JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Hopkins Engineering Applications & Research Tutorials EN.500.111
Mathematical Modeling and Computer Simulations in Physiology and Medicine - Fall, 2024

Course Title
Mathematical Modeling and Computer Simulations in Physiology and Medicine

Instructor Information
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Office: Wyman Park Building S413 and Hackerman Hall 219
Office hours: TBD, and by appointment.

Meetings
Monday, 12:00 - 1:15, Gilman 217
26 August 2024 – 11 November 2024.

Description
In computational medicine and biology, having a strong intuition of the underlying mathematical and physiological concepts is crucial for making advancements in research. This course will introduce students to the basics of mathematical modeling and computer simulations for describing physiological and biological processes and provide a high-level understanding of how these tools can be leveraged for understanding organ systems and treating adverse events. The first half of most lectures will provide a general overview of physiological processes and relevant modeling techniques to simulate them. In the second half, the instructor will provide students with sample code which can be easily modified to simulate and graphically visualize results. In-class coding workshops and demonstrations will provide students with a hands-on learning opportunity to interact with the visual graphics produced by the mathematical descriptions and formalisms discussed in the lecture component.

Course Topics

- What is "mathematical modeling"? Resources for learning MATLAB, GitHub, LaTeX, Python, Introduction to steady state linear blood flow model.
- Steady state model ct. (with code). Begin numerical methods for blood flow modeling: 0D Pulsatile dynamic model, Euler's method.
- Pulsatile model derivation ct.
- Coding a compartmental, pulsatile circulation model of blood flow
- Modeling crossbridge dynamics during muscle contraction
- Epidemiology modeling and population genetics
- Modeling cell volume control mechanisms
- Modeling neuronal dynamics: Hodgkin Huxley Kinetics
- Neuronal Dynamics and action potential propagation with 3D visual graphics

Textbook The textbook that many of my lectures will follow can be found here:

- Charles S. Peskin, Frank C. Hoppensteadt, *Modeling and Simulation in Medicine and Life Sciences*, Second Edition, Springer Link, (2002). Textbook-PDF

Course Expectations
Lectures will be held weekly for 10 weeks during the semester. There will be no quizzes or exams. Attendance to lectures is mandatory and active class participation is highly encouraged. There will be frequent coding workshops to engage with the course material.

Assignments & Grading
The class is graded on a satisfactory/unsatisfactory (pass/fail) basis. Grading for this class is based solely on attendance and participation. Show up to class, engage in discussions and coding workshops; if you complete these basic requirements, you will pass the course.

Course Objectives
Throughout the duration of the course, students will learn to conduct literature review and formulate their own ideas. They will also learn about common challenges in the field related to clinical translation and strategies to overcome said challenges. It is intended that students learn real-world problem-solving skills which they can generalize and apply to their own educational, professional or research career. The concepts that are presented in this course are accessible to a student population of varying backgrounds, lectures will be brief and serve as grounds for more advanced investigations depending on interest. The mathematical and biological prerequisite knowledge required is that of a typical high school curriculum and any advanced concepts will be developed or reviewed during the course.

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. You can find more information about university misconduct policies on the web at these sites: e-catalog.jhu.edu/undergrad-students/student-life-policies/

Students with Disabilities
Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Student Disability Services, 385 Garland, (410) 516–4720, studentdisabilityservices@jhu.edu.