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. Though we will look briefly at curve fitting and the use of spreadsheets, our main focus will be on System Dynamics Modeling. System Dynamics is the quantitative study of the actual causal structures and typical behaviors (causes, effects, and feedback loops) underlying system actions. The underlying mathematics is difference equations and ordinary differential equations (but you don't need to know that to get started).

Instructional Personnel and Contact Information

Dr. John Mayer	CH 490A	mayer@math.uab.edu	934-2154	TBA
Robert Cusimano	CH 478B	rob5236@uab.edu	934-2154	MW 4:00 – 6:45 PM
Martin Kendrick	CH 457	mkgrad@uab.edu	934-2154	MW 5:15 – 8:00 PM
Math Department	CH 452	(leave message)	934-2154	M-F 8AM-5PM

Class Meetings

Lectures will be given Monday/Wednesday, 5:30 – 6:45 PM in CB15 112, the Mathematics Computer Lab. Additional assisted lab time will be held Monday/Wednesday, 4:00 – 5:30 PM and 6:45 – 8:00 PM, in CB15 112. New material will be presented, and handouts and assignments distributed, in lectures. Moreover, students will be following along using the computer software during much of the lectures. The additional reserved hours of computer lab are available for working on assignments and projects; during this time teaching assistants (Mr. Cusimano and Mr. Kendrick) 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.

Software

We will use *Microsoft* EXCEL and *High Performance Systems* STELLA. If you prefer to work at home, student versions are available (bookstore for EXCEL and online at www.iseesystems.com for STELLA). The version of STELLA in our lab is 8.0.

Computer Lab

The only computer labs that have STELLA installed are CB15 112 and EDUC 149A. You should **always** bring a formatted 3.5 inch diskette to the lab in order to **save your work** (**frequently**). The disk should be labeled "Math Modeling, Spring, 2006, Your Name, Math Phone Number: 934-2154" so that if you misplace it, it will likely find its way back to you. Information left on the lab computers will be erased automatically overnight (and whenever the computer is restarted).

Material to be Covered

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

1. Elements of data analysis, principally curve fitting, using EXCEL.
2. Recurrence Relations and Difference Equations, using EXCEL.
3. Introduction to System Dynamics, using STELLA, including
    a. Simple population models.
    b. Generic processes.
4. Introduction to Cellular Automata, using EXCEL.
    a. Simple Averaging Automaton and the Morteville Story
5. Applications of System Dynamics, using STELLA, including
    a. Advanced population models, including overshoot and collapse.
    b. Epidemological models, including variations on the SIR algorithm – a small group activity.
    c. Predator-Prey – an in-class group activity.
    d. Drug assimilation (pharmacokinetic) models.
6. System Dynamics Stories (guided projects), using STELLA.

There is no textbook for the course. (A reference is Douglas Mooney and Randall Swift, *A Course in Mathematical Modeling*, Mathematical Association of America , 1999). Worksheets, which may be printed out, will be available online (http://www.math.uab.edu/mayer/MA261Sp06.html), or in class. 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.

Assignments

There will be one or two assignments made every week. These will almost always involve computer work and written work. Written work must be neat and in complete sentences, as learning to communicate mathematics and science effectively is one of the aims of the course. Written mathematical work must show all steps. Computer printouts should be limited to those expressly requested or clearly needed. Producing piles of paper is not the goal.

The first few assignments will have two due dates: assignments turned in by the first due date will be marked and returned by the next meeting. They may be corrected and turned in again by the second due date, at which point an improved grade may be earned. Of course, you can wait until the second due date to turn in the assignment for the first time, but why deprive yourself of the opportunity to earn a better grade? Assignments turned in after the second due date will be severely downgraded, if graded at all. After the first few assignments, double-grading will cease and assignments will be graded only once.

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, except with advance permission) 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 major project.

Midterm Tests

There will be two midterm tests, at about 5 week intervals, 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 midterm 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 help on the tests. The midterm tests will include both "process" and "knowledge" questions, including questions designed to determine if you understand the mathematics and logic behind the computer models.

System Dynamics Stories and Projects

About midway through the course you will be provided with a list of several "System Dynamics Stories," scenarios describing realistic situations to be modeled. Each story provides all the data required for the model. The model will be developed in stages, called "Problems," with testing and validation of the model at each stage. 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 independent written report. You may not work jointly. (This is a fine line – be professional.)

You will turn in answers to the System Story Problems and a copy of your **working** model at least three weeks before the **project due date (to be announced)**, for a preliminary evaluation and model scoring. We will discuss your model with you promptly. Subsequently, you will revise the model, 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, and a rating of the difficulty of each Story, which will be taken into account in grading your model and paper.

Grading

Students taking the course under different course numbers will be subject to different expectations, appropriate to the level of the course designation and catalog description.

Students registered for MA 261: the final grade for the course will be based 40% on assignments, 15% on each midterm test, and 30% on a System Dynamics Project (10% model plus 20% report) modeling one of the System Dynamics Stories provided.

Students registered for MA 419: the final grade for the course will be based 30% on assignments, 15% on each midterm test, 30% on a System Dynamics Project (10% model plus 20% report), and 10%

on a lesson plan describing how one might use the model in a high school or middle school class (lesson plan form provided).

Students registered for MA 519: the final grade for the course will be based 30% on assignments, 12.5% on each midterm test, 10% on one System Dynamics Project model only, 25% on a second, complete Systems Dynamics Project (10% model plus 15% report), and 10% on a lesson plan describing how one might use either model in a high school or middle school class (lesson plan form provided).

There is no final exam; the System Dynamics Project serves in its stead. Work turned in on the Project must be entirely your own. Students are not permitted to work jointly on a Project.

Withdrawal

The usual rules apply for withdrawing from the course. Note that undergraduate and graduate students have different withdrawal deadline dates.