Mathematical Modeling in Biology
MATH 463/ BIOINF 463/ BIOPHYS 463, Section 001
Fall 2011

Math 463 provides an introduction to the use of continuous and discrete differential equations in the biological sciences. We will develop and analyze mathematical models to investigate mechanisms underlying specific biological processes. Another major emphasis of the course is illustrating how these models can be used to generate predictions about currently untested conditions. The course moves from classical to contemporary models at the population, organ, cellular, and molecular levels. The goals of this course are: (1) Critical understanding of the use of differential equation methods in mathematical biology and (2) Exposure to specialized mathematical and computational techniques which are required to study ordinary differential equations that arise in mathematical biology. By the end of this course students will be able to derive, interpret, solve, understand, discuss, and critique discrete and differential equation models of biological systems. Approximately one class period each week will be held in the mathematics computer laboratory where numerical techniques for finding and visualizing solutions of differential and discrete systems will be discussed. Note: this course is cross-listed as Biophysics 463 and Bioinformatics 463.

Meeting times: M,W 9:10-10am, East Hall 3088; F 9:10-10am, Computer lab in East Hall B745 (after 11/18, we will meet in EH 3088 on Fridays)

Instructor: Victoria Booth, East Hall 4075, 763-4730, vbooth@umich.edu

Office hours: M,W 10-11am, Th 3:30-4:30pm and by appointment

CTOOLS website: BIOINF 463 001 F11
Class email address: math463001f11@ctools.umich.edu

Required textbook: Leah Edelstein-Keshet, *Mathematical Models in Biology*, 1988.
Supplementary textbook: J. D. Murray, *An Introduction* (to Mathematical Biology), 2002. Available on-line through UM library.

Homework: Weekly homework assignments will be due on Fridays, to be turned in with completed computer labs at the end of class period. NO late homework will be accepted. Students may work together but must submit their work individually. For each problem set, a random subset of assigned problems will be graded.

Computer Labs: On Fridays (until 11/21), class will be held in the computer lab in the basement of East Hall (Rm B745). Lab assignments are to be completed during this time and handed in at the end of the class period. Assignments will be implemented using MATLAB and will consist of numerically solving and analyzing models related to the week's lectures.

Exams: MIDTERM EXAM: FRIDAY, OCT 28 – in class
TAKE-HOME FINAL EXAM: Assigned Dec 12, Due Dec 19 by 5pm

Course Project: A mathematical biology modeling project will occupy a substantial portion of your time and effort in the course. Students should work in teams of two, preferably, although you can discuss with me the possibility of individual projects or teams of 3 people. For the project, you will give a 20-minute in-class presentation during the last 2-3 weeks of class and submit a research paper. Be prepared to submit project topics in early October and project outlines in early November. Start early thinking about a biological topic (process, system, environment, interaction) that you are interested in learning about and doing internet searches on modeling approaches in that topic. For the project, you can develop a novel mathematical model related to your topic, or provide extensions or new applications for an existing mathematical model. It will not be sufficient to study an existing model and present already reported results for the model; there must be a novel component to your project. More details on the requirements for the project and possible project topics will be given later.

Grading: Homework, computer labs and class participation= 25%, Midterm and final exams = 50%, Course project = 25%.

Topics covered:

9/7: Introduction, Difference equation models
9/9: Computer lab 1

9/12,14: Linear difference equations (Chap 1); Breathing model; Apoptosis and tumorigenesis model
9/16: Computer lab 2

9/19,21: Apoptosis and tumorigenesis model continued; Nonlinear difference equations (Chap 2);
9/23: Computer lab 3

9/26,28: Systems of nonlinear difference equations; host-parasitoid system models (Chap 2 and 3)
9/30: Computer lab 4

10/3,5: Differential equations; bacterial growth models, Spruce Budworm model (Chap 4)
10/7: Computer lab 5

10/10,12: Systems of differential equations; Chemostat model; phase plane analysis (Chap 4 and 5)
10/14: Computer lab 6

10/19: Enzyme kinetics (Chap 7)
10/21: Computer lab 7

10/24,26: Multispecies models (Chap 6); review

10/28: **EXAM 1** – in class

10/31,11/2: Pharmacokinetic models; Cancer models
11/4: Computer lab 8

11/7,9: Infectious disease models (SIR and SIRS models, Sec 6.6)
11/11: Computer lab 9

11/14,16: Cell cycle model; Neuroscience modeling (Chap 8)
11/18: Computer lab 10
11/21,23: Neuroscience modeling

11/28: Review
11/30,12/2: Project presentations

12/5,7,9: Project presentations

12/12: Project presentations

12/19: FINAL EXAM DUE by 5pm