Department of Mathematics, UAB
Mathematical Modeling
MA361/519-OW Summer 2022

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Class Meeting Times: TuTh: 12:40 – 2:40pm.
Office Hours. After class in my office; you may also email to arrange for additional office or Zoom meetings.
My Zoom Meeting Number: 367-980-5688
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 June 06, 2022. Independence Day: Monday July 04, 2022. Last day of classes: Friday August 05, 2022.

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, Linux, and Windows that may be obtained by clicking the download button Download 9.5 on this website. The Mac machines in HHB221 have this software already installed for use during class. SageMath is a computer algebra system with features covering many aspects of mathematics, including calculus, statistics, numerical analysis, algebra, combinatorics, graph theory, and number theory, 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 modeling 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

Lab/Homework File Submission. For each Homework and Lab assignment you are required to submit a **single *.pdf file** in Canvas on or before the due time. Paper homework sheets can be scanned to a single pdf file using a mobile scanning app such as Adobe Scan, for example.

Syllabus. In the course we teach mathematical modeling as a tool for understanding the 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 will be introduced when needed. Please note that no background in computer programming is required for this course.

As we proceed you will notice that the process of modeling involves rewriting real-world problems in mathematical terms so as to facilitate their solution. Inevitably, in pursuing these ends one must bump into the fundamentally powerful ideas and techniques of Calculus, but for us this will not happen right away. Rather, we use the model problems themselves to uncover the need to use Calculus, and thereby obtain a deeper understanding of both.

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 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;
- derive models of systems that exhibit bi-stability or switch-like behavior using the concept of positive feedback;

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 either me or KJ if your code is not behaving properly.