasis will be put on developing physical insight rather than focusing on detailed mathematical solutions of analytical models.
The course is aimed at graduate students, with prior exposure to introductory mechanics and calculus (e.g. partial differential equations). Prior exposure to a physiology course is suggested but not mandatory.

Prerequisites

- Fundamental of Biomechanics (334222 or equivalent from other departments: Solid Mechanics 034029)
- Recommended: Body Systems physiology for engineers (276011 or similar)

Instructor

Asst. Prof. Netanel Korin, korin@bm.technion.ac.il

Office: Julius Silver (Biomedical Engineering) 226, +97282946114

Lectures: Sunday 10:30am – 12:30am

Office hours: TBD

Teaching Assistant

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Tutorials: Sunday 12:30am – 1:30pm

Office hours: TBD

Textbook

- Fung, Y.C., 2013. Biomechanics: mechanical properties of living tissues. Springer Science & Business Media.
- Fung, Y.C., 1997. Biomechanics: Circulation. Springer Science & Business Media.

Online Resources

Moodle: all lecture notes / supplementary material / slides are available there.

Course Objectives

- To teach students solid viscoelastic models and how to implement viscoelastic models in tissue biomechanics problems
- To teach students fundamentals of hyper-elastic models and their application in biomechanics
- To teach students the biophysical principles governing the mechanics of blood vessel
- To teach students how to model the mechanics of Red blood Cell membrane
- To teach students on endothelial cells mechano-responsiveness
- To teach students the basic physical models of cell adhesion under flow

Course Topics

Introduction to Continuum Mechanics

- The deformation Tensor , Finite Deformatio
- The Stress Tensor
- Material Constitutive Laws

Soft Tissue Mechanics

- Viscoelastic models (Kelvin-Voigt, Maxwell, SLS)
- Hyper-elastic models (neo-Hookean solid)
- Anisotropy

Mechanics of blood vessels

- Blood vessel structure, anatomy and mechanical properties: cell orientations, different layers, collagen structures
- Modeling the blood vessel wall
- Mechanics of the vessel layers

Cell-mechanics

- Red blood cells: Mechanics of erythrocyte membrane and cell membrane experiments
- Endothelial cells: Mechanics the endothelium and endothelial cells mechno-sensing
- Modeling the adhesion under flow of blood cells and particles
- Models of thrombus formation and dissolution

Assignments & Readings

The course will include two lectures and one tutorial per week.

Breakdown of course grading:
Homework– 35% (approx. 1 homework assignment per week; mandatory handing in)
Final Project – 65% (a final project to be approved by instructor, includes an oral presentation and a written report)

Key Dates
TBD

Assignments & Readings
Weekly lecture notes (available through Moodle).
Homeworks and all supplementary material will be made available through Moodle.

Ethics

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

Report any violations you witness to the instructor.

Students with Disabilities

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Technion International's guidance counselor, at counselor@int.technion.ac.il

ABET Outcomes

(a) Ability to apply knowledge of mathematics, science and engineering.
(b) Ability to design and conduct experiments, as well as to analyze and interpret data.
(c) 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) Ability to function on multidisciplinary teams.
(e) Ability to identify, formulate, and solve engineering problems.
(f) Understanding of professional and ethical responsibility.
(g) Ability to communicate effectively.
(h) The broad education necessary to understand the impact of engineering solutions in a global,
economic, environmental, and societal context.
(i) Recognition of the need for, and an ability to engage in life-long learning
(j) Knowledge of contemporary issues.
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering
practice.