MA 168 - 6C – Mathematics of Biological Systems I

UAB Department of Mathematics - Spring 2024

Instructor: Dr. Tricia Phillips
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Class Time: MW 12:20-2:10pm (Heritage Hall 221)
Office Hours: M 2:30-3:30, W 3:30-4:30, R 12:30-1:30, or by appointment
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Class Materials:

- Course notes: available on Canvas.
- Textbook: *Modeling Life* by Alan Garfinkel, Jane Shevetsov, and Yina Guo, Springer International Publishing AG 2017.
- SageMath Software: access required. Free package download from https://www.sagemath.org/ by clicking Install 10.1, with available binaries for Mac and Linux, and installation via WSL for Windows. Mac laptops with SageMath installed are available for use in our classroom, as well as Heritage Hall 202 (Math Learning Lab). Access is also available online via https://cocalc.com but should be used as a last resort since it is not as reliable.

Course Description: (4 semester hours). The course teaches mathematical modeling as a tool for understanding the dynamics of biological systems. We will begin with the fundamental concepts of single-variable calculus, and then develop single- and multi-variable differential equation models of dynamical processes in ecology, physiology, and other applications in which quantities change with time. The laboratory will run prepackaged computer programs for problem-solving, visualization, plotting and simulation. Basic programming concepts like program flow control and data structures will be introduced. No background in computer programming is required. This course meets Blazer Core Quantitative Literacy.
Prerequisite: MA 106 (min grade C), MA 107 (min grade C), MPL 70, A02 29, or SAT2 680.

Note: As we proceed in this course, 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 will bump into the fundamentally powerful ideas, techniques, and notations of Calculus, but for us this will not happen right away. Rather, we use the modeling 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.

Learning Outcomes: Upon successful completion of this course, a student will be able to:

- 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 on a computer via SageMath;
- understand the meaning of the terms point attractor, periodic attractor, and chaotic attractor for a dynamical system insofar as they relate to homeostasis and dynamical stability in biological systems;
- derive models of biological systems that exhibit switch-like behavior using the concept of positive feedback; use negative feedback to model the neuron as an excitable oscillatory dynamical system;
- use chaos and dynamical system trajectories formed from electrocardio-graph (ECG) data to investigate heart arrhythmias; and
- identify and utilize tools of quantitative reasoning to solve problems that impact academic understanding and public life.

  In addition to developing specific mathematical skills, these learning outcomes promote students' development of quantitative literacy, critical & analytical thinking, data-driven decision-making, excellent communication skills, and lifelong learning and reasoning skills.

Grades

Grade Components: All grades will be posted on Canvas.

Assignment	Percent
Attendance	4
Labs	16
Homework	20
Midterm Review	15
Midterm Exam	15
Final Review	15
Final Exam	15

Final Grades: The final grade for this course will be assigned using the following scale:

Total Points	88-100	75-87	62-74	50-61	0-50
Letter Grade	A	B	C	D	F

Assignment Descriptions

Attendance:

Attendance for class sessions is required to be able to interact with the instructor and peers to thoroughly learn concepts and meet learning objectives.

Labs:

Lab assignments will be available on Canvas and are due Mondays by 11:59pm on Canvas by submitting one .ipynb file. Collaboration with classmates is encouraged for deeper understanding of the material but each student is responsible for their own work and individual submissions.

Homework:

Homework assignments will be available on Canvas and are due on Wednesdays at the beginning

of class on their due dates by handing in a paper copy. You may write directly on the homework assignment .pdf with a tablet and print it off or you may print out the homework assignment to write on it. Collaboration with classmates is encouraged for deeper understanding of the material but each student is responsible for their own work and individual submissions.

Midterm Review (Group):
Each student will be assigned to a group to work on a set of midterm review problems together. The group will then submit one paper copy containing their mutually agreed upon solutions at the beginning of class on the due date. This will be graded before the Midterm Exam.

Midterm Exam (Individual):
The Midterm Exam will be an in-class, individually written exam based upon the review problems previously worked out and provided feedback on.

Final Review (Group):
Each student will be assigned to a group to work on a set of final review problems together. The group will then submit one paper copy containing their mutually agreed upon solutions at the beginning of class on the due date. This will be graded before the Final Exam.

Final Exam (Individual):
The Final Exam is cumulative and will be an in-class, individually written exam based upon the review problems previously worked out and provided feedback on.

Class Policies & Student Expectations
Class Preparation:
I expect you to show respect to the instructor and classmates by putting away distracting items such as cell phones and coursework not related to our class. During group work, I expect everyone to contribute to the discussion (if you don't know how to answer the question, then *ask* a question). You may collaborate on homework and labs and I hope you will learn from one another and benefit from working together. However, it is imperative that you *understand* any work you submit and are able to solve problems on your own.

Make-up Policy:
There are no make-ups for assignments and no late submissions are accepted. If a student has an unplanned, emergency circumstance that temporarily prevents them from participating in the class (such as a documented hospitalization or mandated isolation for Covid-19), then the instructor should be contacted to discuss.

Instructor Support - Emails & Office Hours:
I will respond to your emails as promptly as possible (usually within 24 hours, except on weekends). If you email me after 5pm, expect a response the next day unless it is over the weekend in which case I will respond the beginning of the following week. Please check your email and Canvas course regularly for announcements and updated class documents. Students are expected to check their UAB email daily and respond within 24 hours to instructor emails (with the exception of weekends). All students are required to obtain and use the UAB email address that is automatically assigned to them as UAB students, as official correspondence will be sent ONLY to your @UAB.edu email address.

During office hours, you may drop by without making an appointment to receive assistance on

any assignment or programming. For SageMath and Python, online documentation is available for support, as well.

AI Tools:
The use of AI tools is strictly prohibited in this course. Academic misconduct is present in an academic work wherever AI assistance has been used when unauthorized. Such behavior is considered deceit and a violation of UAB's shared commitment to truth and academic integrity. Deceit constitutes academic misconduct and is subject to review according to UAB's Academic Integrity Code. The developments around AI are in flux and the rules that are expressed in this syllabus are subject to change on short notice.

Success Tips:
Hard work goes a long way and the more effort you put in, the more understanding you will have – that includes coming to class on time, fully participating in the activities of the day, and spending 8-12 hours each week outside of class on course material. Actively participating in class dialogue, rather than simply observing, is essential for understanding. Most importantly, ask questions – inside the classroom, in office hours, or over email. The earlier on you ask questions, the better, since concepts in mathematics build upon each other. Although you are responsible for your own learning, I encourage you to communicate with me so I know best how to help you succeed. I offer the following pieces of advice for your consideration:

- Review notes and do math every day.
- Actively participate in class every day.
- Help each other.
- Go to office hours.
- Analyze and understand your mistakes.
- Ask plenty of questions.
- Don't let yourself get behind.
- Go to the Math Learning Lab.

UAB Policies & Resources:

Math Learning Lab (MLL):
Located in Heritage Hall 202, the MLL offers in-person tutoring (no appointment needed). Tutors will not help with graded assignments, solve all of your problems, or work with you for extended periods of time, but they will help guide you so that you can complete your work independently. Be sure to bring your class materials with you. The MLL is open Monday-Friday from the first day of class to the last day of class. Tutoring is not available during holidays, breaks, and Final Exam week. No food or drink is allowed except bottled water.

University Academic Success Center (UASC):
The UASC provides students with a host of free services and resources that include Tutoring and Supplemental Instruction. For more information, click here.

Academic Misconduct:
The University of Alabama at Birmingham expects all members of its academic community to function according to the highest ethical and professional standards. It will be important that you review and become familiar with the University's Academic Integrity Code found here.

Disability Support Services Accessibility Statement:
UAB is committed to providing an accessible learning experience for all students. If you are a student with a disability that qualifies under the Americans with Disabilities Act (ADA) and Section 504 of the Rehabilitation Act, and you require accommodations, please contact Disability Support Services for information on accommodations, registration, and procedures.

Requests for reasonable accommodations involve an interactive process and consist of a collaborative effort among the student, DSS, faculty, and staff.

If you are registered with Disability Support Services, please contact them to discuss accommodations that may be necessary in this course. If you have a disability but have not contacted Disability Support Services, please call (205) 934-4205, visit their website, or visit their office located in Hill Student Center Suite 409.

Title IX Statement:
UAB is committed to providing an environment that is free from sexual misconduct, which includes gender-based assault, harassment, exploitation, dating and domestic violence, stalking, as well as discrimination based on sex, sexual orientation, gender identity, and gender expression. If you have experienced any of the aforementioned conduct we encourage you to report the incident through one of several avenues for reporting. For more information about Title IX, policy, reporting, protections, resources and supports, please visit the UAB Title IX webpage for UAB's Title IX, UAB's Equal Opportunity, Anti-Harassment, Duty to Report, and Non-Retaliation policies.

Note: The course syllabus and schedule serve as a contract by which the student must comply. The syllabus and schedule are subject to changes through announcements made in class and/or email.

Tentative Schedule

Date	In-Class	Assignment Due
M: Jan 8	Course Intro, 1.1, SageMath Download	
W: Jan 10	Lab 1, 1.2	
M: Jan 15	*Martin Luther King Jr. Day - No Classes*	
T: Jan 16		*Last Day to Drop/Add*
W: Jan 17	1.2, Lab 2	
M: Jan 22	1.3	Lab 1
W: Jan 24	1.4	Homework 1
M: Jan 29	1.5, 1.6, 1.7	Lab 2
W: Jan 31	Lab 3	Homework 2
M: Feb 5	2.1	
W: Feb 7	2.2, 2.3, Lab 4	
M: Feb 12	2.1.4, 2.1.5, 2.1.6	Lab 3
W: Feb 14	2.1.6	Homework 3
M: Feb 19	Midterm Review	Lab 4
W: Feb 21	2.5	Homework 4
M: Feb 26	2.6	Midterm Review
W: Feb 28	2.6	
M: Mar 4	Midterm Exam	
W: Mar 6	Lab 5	
Mar 11-17	*Spring Break - No Classes*	
M: Mar 18	3.1, 3.2	Lab 5
W: Mar 20	Lab 6	Homework 5
F: Mar 22		*Last Day to Withdraw ("W")*
M: Mar 25	3.3	Lab 6
W: Mar 27	Lab 7	Homework 6
M: Apr 1	4.1, 4.4	Lab 7
W: Apr 3	Lab 8	Homework 7
M: Apr 8	Final Review	Lab 8
W: Apr 10	Final Review	Homework 8
M: Apr 15	Final Review	
W: Apr 17	Final Review	Final Review
R: Apr 18		
W: Apr 24	Final Exam @ 10:45-1:15pm	