Department of Mathematics, UAB
Mathematical Modeling
MA361-2A Spring 2024

Instructor: Dr Ian Knowles, Room 4024, University Hall.
Email: iknowles@uab.edu
Class Meeting Times: TuTh: 08:00 – 09:15, HHB 221.
Office Hours. Let me know after class: we can meet in my office; you may also email to arrange for additional office or Zoom meetings.
Textbook. None: we use my lecture notes; download these from Canvas.
Prerequisite Course. Calculus I (MA125), or permission of instructor.
Term Dates. First day of classes: Monday January 08, 2024.
Martin Luther King holiday: Monday January 15, 2024.
March 10–16: Spring Break.
Last day of classes: Friday April 19, 2024.
SageMath Software. Access to the SAGEMATH software package is needed for this course. This package may be freely downloaded from the SageMath website `https://www.sagemath.org/` (this is a "live" URL), with available binaries for Mac and Linux, and installation via WSL for Windows, that may be obtained by clicking the download button DOWNLOAD 10.1 on this website. Aside from the machines located in our classroom HHB221, additional Mac computers with SageMath installed are available in the Math Learning Lab in HHB202. Free access to SageMath is also available online via the COCALC website located at `https://cocalc.com` (also a "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, while you will develop the necessary programming skills during the course, no prior computer skills are assumed at the beginning of the course.

Grading. There will be approximately one written Homework assignment and one computer Lab assignment per week; these collectively will constitute 100% of the course grade. There are no other written examinations in this course. Your final grade is determined from your course grade according to the following table:

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

Homework/Lab File Submission. For each Homework assignment you should submit a **single *.pdf file** in Canvas on or before the due time. The easiest way to produce the requisite pdf file is to write directly on the downloaded homework pdf file (obtained from the Canvas directory `Files/Assignments` by scrolling down to the bottom of the left menu) using a tablet computer (such as an iPad). Alternately, hand-written paper homework sheets can be scanned to a single pdf file using a mobile scanning app such as Adobe Scan.

For each Lab you should download the appropriate *.ipynb lab file from the `Files/Computer Labs` directory (located by scrolling down to the bottom of the left menu in Canvas), work on it inside SageMath, and then submit the completed *.ipynb file in Canvas on or before the due time.

Syllabus. In the course we teach mathematical modeling as a tool for predicting the long-term behaviour (dynamics) of physical and biological systems. We begin with models of dynamical processes occurring in physics, chemistry, biology, ecology, physiology, and other applications in which quantities change with time. In the lab session parts of each class, we will often run prepackaged computer programs for problem-solving, visualization, plotting and simulation. Basic programming concepts like program flow control and data structures are introduced as needed.

Class Schedule.

Week	Tuesday	Thursday
01/08 − 01/12	First Class/Lab 1	HW1
01/15 − 01/19	Lab 2/Lab 1 due	HW2/HW1 due
01/22 − 01/26	Lab 3/Lab 2 due	HW3/HW2 due
01/29 − 02/02	Lab 4/Lab 3 due	HW4/HW3 due
02/05 − 02/09	Lab 5/Lab 4 due	HW5/HW4 due
02/12 − 02/16	Lab 6/Lab 5 due	HW6/HW5 due
02/19 − 02/23	Lab 7/Lab 6 due	HW7/HW6 due
02/26 − 03/01	Lab 8/Lab 7 due	HW8/HW7 due
03/04 − 03/08	Lab 8 due	HW8 due
03/11 − 03/15	Spring Break	
03/18 − 03/22	Lab 9	HW9
03/25 − 03/29	Lab 10/Lab 9 due	HW10/HW9 due
04/01 − 04/05	Lab 11/Lab10 due	HW11/HW10 due
04/08 − 04/12	Lab 11 due	HW11 due
04/15 − 04/19		Last Class
04/22 − 04/26	UAB Spring Final Exam Week	

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 steady-states and oscillations, and their causes 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 Euler's method by hand and via PYTHON or SAGEMATH;
- understand the meaning of the terms point attractor, periodic attractor, and chaotic attractor for a dynamical system;
- derive models of systems that exhibit bi-stability or switch-like behavior using the concept of bifurcation.

Reference Material. As mentioned above, there is no prescribed textbook for this course. The book *Modeling Life* by Alan Garfinkel, Jane Shevetsov, and Yina Guo, Springer International Publishing (2017) is useful as a supplementary reference if you seek more than is in my notes. Likewise, there is no text for the Lab component of the course, which we will do as an in-class/homework activity. Regular class attendance is highly recommended for this reason. For SAGEMATH and PYTHON, the online documentation is quite good and of course you should never hesitate to ask me if your code is not behaving properly.