Department of Mathematics, UAB
Mathematical Modeling
MA361-2E

Instructor: Dr Ian Knowles, Room 4024, University Hall.
Email: iknowles@uab.edu
Class Meetings: TuTh: 2:00–3:15pm, HHB221.
Office Hours. After class; you may also email to arrange for additional office or Zoom meetings.
My Zoom Meeting Number: 367-980-5688
Reference Texts. My lecture notes; download these from Canvas. *Modeling Life* by Alan Garfinkel, Jane Shevetsov, and Yina Guo, Springer International Publishing AG 2017.
Prerequisite Course. MA168, or MA125, or MA225.
Term Dates. First day of classes: Mon Jan 12, 2026. MLK Holiday: Mon Jan 19, 2026. Spring Break: Mar 9–15, 2026. Last class day: Friday April 24, 2026.

SageMath Software. Access to the SageMath software package is needed for this course. This package may be freely downloaded from the website `https://github.com/3-manifolds/Sage_macOS/releases` (this is a "live" URL). For Apple silicon Macs, download the package `SageMath-10.8_arm64.dmg` and install (be sure to install the package `Recommended_10_8.pkg` when asked); use `SageMath-10.8_x86_64.dmg` for older intel Macs. Go to the alternate website `https://github.com/flatsurf/sage-flatsurf/releases/` (also a "live" URL) and download and execute the binary `sage-flatsurf-0.8.0.exe` to install SageMath on a Windows machine.

Aside from the machines located in our classroom HHB221, additional Mac computers with SageMath installed are available in the Math Learning Lab in HHB202 (ask at the entrance desk). Free access to SageMath is also available online via the CoCalc website located at `https://cocalc.com` (another "live" URL).

SageMath is a computer algebra system with features covering many aspects of mathematics, including calculus, statistics, numerical analysis, and algebra. Together with the web-browser-based Jupyter Notebook this software contains much of the functionality of the commercially available packages Mathematica, Maple, and Matlab and uses a similar command set to the popular programming language Python whose syntax you will naturally acquire as you use SageMath. Please note that you will develop the necessary programming skills during the course, and in particular no prior computer skills are assumed at the beginning.

Syllabus. In this course we use mathematical modeling as a tool for understanding how biological and physical systems evolve over time. We consider the biology and physics of a variety of problems that arise in nature, science and medicine, and first review then build upon the calculus ideas already developed in the prerequisite course, adding additional mathematical tools as needed to facilitate the solution of these problems.

The new mathematics includes an introduction to the dynamics of linear and nonlinear systems of differential equations, mathematical chaos in biological systems, introductory linear algebra (matrices, eigenvalues, eigenvectors) and its use in determining the stability of equilibrium points, thereby providing a mathematical underpinning for homeostasis, and introductory multivariable calculus (Taylor series, partial differentiation, Jacobians and linear approximation). Biological topics include single species and interacting population dynamics, modeling infectious and dynamic diseases, regulation of cell function, and biological oscillators. There will also be discussions of current topics of interest such as loss of chaos and its connection to cardiac arrhythmias, and how dynamically stable limit cycles relate to neuron action potentials.

The overall focus of the course is to use the math to help us understand the science.

Aims of the Course. Upon successful completion of the course a student can

- describe the dynamics in practical systems and the different types of behaviors of complex systems including those involving steady-states, oscillations, and mathematical chaos, and their relationship to homeostasis, the central organizing principle of physiology, and understand the causes of these behaviors, including the effects of delay, and positive and negative feedback;
- explain how the variables in each term in the differential equations arise from practical observations and assumptions;
- translate a verbal description of interacting variables into a differential equation model of a dynamical system, using the concepts of state space and tangent space;
- simulate differential equation models using SageMath;
- relate mathematical chaos and cardiac arrhythmias;
- use eigenvalues and eigenvectors to investigate the long term behavior of linear models in black bear populations;
- use Jacobians to analyze the stability of equilibrium states in nonlinear models such as the model for the neuron action potential and the related model for the pacemaker neuron.

Lab/Homework File Submission. For each Homework assignment you are required to submit a **single** *.pdf file in Canvas on or before the due time. It is recommended that you download each assignment pdf file from Canvas to a tablet (such as an iPad) work on it in the tablet, and then upload the completed pdf file back to Canvas. Paper homework sheets can also be scanned using a mobile scanning app such as Adobe Scan. In the latter case, be sure to combine the scanned sheets into one pdf file before submission.

Likewise, for each Lab assignment you need to submit the completed *.ipynb file in Canvas on or before the due time.

Grading. There will be approximately one homework assignment and one computer lab assignment each week; collectively the homework assignments and the labs will each constitute 50% of the course grade. Your final grade is determined from your course grade out of 100 by following table:

Course Grade:	88-100	75-87	62-74	50-61	below 50
Final Grade:	A	B	C	D	F

Class Schedule

Week	Tuesday	Thursday
01/12 – 01/16	First Class/Lab 1	
01/19 – 01/23	MLK Holiday	HW1
01/26 – 01/30	Lab 2/Lab 1 due	HW2/HW1 due
02/02 – 02/06	Lab 3/Lab 2 due	HW3/HW2 due
02/09 – 02/13	Lab 4/Lab 3 due	HW4/HW3 due
02/16 – 02/20	Lab 5/Lab 4 due	HW5/HW4 due
02/23 – 02/27	Lab 6/Lab 5 due	HW6/HW5 due
03/02 – 03/06	Lab 6 due	HW6 due
03/09 – 03/13	Spring Break	
03/16 – 03/20	Lab 7	HW7
03/23 – 03/27	Lab 8/Lab 7 due	HW8/HW7 due
03/30 – 04/03	Lab 9/Lab 8 due	HW9/HW8 due
04/06 – 04/10	Lab 10/Lab 9 due	HW10/ HW9 due
04/13 – 04/17	Lab 10 due	HW10 due
04/20 – 04/24		Last Class
04/27 – 05/01	No Final Exam in this Course	

Reference Material. The text, *Modeling Life* by Alan Garfinkel, Jane Shevetsov, and Yina Guo, Springer International Publishing (2017) is useful inter alia as a supplementary reference if you seek more than is in my lecture notes. There is no formal text for the Lab component of the course, which we will do as an in-class/homework activity. Regular class attendance, while not mandatory, is highly recommended for this reason. For SageMath, online documentation is available, but of course you should never hesitate to ask me if you have code problems.