BME 5742
Bio-Systems Modeling and Control

(27010, 27011,27012)

Course Syllabus

Dr. Zvi S. Roth

Instructor

Dr. Zvi Roth, Professor of Electrical Engineering

Engineering East, Room 519

561-297-3471 (from campus phones dial 7-3471)

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Class and Office Hours

- **Studio Time:** **T Th** 2:00-3:20 pm.
- **Office Hours:** **T Th** 9:00 – 10:00 am and 3:30-4:30 pm
- Other times – by appointment (by phone or e-mail)

Live vs. Video Lectures

- See course calendar for scheduled sessions and other deadlines.
- All lectures are live and run in a recording studio.
- Lecture videos are posted in the course's Blackboard page at the end of each session. The videos are accessible to all students who are registered to the course.

FAU Bioengineering MS Program

- This is one of the core courses for the program.
- The four core courses are designed to bring students having diverse backgrounds to some sort of a “common denominator”.
- Students with life science background (who may be deficient in Differential Equations and Computer Programming) will learn how to do dynamic modeling and simulations.
- Students with engineering background (who may be deficient in Biology) will become exposed to many biological and physiological systems and concepts.

No prior knowledge in Biology, Differential Equations, Signals & Systems and Control Systems is assumed

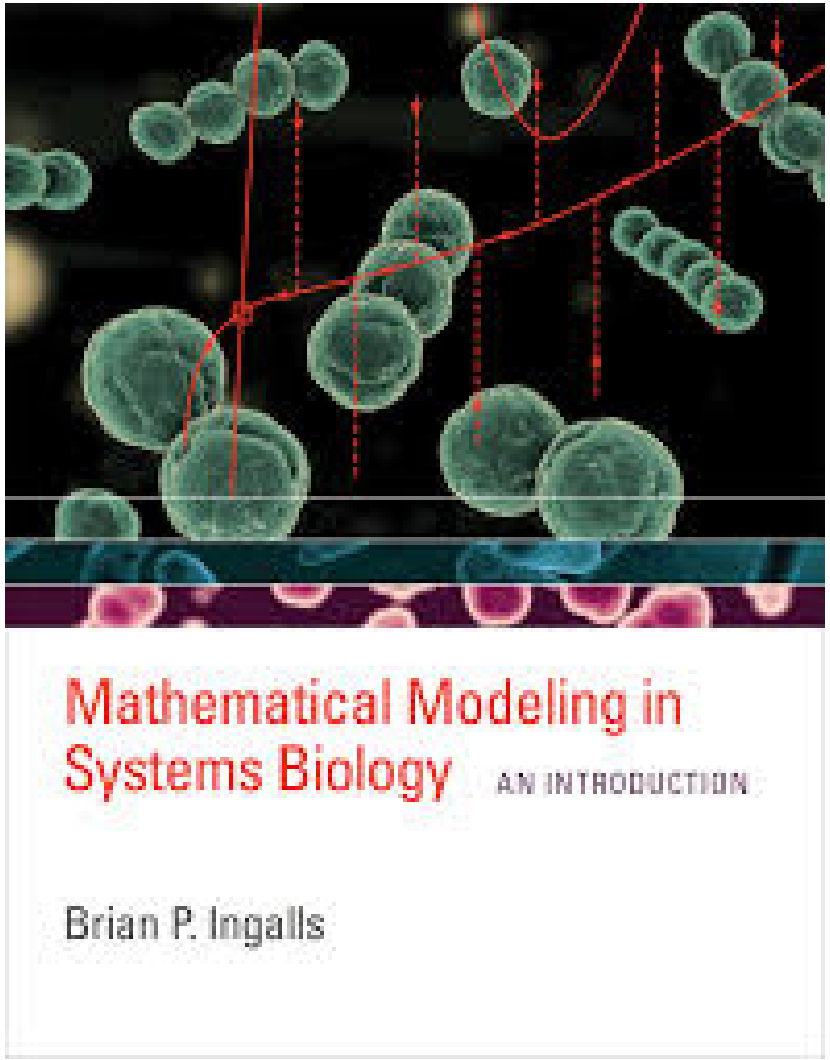
About Differential Equations

- A differential equation relates the system variables and their rates of change to initial conditions and input signals.
- In a typical basic course on differential equations the focus is on techniques for finding analytic solutions of the equations.
- In our course we just need to set up the model, so that we can solve and analyze by means of simulations.

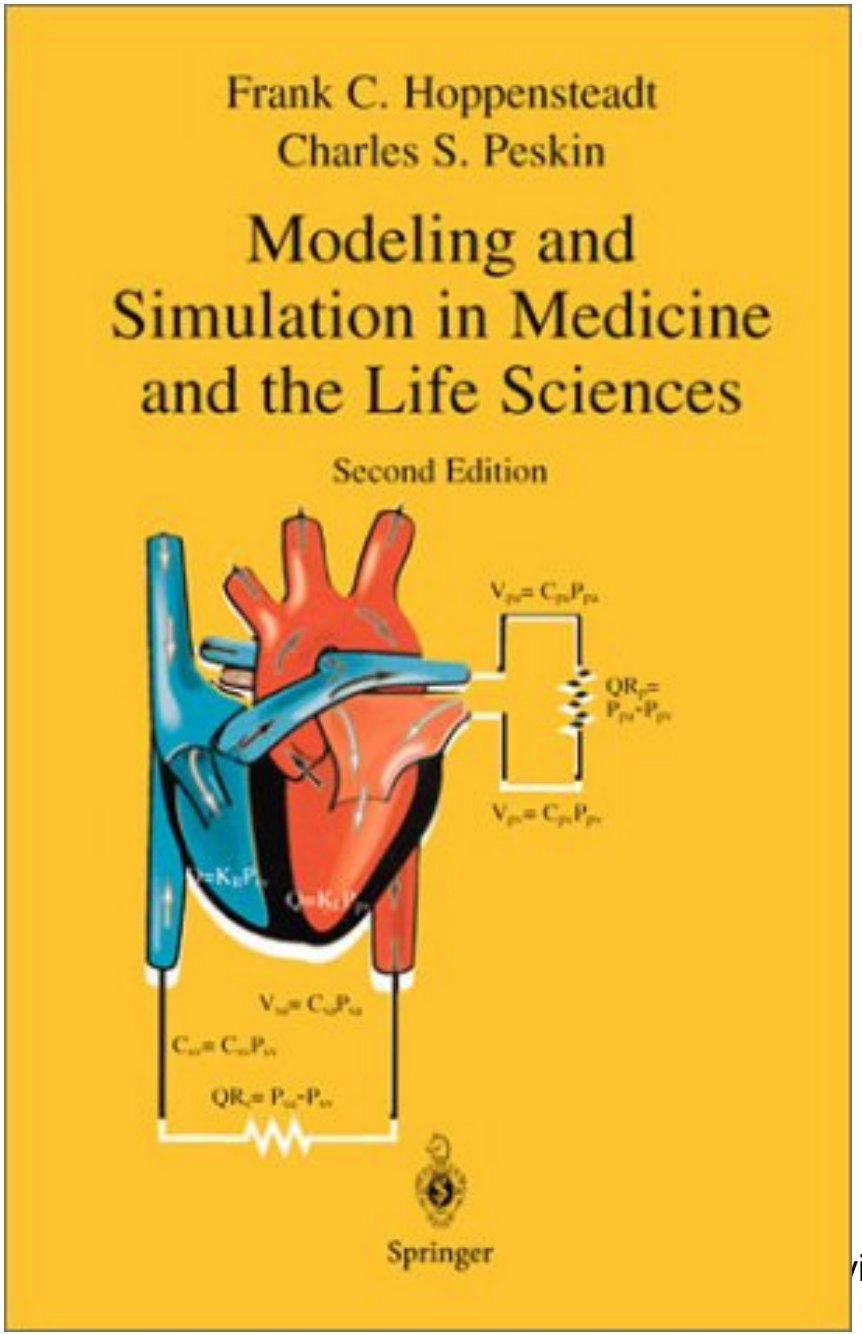
Modeling vs. Control Balance

- In all past offerings of the course the balance was "MODELING vs CONTROL"
- We'll keep it this way.
- The course is mostly about modeling and only a little bit about control.

Textbook



- **Mathematical Modeling in Systems Biology – An Introduction**
- Brian Ingalls
- MIT Press, 2013



Reference

Modeling and Simulation in Medicine and the Life Sciences (2nd Edition)

Frank C. Hoppensteadt and Charles S. Peskin

Springer, New York , 2002

Available MATLAB programs

Please visit Hoppensteadt's web page at http://www.eas.asu.edu/~sserc/people/fchoppen/books.htm, and download all Matlab m. files provided for the book (optional).

(Required) Do the same at Peskin's web page http://www.math.nyu.edu/faculty/peskin

Simulation Software

- MATLAB 6.5, Student Edition, Release 13, with SIMULINK 5

  [A later version is now available – Release 14, Matlab 7, Simulink 6. Earlier versions may be ok. Check with instructor]

- Textbook also advocates the free app of a program XPP (To be checked soon)

Course Topics

- MATLAB+SIMULINK tutorials (via analysis of Population Growth Dynamics)
- Single-species Growth Models; Multi-Species Growth Models: Predator-Prey, Competition, Symbiosis
- Linearization and study of equilibrium points
- Spread of Infectious Diseases Models
- Viral Dynamics models
- Chemical Reaction Rate – Law of Mass Action
- Compartmental Modeling
- Diffusion Dynamics and Fick's First Law

Course Topics (cont'd)

- Enzyme Kinetics – Michaelis-Menten theory, Cooperation, Competitive and Allosteric Inhibition, Allosteric Activation
- Hormones: Insulin and Glucagon; Glucose Metabolism; Diabetes Models
- Modeling of Unregulated and Regulated Gene Expression; Gene Networks and Switches
- Linear dynamic models – generalized Ohm and Kirchhoff's Laws.
- Steady-state and Transient analysis of the Heart and Blood Circulation.
- Control of Cell Volume and Action Potential of Nerve Cells (Hodgkin-Huxley model).

Grading Policy

- Midterm Exam 20%
- Final Exam 20%
- 6 simulation assignments 60%

Grades Conversion Scale

- A= 90-100%, A-=85-89%, B+=80-84%, B=75-79%, B-=70-74%, C+=65-69%, C=60-64%, C-=55-59%, D+=50-54%, D=45-49%, D-=40-44%, F=0-39%. [At least, this part of the course is linear…]
- There will be no "grade-curving" of any sort.
- All final grades that fall within 1% of a grade threshold will be reviewed. Special consideration to overcome a 1% grade deficit will be extended only to students who demonstrated consistent and punctual hard work throughout the semester

Software Demonstration in Class

- Tutorial sessions of the course's simulation software and demonstrated examples will be integrated into each lecture.
- All assignments will also be posted in Bb (in the Course Documents section).
- A collection of old homework solutions (using the software tools) is posted in Bb for further reference.

Homework Format

- Each homework must be submitted both by e- mail and by a printout.
- Posting in Blackboard's Digital Drop Box is discouraged. If you do it make sure to alert the instructor by an e-mail.
- Submission as a Microsoft Word file or as a pdf file. All simulation diagrams and results must be embedded within the homework text (preferably as jpg images).

Each project should include the following items:

- Some analysis or design explanation text, predicting approximately the expected outcome. In case of a design activity, need to explain your design considerations and approach.
- System diagram (if it is a Simulink program), including diagrams of the sub-systems. In the case of a Matlab program, include the text of the respective m files. It is highly encouraged that you annotate the software: Include labels and text blocks in the diagrams, and comments text for programs.

Homework Format (cont'd)

- Output results – Be selective and use only the most relevant output. Don't dump on me your entire collection of computer printouts. In particular, never submit graphs that you cannot explain. Again, annotate the results for best readability.
- Brief conclusions – Did the system perform as expected? If the results are far from your hand-calculation prediction, where is the difference coming from?

Getting Help in Homework

- To better manage your time try not to get stuck for hours "fighting against the program". Instead e-mail me your diagrams and/or results copied and pasted on a Word document.
- For instance, you may use Print Screen, followed by editing of the image (using Microsoft Photo Editor, or a similar tool) and saving of the image as jpg file. I will then be able to watch your Word file question and quickly help you with the debugging. <u>Do not e-mail any raw m files or Simulink models</u> – it is too time consuming to “fish” these out from the e-mail attachments.

Blackboard

- Every registered student is assigned an account to the course's **Blackboard** web page.
- Bb site includes: instructor's announcements and posted course material. All PowerPoint lecture notes will posted in Course Documents. Please consult the blackboard page periodically for new announcements, posted material and the On-line Grade book.
- All lecture videos will be posted in Bb.

Final Exam

- Tuesday 4/29/2014 1:15-3:45
- Exam will be about material covered in the second half of the course (represented by HW4 – HW6)
- Closed books and notes, except for a single 8.5”x11” formula sheet (containing any information chosen by the student)
- Simple Scientific Calculators are allowed.

Midterm Exam

- 2/20/2014
- 1 hour and 20 minutes long
- Exam will cover the material of the first half of the course (HW1 – HW3)
- Same rules as for the Final Exam

Wishing you a productive Spring 2014 semester!