# MATH 5131: Mathematical Modeling Summer II 2020

In this course classical differential equations will be used to model the evolution of processes involving growth and decay, interacting species, and heat transfer. Examples will be drawn from current case studies, and will cover topics such as population dynamics, drug assimilation, epidemics, the spread of pollutants in environmental systems, competing species, and heat conduction. This course serves as both a required course for the MS in Applied Math, and as a capstone in the undergraduate math program.

INSTRUCTOR: Prof. Nate Bade, 539 Lake, e-mail: n.bade@northeastern.edu

OFFICE HOURS: By appointment, or on the forum.

TEXT: Barnes and Fulford, Mathematical Modeling with Case Studies

TOPICS:

* Compartmental Models
* Growth and Decay of a Single Population
* Interacting Populations
* The Phase Plane, Linear and Non-Linear Analysis
* Extended Population Models
* Heat and Thermal Conduction Models
* Traffic Flow Modeling

LECTURES: MW 1:00 - 4:00 EST on Zoom. Lectures will be recorded and available through both Zoom and YouTube.

ASSIGNMENTS: There will be an assignment each week (some homework’s, some labs) to be turned in by Sunday Evening at 12:00 PM. There will also be a final project

GRADING:

* Weekly Assignments: 70%
* Final Project: 30%

There will be no final exam for this course.

Weekly Schedule (Tentative):

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| Week 1 | 6/28-7/4 | Introduction to Modeling. Constructing models for Radio Carbon Dating, Waterborne Pollution, Population Density and Population Control. Mathematics of first order single variables ODEs. Logistic equation.  *Assignment: Homework 1.*  *Readings: Barnes & Fulford: Chapters 2-3* |
| Week 2 | 7/5-7/11 | Autonomous Differential Equations and their phase spaces. Chemical Kinetics and Drug Transport. The mathematics of systems of linear equations.  *Assignment: Lab 1 – Simulating ODE’s with Python.*  *Readings: Barnes & Fulford: Chapters 5*  *Handout: Linear Algebra and Differential Equations* |
| Week 3 | 7/12-7/18 | Fully classifying first order systems of linear equations. Systems of nonlinear autonomous ODEs. Competition and epidemic models.  *Assignment: Lab 2 – Systems of ODE’s with Python.*  *Readings: Barnes & Fulford: Chapters 7* |
| Week 4 | 7/19-7/25 | Predator-prey equations. Advanced non-linear systems and phase portrait analysis. Classifying model behaviors within parameter space.  *Assignment: Lab 3 – Phase Planes with Python.*  *Readings: Barnes & Fulford: Chapters 6, 8* |
| Week 5 | 7/26-8/1 | Heat transfer and special differential equations. Diffusion and conduction. The heat equation and PDEs. Lake model revisited and the method of characters.  *Assignment*: *HW 2: Spacial Systems of ODEs*  *Readings: Barnes & Fulford: Chapters 9-12*  *Handouts: Brownian Motion and the Heat Equation* |
| Week 6 | 8/2-8/8 | Traffic flow and shockwaves: new behavior that comes from PDEs.  Handouts: Traffic Flow and Shockwaves |
| Week 7 | 8/9-8/15 | Finish PDES. Final Projects and Presentations. |
| Week 8 | 8/16-8/22 | Exam Week (No class, presentation overflow). |