

Math 319: Math Modeling

Fall Semester 2008

Basic Information

Note: this syllabus is temporary, and may change up to the first day of class.

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General Description

Math Modeling is the art of taking a real-world problem and stating it in mathematical terms. It often involves making simplifying assumptions. In our class, we get in the habit of doing all the parts of the math modeling cycle: modeling, solving, checking, and guessing. Often, a large part of the problem is even deciding which problem to solve. For example, should you find the best schedule for your staff at one location, or consider opening new locations? Should you start with a theoretical model then match it to data, or just model the data directly? We will also consider a lot of common mathematical models, and explore their properties.

Course Catalog Entry

The modeling process; model building and evaluation, techniques of modeling; model fitting and models requiring optimization; empirical model construction---experimental models, dimensional analysis, simulation models, dynamic models; use of derivatives in the modeling process, single and multivariable dynamic models.

Prerequisites

Math 120 and Math 122.

Some experience using Excel, VBA, Mathematica, Maple, or Matlab will also be VERY helpful, but it is not strictly a prerequisite.

Follow-up courses: Math 325 Differential Equations, Math 418 Modeling with Linear Algebra, Math 419 Advanced Math Modeling (stochastics), Math 425 Math for Scientists, Math 436 Numerical Analysis

Class Meetings

Mon, Wed, Fri 1:00pm - 1:50 in Pray-Harrold 402, though Fridays we will often be in P-H 503

"Final Exam" schedule: Mon, Dec. 15, 1:00-2:30pm

CRN 13783, 3 credit hours.

Class meetings will be mostly interactive lectures, with some time to work on problems in class, and some time to discuss homework.

Instructor information

Professor Andrew Ross

Pray-Harrold 515b

andrew.ross@emich.edu

<http://people.emich.edu/aross15>

(734) 487-1064, but I strongly prefer e-mail instead of phone contact.

Math department main office: Pray-Harrold 515, (734) 487-1444

Office Hours and other help

Office Hours: tentatively

- M/W/F 8:30-8:55am
- M/W/F 11:00-11:30am
- M/W/F 12:30-12:55pm
- M/W/F 2:00-2:30pm

I am also happy to make appointments if you cannot come to the general office hours. Please send me e-mail to arrange an appointment.

I am definitely unavailable during the times I teach other classes:

- M/W/F 9:00- 9:50pm
- M/W/F 10:00-10:50pm

The Mathematics Student Services Center (or "Math Lab") is also here to help you, in Pray-Harrold 220. Their hours for Fall 2007 were:

- Monday through Thursday 9am to 7pm
- Friday 10am to 2pm

Please give them a call at 734-487-0983 or just drop by.

Many assignments in this course will be in the form of papers, which I want to be well written. Please consult with [The Writing Center](#) for help in tuning up your writing.

(not-absolutely-)Required materials

Most students do well in this course without a textbook. For those who feel the need to have one just in case, I suggest "A First Course in Mathematical Modeling", 3rd or 4th Edition, by Giordano, Weir, and Fox.

A lot of our work will be done on computers, specifically in Excel. If you had been waiting for a good reason to buy a laptop, this is it.

Course Web Pages

I will post data files, homework assignment files, etc. on [my home page](#).

We will use the [WebCT system](#) to keep track of grades. You are expected to keep an eye on your scores using the system, and get extra help if your scores indicate the need.

Supplementary Materials

Here is a list of books that I have found interesting and related to math modeling. Perhaps some of them will strike your fancy, too. I own the ones that are starred (*) and can lend them to you. Others you will have to find at the library or on the usual Internet booksellers. Links are given to Amazon, but I do not specifically endorse them or any particular bookseller. Of course, if you like a book you can see what similar books the online bookseller recommends.

- *[Towing Icebergs, Falling Dominoes, and Other Adventures in Applied Mathematics](#) by Robert B. Banks, and its sequel:
- *[Slicing Pizzas, Racing Turtles, and Further Adventures in Applied Mathematics](#) by Robert B. Banks
- [Race car vehicle dynamics](#) by William F. Milliken, Douglas L. Milliken
- [Going Faster: Mastering the Art of Race Driving](#) by Carl Lopez
- [Logistics Systems Analysis](#) by Carlos Daganzo
- [The nature of mathematical modeling](#) by Neil Gershenfeld

Other Stuff:

- Microsoft Excel, or other spreadsheet software
- Mathematica, Maple, or Matlab
- Numb3rs

Course Content

Course Goals

Our primary goal is to teach you to be a good (or great!) math modeler. To be a good modeler, you need:

- Good habits and procedures, just like a scientist, and
- Knowledge of common math models.

We have a few secondary goals, which may be more or less applicable to your personal situation:

- Get enough people together to form a few teams for the [Math Contest in Modeling \(MCM\)](#), mid-February, 2009. I participated in this 3 times as an undergrad and had a lot of fun.
- Give future teachers some great ideas to show your kids how high-power math is used in the real world. You may enjoy reading [Meaningful Math](#).
- Give computer-science students lots of interesting things to program. You may like reading this blog entry about [math for programmers](#).
- Get everyone using Mathematica, Maple, or Matlab/SciLab.
- Teach you how to communicate your math models by writing math papers and giving math presentations.

Student Outcomes

By the end of the course, students will be able to:

- (General modeling skills):
 - categorize problems into operational/tactical/strategic categories,
 - identify nearby problems in the oper./tact./strat. hierarchy,
 - evaluate models by constructing simple test cases,
 - select the most important variables to start modeling with,
- (Empirical modeling skills):
 - use ordinary, semilog, and loglog plots to evaluate relationships in data sets,
 - perform linear regression in software,
 - interpret the correlation coefficient,
 - perform transformations before regression as appropriate,
 - fit a function to data using nonlinear regression, e.g. sine waves
- (Communication skills):
 - write a technical report,
 - differentiate between literature of varying quality, e.g. peer-reviewed vs. working paper vs. white paper vs. web site,
 - design appropriate figures to communicate models and results,
- (Optimization skills):
 - Formulate non-linear programs (NLP) as appropriate,
 - solve NLP using software,
 - describe the (im)possibility of multiple optimal solutions (convexity/concavity)
 - formulate linear programs (LP) as appropriate,
 - solve LP using software,
 - describe the nature of LP solutions,
 - identify common LP models: network flow, diet/blending, inventory, minimax, assignment,

Homework papers should be submitted on-line, where they may be checked by [TurnItIn.com](https://www.turnitin.com) or a similar service. This is partly to help keep you honest, and partly to help you learn acceptable ways to cite the work of others. A side benefit is that sometimes TurnItIn finds papers relevant to your work that you would not have found otherwise!

Exams

There will be no exams, unless the class demonstrates an unwillingness to be motivated any other way.

Projects

Instead of a mid-term and a final exam, you will do a mid-term and a final project. Your results will be reported in a paper and a presentation to the class. You may work by yourself or in a team of 2 people, but no groups larger than 2 will be allowed. You may switch project partners at your will. Your project grades will each be split something like this:

- 10 pct: proposal
- 80 pct: work and written report
- 10 pct: presentation

The final presentations will be made during the time slot reserved for the final exam.

On average, students should spend a total of about 30 minutes in office hours discussing the project. Plan for this in advance!

Overall Grades

No scores will be dropped, unless a valid medical excuse with evidence is given. In the unfortunate event of a medical need, the appropriate grade or grades will be dropped entirely, rather than giving a make-up. You are highly encouraged to still complete the relevant assignments and consult with me during office hours to ensure you know the material.

Your final score will be computed as follows:

- 50 percent for all the homework together,
- 20 percent for the mid-term project, and
- 30 percent for the final project.

Final percentage scores will be given letter grades as follows:

- 92.0 and above : A
- 88.0 to 92.0: A-
- 84.0 to 88.0: B+
- 80.0 to 84.0: B
- 76.0 to 80.0: B-
- 72.0 to 76.0: C+, etc.

General Caveat

The instructor reserves the right to make changes to this syllabus throughout the semester. Notification will be given in class or by e-mail or both. If you miss class, it is your responsibility to find out about syllabus and schedule changes, especially the due dates and times of projects, assignments, or presentations.

Advice from Other Math Modeling Students

In the last two semesters, I've asked my math modeling students to give advice to you, future math modeling students, based on their experiences in my course. Here are some of the highlights:

- * work in groups * start the first day assignment is given * don't take too many credits w/ this class * ask a lot of questions * utilize Dr. Ross
- Do go to his office hours more than you normally would; if you have a question ask don't wait.
- See Prof. Ross in office hours and don't be afraid to email him. He is usually very helpful and approachable.
- Plan on visiting Prof. Ross during office hours in order to do well in the class. You will learn a lot in the end, but be ready to work.
- [prof ross:] add a note to the syllabus stating something to the effect of, "This class will not be like other math classes. Instead of straight-up problems or proofs, the biggest amount of work will be setting up the models, exercises, etc. and in analysing what your results mean. It will not be the mathematical work done to obtain the results that is the tricky part." But word the note better.
- attend the office hours Prof Ross is really good at explaining & helping out with the homework
- **WORK TOGETHER!**
- Take notes during the computer lab days and send yourself the excel sheets.
- Go to class. The computer lab days help even if you know excel well.
- Go to class. Go to office hours and pick project that you're energized about and interested in even if they're harder. It will make this math class the best one you've ever taken.

Schedule

Date	PC Lab?	Category	Description
03-Sep		modeling	First Day of Class
05-Sep		modeling	What Is a Math Model?
08-Sep		modeling	Modeling Procedures; oper/tact/strat; rental car gas problem
10-Sep		modeling	more modeling, Graph/Net terminology, writing tips, publication types
12-Sep	Yes	other	Excel intro, incl. plotting
15-Sep	Yes	fitting	Exploratory Data Analysis (EDA), plotting in Excel
17-Sep		fitting	model fitting, Linear Regression
19-Sep	Yes	fitting	Correl. Coeff.
22-Sep		fitting	Semilog and Log-Log
24-Sep		fitting	time-of-day/week/year modeling
26-Sep	Yes	fitting	Multiple Linear Regression, polynomial regression, non-linear regression
29-Sep		fitting	Lagrange Polynomials, Splines
01-Oct		stochastics	Simulation (Ch 5)
03-Oct	Yes	stochastics	Queueing
06-Oct		stochastics	Queueing
08-Oct		LP	Linear Programming (Ch 7)
10-Oct	Yes	LP	LP in Excel
13-Oct		LP	LP: feasible, infeasible, optimal; transportation, assignment
15-Oct		IP	Integer Programming: basic, and sneaky;
17-Oct	Yes	IP	IP: Fixed-Charge
20-Oct		NLP	Non-Linear Programming (Ch 13): economies/diseconomies of scale
22-Oct		NLP	unconstrained NLP: L2 facility location, regression
24-Oct	Yes	NLP	protein folding movie, minimize concave down gives many local minima, solution is jumpy
27-Oct		NLP	LP/IP/NLP loose ends
29-Oct		other	writing tips/presentation tips/flex-time
31-Oct		presentations	projects due;Project Presentations
03-Nov		presentations	Project Presentations
05-Nov		presentations	Project Presentations
07-Nov		other	Graph applications (TSP, Min Spanning Tree, PERT)
10-Nov		DS	Dynamical Systems
12-Nov		DS	Rent-to-own, drug dosing, transient/equilibrium
14-Nov	Yes	DS	equilibrium, stability, Newton's Law of Cooling, Limited Growth
17-Nov		DS	multivariate dynamical systems, 2-state DTMC
19-Nov		DS	multivariate equilibrium, 3-state DTMC
21-Nov	Yes	DS	lab day
24-Nov		other	Dimensional Analysis (Ch 8)

26-Nov		no class (Thanksgiving break)
28-Nov		no class (Thanksgiving break)
01-Dec	DE	Differential Equations (Ch 11+)
03-Dec	DE	Differential Equations
05-Dec	Yes DE	Differential Equations
08-Dec	DE	Differential Equations
10-Dec	other	course overview; last day of class
12-Dec		no class--other classes having finals
15-Dec	presentations	projects due;Final Presentations

Standard University Policies

Religious Holy Days

I support students' right to observe religious holidays without penalty. To the best of my ability, I will schedule exams to not conflict with major religions' holidays. Students are to provide advance notice to the instructor in order to make up work, including examinations that they miss as a result of their absence from class due to observance of religious holidays. If satisfactory arrangements cannot be made, the student may appeal to the head of the department.

Academic Honesty

Academic dishonesty, including all forms of cheating and/or plagiarism, will not be tolerated in this class. Penalties for an act of academic dishonesty may range from receiving a failing grade for a particular assignment to receiving a failing grade for the entire course. In addition, you may be referred to the Office of Student Judicial Services for discipline that can result in either a suspension or permanent dismissal. The Student Conduct Code contains detailed definitions of what constitutes academic dishonesty, but if you are not sure about whether something you're doing would be considered academic dishonesty, consult with the instructor.

Classroom Behavior

Students are expected to abide by the Student Conduct Code and assist in creating an environment that is conducive to learning and protects the rights of all members of the University community. Incivility and disruptive behavior will not be tolerated and may result in a request to leave class and referral to the Office of Student Judicial Services (SJS) for discipline. Examples of inappropriate classroom conduct include repeatedly arriving late to class, using a cellular telephone, or talking while others are speaking. You may access the Code online at www.emich.edu/sjs.

Special Needs Accommodations

If you wish to be accommodated for your disability, EMU Board of Regents policy #8.3 requires that you first register with the [Access Services Office \(ASO\)](#) in room 203 King Hall. You may contact ASO by telephone at (734) 487-2470. Students with disabilities are encouraged to register with ASO promptly as you will only be accommodated from the date you register with them forward. No retroactive accommodations are possible.

Student and Exchange VISitors (SEVIS)

The Student Exchange Visitor Information System (SEVIS) requires F and J students to report the following to the [Office of International Students](#), 229 King Hall within ten (10) days of the event:

- Changes in your name, local address, major field of study, or source of funding.
- Changes in your degree-completion date
- Changes in your degree-level (ex. Bachelors to Masters)
- Intent to transfer to another school

Prior permission from OIS is needed for the following:

- Dropping ALL courses as well as carrying or dropping BELOW minimum credit hours
- Employment on or off-campus
- Registering for more than one ONLINE course per term (F-visa only)
- Endorsing I-20 or DS-2019 for re-entry into the USA

Failure to report may result in the termination of your SEVIS record and even arrest and deportation. If you have questions or concerns, contact the OIS at 487-3116, not your instructor. Also, see the [EMU SEVIS page](#).