Spring 2016

Math 304 – Mathematical Modeling: Deterministic Models (3)

Course Description:
Deterministic mathematical modeling emphasizing models and tools used in the biological sciences. Topics include difference equations, qualitative behavior solutions of ODEs and reaction-diffusion equations. A computer lab may be taken concurrently.

Prerequisite:
Math 216, or Math 242, or Math 252A, or consent.

Time:
150 minutes of lecture weekly.

Suggested Textbooks:
Edelstein–Keshet, L. (2005) *Mathematical Models in Biology*, SIAM, 586 pages
David Logan and William Wolesensky (2009), Mathematical Methods in Biology, Wiley

Tentative Course Outline (based on Edelstein-Keshet):

Week 1 Introduction: Why Model?; discrete time models for population dynamics, linear difference equations (Chapter 1)
Week 2 Introduction to nonlinear discrete dynamical systems: graphical analysis, fixed points, linear stability analysis, (possibly postpone for later:) bifurcation, chaotic dynamics, systems of difference equations (Chapter 2)
Week 3 Applications of nonlinear difference equations (Chapter 3)
Week 4 More discrete time models: host–parasitoid, age–structured models
Week 5 Introduction to continuous time models: logistic equation for single species population dynamics; some techniques for ordinary differential equations: equilibrium points, stability, linearization (Chapter 4)
Week 6 *Midterm exam 1*
Week 7 Introduction to continuous dynamical systems: geometric (phase plane) analysis of 2–dim systems, linear systems (Chaper 5)
Week 8 Nonlinear systems, linearization, periodic solutions (Chapter 5)
Week 9 Continuous time models for single species population dynamics: harvesting, metapopulations (patchy environments)
Week 10 Interacting populations: predator and prey models, competition, infectious disease models (Chapter 6)
Week 11 *Midterm exam 2*
Week 12 Biochemical kinetics (Chapter 7)
Week 13 Poincaré–Bendixon theory, oscillations in simplified nerve models (FitzHugh–Nagumo equations) (Chapter 8)

Week 14 Hopf bifurcations (Chapter 8)
Week 15 If time allows: Cable equation; introduction to partial differential equations: classification and boundary conditions
Week 16 If time allows: Introduction to reaction–diffusion equations, traveling wave solutions (Chapter 10)

Optional Lab: Student's interested in working for the Certificate in Mathematical Biology must sign up for the optional concurrent one credit lab, which will consist of studying a programming language such as Matlab (determined by the Instructor) and completing a modeling project. Other Math 304 students may enroll in the lab if they wish. The lab will be taught as Math 304L; contact the Instructor to enroll in the lab. The modeling project will consist of choosing a model to study either from a published research paper or an extension of a model in a textbook; simulating the model, and reproducing the basic results from the paper (textbook). In addition, students will formulate a question that is not fully addressed in the paper, and modify the model to study it, or extend the analysis of the behavior of the model beyond that of the paper. A more open–ended project that requires formulation of a new model is also possible. Students will be required to turn in a written report on their project.

Student learning objectives

Upon successful completion of Math 304, the student will be able to use difference and differential equations to construct models for change in various scientific fields, and to mathematically analyze these models to predict behavior.

Program objectives

Math 304 is a junior level course in deterministic modeling, which is an important subject in the application of mathematics to all fields of science. This course promotes our goal that our students learn, understand, and be able to apply several mathematical topics at the junior and senior level, and that our students acquire the ability and skills to apply mathematics to other fields. The approach emphasizes computation and application over theory. The course material is geared for both math and science students, so fulfills a service role as well as part of our major program.