Mathematical Modeling
Math 450, Section 001
Spring 2017

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MATH 450 Through the semester we will introduce mathematical modeling, i.e., the use of mathematical ideas and tools and the construction of mathematical equations and formulations to study the natural world. Particular emphasis will be placed on open-ended problems: the process of creating a mathematical model from a physical, biological, or social science scenario. We will focus on some of the heuristic, intuitive, and systematic mathematical approaches used in making models. Once a model has been developed, we will use a combination of analysis and computational experimentation to determine its properties and relevance - and to make predictions (while solution techniques will be discussed, they are not the emphasis of the course). Often the first modeling attempt is unsatisfactory; it may not adequately explain observations, or its predictions are not borne out... so we go back and tweak the model or start from scratch! It is the goal of this course to engage you in this cycle.

Prerequisites: MATH 315 and MATH 430 or MATH 405 or MATH 412.
Practically speaking: You'll need some calculus, matrix algebra, differential equations. A little programming wouldn't hurt.

Textbook: No required textbook, we'll be drawing material from a number of sources. However there are a few recommended textbooks that will offer alternative perspectives on the material and may improve your understanding:

- "Mathematics for dynamic modeling," 2nd Ed., by Edward Beltrami
- "An introduction to mathematical modeling" by Edward A. Bender
- "A first course in mathematical modeling" by Frank R. Giordano, William P. Fox, Steven B. Horton, and Maurice D. Weir
- "Topics in mathematical modeling" by K. K. Tung

These books will be placed on reserve at the library. In addition, "A primer on scientific programming with python" by Hans Langtangen provides a good resource for python programming.

Software: Some of the homework will require programming. No prior experience with programming is required, you'll learn everything you need as we go along.

This course will incorporate computer programming of models using the python computer language. Python is a free and widely used language, so the skills you gain with it will be valuable long after you leave PSU. We will be using Canopy (https://www.enthought.com/products/canopy/), which is free for academic use, available for Windows, Mac, and Linux platforms, and encapsulates all the standard python modules for easy install. Download, install, and try it out, first chance you get.

Note: You are not required to use python; if you're already more comfortable with another language used for scientific programming, such as Matlab or C, you are permitted to use that for your homework (and project).

Course format: There are three 50-minute lectures each week.

Electronic aides: NO calculators, cell phones, tablets, smart watches, <insert device here>, are allowed on the midterm, or on the final examination.

Examinations: There will be one comprehensive final exam.

Final examination: The final examination will be given during the week of May 1 - May 5, 2017. Students may access their final exam schedules after February 13, through their lionpath accounts. Notification of conflicts is given on the student's final exam schedule. A student must take action to request a conflict exam through lionpath between February 13 and March 5. Conflict final examinations cannot be scheduled through Dr. Conway or the mathematics department.

Drop/add: Students may add/drop a course without academic penalty within the first ten calendar days of the semester. For the Spring 2017 semester, the deadline to drop a class is January 14 at 11:59 p.m., and the deadline to add a class is January 15 at 11:59 p.m.

Late drop: Students may add/drop a course without academic penalty within the first ten calendar days of the semester. A student may late drop a course within the first twelve weeks of the semester but will accrue late drop credits equal to the number of credits in the dropped course. A baccalaureate student is limited to 16 late drop credits. The late drop deadline for the Spring semester 2017 is April 7, 2017.

Evaluation: Your final grade will be calculated over a total of 100 points, distributed as follows: Quizzes & Participation (10%), Homework (50%), Project (15%), and Final exam (25%). Grades will be assigned out of 100 points as follows:

93-100,	A	83-87,	B	70-77,	C
90-93,	A-	80-83,	B-	60-70,	D
87-90,	B+	77-80,	C+	0-60,	F

Deferred grades: Students who are currently passing a course but are unable to complete the course due to illness or emergency may be granted a deferred grade which will allow the student to complete the course within ten weeks of the last day of classes. Note that deferred grades are limited to those students who can verify and document a valid reason for not being able to take the final examination. For more information see http://handbook.psu.edu/content/deferred-grade.

Homework: There will be 8-10 homework assignments. You may work together but each student must submit an individual homework assignment, written in their own words. **Late home work will NOT be accepted.**

Students are encouraged to type up their homework assignment. LaTeX is an excellent option; LyX (http://www.lyx.org/) is a nice LaTeX front-end.

Reading & Quizzes: Through the semester we will read commentaries, historical perspectives, and philosophical discussions on applied mathematics and mathematical modeling. The aim is to expand your knowledge and understanding of the applications of mathematics. There will be in-class discussion, in addition to occasional reading quizzes to make sure you're on top of the reading. Quizzes will be announced ahead of time.

Project: You will be assigned a final modeling project; evaluation for the final project will include meeting interim deadlines (e.g. outline), peer review participation, report and a 15 minute final presentation in the last weeks of class. Final project problems will be along the lines of the problems in the "Mathematical Contest in Modeling" (https://www.comap.com/undergraduate/contests/mcm/previous-contests.php), although not all problems there will be projects, and there may be others available. We will begin discussing final projects towards the end of February.

Academic Integrity: Collaboration on exams is **not permitted**. All Penn State Policies (http://www.psu.edu/ufs/policies/) regarding ethics and honorable behavior apply to this course.

Students with Disabilities: Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Office for Disability Services (ODS) Web site provides contact information for every Penn State campus: http://equity.psu.edu/ods/dcl. For further information, please visit the Office for Disability Services Web site: http://equity.psu.edu/ods.

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: http://equity.psu.edu/ods/doc-guidelines. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. You must follow this process for every semester that you request accommodations.

Important dates: Please see http://registrar.psu.edu/academic_calendar/spring17.cfm for important dates including holidays and administrative deadlines.

Questions, Concerns, or Comments: If you have questions or concerns about the course, please consult Dr. Conway first. If further guidance is needed, you may contact Dr J. Sellers (`jxs27@psu.edu`), the Director for Undergraduate Study.

Rough topics overview

We will aim to discuss these topics, but other interesting nuggets may also pop up!

- Linear regression and scaling laws
- Dimensional analysis
- Geometric methods
- Mechanics, Newton's laws
- Differential equations modeling and data
- Probability modeling - probabilistic geometry, Markov chains, Zipf's law, Master equations
- Spatial modeling - lattice models, cellular automata
- Difference equation modeling and chaos
- Modeling problems: age of the earth, global climate, lubrication theory, decision processes