Introduction to Mathematical Modeling

Why Teach Mathematical Modeling?

For most people, the value of mathematics lies in applications, and modeling is one of the most useful applications of mathematics. One may model using mathematical equations, spreadsheets, computer simulations, or physical replicas. Not all forms of modeling are applicable to all problems, but each *validated* model gives insight into how the system under study works. Introduction to Mathematical Modeling is a mathematics course making extensive use of the computer in which students engage in explorations and lab activities designed to strengthen and expand their knowledge of the topics found in "elementary" mathematics (through Calculus 1). Students collect data and explore a variety of situations that can be modeled using linear, exponential, polynomial, rational, and trigonometric functions. Activities are designed to have them take a second, deeper look at topics they have been exposed to previously; illuminate the connections between secondary and college mathematics; illustrate good, as opposed to poor, sometimes counter-productive, uses of technology in teaching and learning; illuminate the connections between various areas of mathematics; and engage in serious (i.e., non-routine) problem solving, problem-based learning, and applications of mathematics.

Instructional Personnel and Contact Information

Dr. John Mayer – Instructor	UH 4022	jcmayer@uab.edu	934-2154	By appointment
Mr. Cameron Hale – Teaching Assistant	HHB 221	n3on@uab.edu	934-2154	W 4:20-5:30, F 2:30-4:00
Math Department	UH 4005	(leave message)	934-2154	M-F 8AM-5PM

Class Meetings

Class meetings will be held Tuesday/Thursday, 11:00 AM -12:15 PM in HHB 221, the Mathematics Computational Lab, and occasionally (announced the class meeting before) in a Physics lab in Campbell Hall. Additional assisted lab time will be held in HHB 221. New material will be presented, and handouts and assignments distributed, in class meetings and on CANVAS. Moreover, students will be following along using the computer software during some of the class meeting, working in groups, and engaging in whole-class discussion (called "**processing**"). The additional reserved hours of computer lab (tba) are available for working on assignments and projects; during this time our modeling teaching assistant (Mr. Hale) will be present to answer questions and to provide assistance. You may also use the lab during other open hours (when a class is not present). Weekly open lab hours will be posted outside the lab. (Additional lab hours without assistance are in HHB 202.)

Software

We will use *Microsoft* EXCEL, *Wolfram* MATHEMATICA, and *isee Systems* STELLA. Your personal copies of EXCEL and MATHEMATICA can be obtained from UAB-IT at no cost. A student copy of STELLA (Stella Professional) can be purchased from *isee systems*.

Computer Lab

The only computer labs that have STELLA installed are HHB 221 and HHB 202. You should **always** bring a thumb drive to the lab in order to **save your work** (**frequently**). Information left on the lab computers may be erased overnight (or whenever the computer is used by someone other than you).

Material to be Covered

We will cover the following topics, using the computer software indicated.

- Functions, rates and patterns involving real numbers, using MATHEMATICA, EXCEL, and STELLA.
- Exploring the concept of *feedback* in a system using STELLA.
- Regression and modeling, using EXCEL.
- Exploring functions in other number systems (e.g., complex numbers), using MATHEMATICA.
- Final project, using MATHEMATICA, EXCEL, or STELLA.

There is no formal textbook for the course, but there will be many handouts of assignments and instructions distributed in class. It is recommended that you secure your own copies of the software, if you have a computer at home or, better yet, a portable. You may bring your own computer to the lab. The mathematics behind the models will be discussed, assuming knowledge of algebra and functions (including linear functions, polynomials, rational functions, and exponential functions), differential calculus (limits, derivatives as rates of change, and linear approximation), and the definition and interpretation of the integral (as an accumulator and as area under a curve).

Assignments. This is an inquiry-based course. Therefore, nearly all assignments will begin in class with you working with other students in a group. Groups are assigned by the instructor. Between one class and the next there will always be an assignment to be done before the next class. This component of your grade will count 120 points. You may discuss assignments with other students in the class, as well as with the instructional personnel, and you may work together with other students on the computer. If two (no more!) students work on an assignment together, you may turn in a single "partnership" assignment with two names. However, you are responsible for learning the material, and you will be expected to perform on your own, particularly on tests and the final project, described below. You will have the opportunity to present your work or that of your group in class as part of participation in processing (see below).

Course Grades. Students earn their grade in the course as determined in the tables below. How each grade component is determined is described in the paragraphs that follow. Points accumulated will be recorded in CANVAS. Important due dates will be listed in CANVAS calendar. Recall that a grade of **D** cannot count toward the mathematics major.

Grade Element	Points
Tests/Quizzes	50-100
Participation	80
Assignments	120
Final Project	100-150
Total	400

Points Earned	Course Grade
350 points	A
300 points	B
250 points	C
200 points	D
Below 200 points	F

Learning Outcomes. Students will

1. Demonstrate ability to use Mathematica, Excel, and Stella to model dynamical systems.
2. Articulate functions, rates, and patterns involving real numbers used in modeling situations.
3. Articulate understanding of functions involving complex numbers.
4. Articulate understanding of the linear regression process and of fitting polynomial trendlines to data, in general.
5. Articulate understanding of feedback in systems that evolve over time.
6. Articulate the mathematics behind the modeling software.

Participation. You are expected to participate actively, particularly in small group work and class processing discussions. Mere presence does not constitute ACTIVE participation. Participation points are awarded as in the following table. Note that it is possible to earn MORE than 80 points total for the semester since we will have about 29 class meetings. Points earned beyond 80 are extra credit. Priority in presenting goes to students with the fewest points.

Level of Participation	Points
Be present in class	1
Make minimal presentation or contribute meaningfully to class/group discussion	2
Contribute significantly to class discussion	3
Make good presentation (substantially correct)	4
Make excellent presentation (completely correct)	5

Midterm Tests and Quizzes. There will be two tests, one at about 7 weeks and another during the final exam period, focused on determining whether or not you have learned independently to use the tools and to understand the basic building blocks relevant to the kinds of models we are constructing. The tests will be given in the computer lab. Even if you work with colleagues on assignments, it is vital that you learn to "drive" the computer yourself. You will have NO partner on the tests. The tests will also include questions designed to determine if you understand the mathematics and logic behind the computer models. There will be a few unannounced quizzes. This component of your work will count 50-100 points, whichever is better for your cumulative grade.

Final Projects. About midway through the course you will be provided with a list of several potential modeling stories, describing realistic situations to be modeled. You may also propose a project of your own design. This is intended to be independent work. You may discuss your project with other students, but you will still be expected to produce an independently constructed model and written report. You may NOT work jointly. (This is a fine line – be professional.) You will turn in a copy of your working model at least three weeks before the project due date (to be announced), for a preliminary evaluation. We will discuss your model with you promptly. Subsequently, you will revise it, if needed, and write a 5-10 page technical paper (plus Appendices) describing your model, following a Technical Paper Template we will provide. We will also give you a copy of the Scoring Guides we will use to grade your model and paper. This component will count 100-150 points, whichever is better for your cumulative grade.

Make-up policy. There are no make-up quizzes or make-ups for absence resulting in decreased credit. If you miss a class for a verifiable emergency, necessary medical appointment, or on UAB official business, the instructor will work with you to find an accommodation. Since participation, particularly in class discussion, is a very important part of the course, repeated unexcused absences (or late arrivals) beyond 25% of the class meetings cannot be tolerated for any reason, and will result in a grade of F for the course.

Withdrawal. You are expected to be aware of official UAB withdrawal policies:

https://www.uab.edu/students/one-stop/classes/add-drop-and-withdrawal-policy

Student Conduct Codes. You are expected to be aware of, and rigorously adhere to, the UAB codes of conduct with regard to academic honesty and inter-personal relations.
http://www.uab.edu/policies/content/Pages/UAB-UC-POL-0000781.aspx

Disability Support Services
DSS offers tutoring and special accommodations to students who qualify:
https://www.uab.edu/students/disability/
The UAB DSS office is located at Hill Student Center, Suite 409, telephone: (205) 934-4205, e-mail: **dss@uab.edu**. Students who have DSS-approved accommodations should see the instructor privately for further information.

Scoring Rubic (10 Point Scale)

	Conceptual Understanding: *Interpreting the concepts of the task and translating them into mathematics* *(Identifying the "core" of the problem)*	**Evidence Of Problem Solving:** *The use of task-appropriate tools and problem solving strategies.*	**Explanation:** *Using verbal reasoning and appropriate constructions to best convey the solution.* *(The explanation flows smoothly.)*	**Accuracy:** *Providing a wholly justified solution for the task at hand.*
3			Explanation is coherent, and the ideas involved follow logically from previously stated ones.	The solution is completely justified, with no gaps in the argument.
2	Student's work has demonstrated that he/she has fully identified the major concepts of the task.	The student's work has demonstrated the strategic use of all task-appropriate tools and problem solving methods.	Explanation is not sufficiently rigorous or something may not immediately follow from what is written.	The solution has one or two minor gaps in justification.
1	Some, but not all, of the major concepts needed were evident.	Not all tools needed for the task are used or the tools are not used in a manner appropriate for solving the problem.	Explanation has multiple gaps or multiple steps need to be inferred.	The solution has major gaps in the justification.
0	Does not achieve minimal requirements for 1 point	Does not achieve minimal requirements for 1 point	Does not achieve minimal requirements for 1 point	Does not achieve minimal requirements for 1 point

This rubric is applied to assignments and test and quiz questions. There is a separate rubric for the Final Modeling Project.

Rules for Groups

1. Each member takes responsibility for his/her own learning.
2. Each member of the group is willing to help every other group member <u>who asks for help</u>.
3. Groups may ask the teacher for help only when <u>all</u> group members have the same question.
4. There is always a further challenge.

These rules apply during all small group discussions. Whole group discussions require adherence to the standard rule of classroom engagement: speak and listen respectfully.