BIOM 315: Computational Biomedical Engineering
Tue & Thu, 11:00a-12:15p, MR-5 1041

Instructor
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Teaching Assistants
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Course webpage
Toolkit page for BIOM 315
Lectures, homework, and announcements will be posted, so please check regularly.

Course objective
This class has the following major goals:
- To help you further develop your skills in developing mathematical and computational models for systems. Such models often provide new insights about biological or engineering systems. As such, models represent a pathway for exploration that is often complimentary to experiment. Furthermore, models are critical tools for predicting the behavior of engineered systems and therefore are an essential part of the design process.
- To introduce you to numerical methods, powerful techniques for solving complex, real-life problems.
- To integrate knowledge gained from other courses (e.g., transport, mechanics, cell & molecular biology) in a computational framework.
- To strengthen and expand your computer programming skills. We will not focus on the details of implementing detailed algorithms, but rather on developing the skills needed to apply existing routines as well as developing a sense of the limitations and dangers of numerical methods. We will use MATLAB extensively and draw upon existing functionality whenever it is available.

To achieve these goals we will use a combination of lectures, homework, exams, and a final project. Much of this work will allow and encourage team cooperation; however, you should recognize the need for you as an individual to be proficient in all aspects of the material.

Textbooks (Highly Recommended)

*Numerical Methods for Engineers*, 2002, by Chapra & Canale

*Mastering MATLAB 6: A comprehensive tutorial and reference*, 2001, by Hanselman & Littlefield (or other good Matlab reference)
Course Lecture & Exam Schedule

1 - Introduction; Linear algebra review
2 - MATLAB; Computers and Numbers – HW assigned (introduction; linear algebra)

Section I – Model Creation: First principles & data-based
3 - Model creation process & examples
4 - First principle-based models
5 - Data-based models – regression – HW assigned (model-building, curve fitting)
6 - Data-based models – interpolation

Section II – Organ-Level Models: How do you model the decrease in cardiac output after a heart attack?
7 - Numerical differentiation
8 - Numerical integration
9 - Root finding – HW assigned (differentiation, integration, root finding)
10 - Exam #1 (introductory concepts, model-building, curve-fitting, numerical differentiation & integration)

Section III – Cell-Scale Models: How do you assess cell viability under a variety of simulated gene knockout experiments?
11 - Systems of linear & nonlinear equations – Part I
12 - Systems of linear & nonlinear equations – Part II
13 - Optimization – Part I – HW assigned (systems of equations, optimization)
14 - Optimization – Part II
15 - Linear programming
16 - Monte Carlo sampling – Part I
17 - Monte Carlo sampling – Part II – HW assigned (optimization, linear programming, Monte Carlo sampling, ODEs)
18 - Exam #2 (systems of equations, optimization, linear programming, sampling)

Section IV – Molecular-Scale Models: How do you quantify the dynamics of autocrine signaling?
19 - ODEs – Part I
20 - ODEs – Part II
21 - PDEs – Part I – HW assigned (ODEs, PDEs)
22 - PDEs – Part II

Section V – Advanced Examples
23 - Tissue morphogenesis
24 - Cellular reaction networks
25 - Image processing
26 - Class project presentations I – Written final project due
27 - Class project presentations II
28 - Class Review (class material overview, wrap-up discussion)
Final Exam Week – Exam #3 - (ODEs, PDEs, advanced examples, class projects)
Grading

Late work will not be accepted for full credit unless there is prior written approval. Homework will be due at the very beginning of the lecture on the day it is due unless noted otherwise on the assignment. Some work will require electronic submission and will need to be submitted before the beginning of lecture on the day it is due. The procedure for turning in the homework will be indicated in class and noted on the class website. **You will lose 20% on the homework for each day that it is late.**

You are encouraged to collaborate on homework, but **you will need to cite your collaborators and all submitted written work must be individual.** If there is any confusion about whether collaboration or drawing upon outside resources is allowed, please contact me.

Grades for the class will be determined using the following formula.

- **36%** Homework Assignments (6 assignments – 6% each)
- **4%** Literature Reviews (4 assignments – one per section – 1% each)
- **36%** Exams (3 exams – 12% each)
- **20%** Written Final Project
- **4%** Final Project Presentation

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The School of Engineering and Applied Science relies upon and cherishes its community of trust. We firmly endorse, uphold, and embrace the University’s Honor principle that students will not lie, cheat, or steal, nor shall they tolerate those who do. We recognize that even one honor infraction can destroy an exemplary reputation that has taken years to build. Acting in a manner consistent with the principles of honor will benefit every member of the community both while enrolled in the Engineering School and in the future. If you have questions about your Honor System or would like to report suspicions of an Honor Offense, please contact either Dan Bowman (dbow@virginia.edu) or Alison Tramba (avtramba@virginia.edu).