

# SPRING, 2016

## Math 450. Mathematical Modeling

**When and Where:** Mon., Wed., and Fr., 11:15 - 12:05 pm, 173 Willard

**Course Web page:** <http://www.math.psu.edu/treluga/450>

**Instructor:** Timothy Reluga, [treluga@math.psu.edu](mailto:treluga@math.psu.edu)

**Office:** 424 McAllister

**Office hours:** Monday, 1:30-2:30 or by appointment.

### Course Description:

The purpose of the course is to introduce mathematical modeling, i.e., the construction of mathematical structures to describe parts of our world. The course will explore mathematical ideas and tools used to study the natural world. Particular emphasis will be placed on open-ended problems, the process of creating a mathematical model starting from a physical, biological, or social scenarios, and then developing the associated mathematical theory. While solution-techniques will be discussed, they are not the emphasis of the course. We will also be reading Nate Silver's "Signal and Noise" as part of a conversation about the philosophy and role of mathematical modeling.

**Prerequisite:** MATH 220 or MATH 250. (calculus, matrix algebra, elementary differential equations, and maybe a little programming)

**Grading:** Grades will be awarded based on regular homework assignments (50%), class presentations (20%), quizzes and class participation (10%), and a final exam (20%). Course grades will be assigned out of 100 points as follows:

A 100-95 A- 95-90 B+ 90-87 B 87-83

B- 83-80 C+ 80-77 C 77-70 D 70-60 F 60-0

**Academic Integrity:** All Penn State and Eberly College of Science policies regarding academic integrity apply to this course. For details, see

<http://www.science.psu.edu/academic/Integrity/index.html>

**Required Textbooks:** The main text will be *Topics in mathematical modeling* by K. K. Tung. We will also be reading *Signal+Noise* by Nate Silver.

**Suggested Supplemental Textbooks:** For a reference on python and scientific programming, I suggest *A primer on scientific programming with python* by Hans Langtangen. You can find it online or through your favorite book store.

**Homework:** Homework's will generally consist of problem sets, and programming assignments. Problem sets will be collected on Wednesday's in class, and will be graded by me. Programming assignments should be submitted through the appropriate drop-box on Canvas (<https://psu.instructure.com/>)

**Presentations:** Students will be required to make three presentations during the course. The first presentation will be a 10 minute introduction to a python module, following our programming crash course. The second will be a 15 minutes research report on one of several current or historical conversations in applied mathematics. The third will be a 15 minute presentation at the end of the course on a modelling problem of your choice.

**Software:** No prior experience with programming is required -- we'll learn everything we need in-class as we go. 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 and encapsulates all the standard python modules for easy install. Download, install, and try it out, first chance you get.

### **Rough Course Outline:**

- Geometry and Symmetry
  - Descriptive Cartesian geometry
  - Climate modelling from scientific principles
  - Dimensional analysis
  - Can King Kong live? Log-log Least squares
- Differential equations
  - Optimality, hanging chain, functional calculus
  - Optics and mirror design by geometry
  - Mechanics, Newton's laws, 2-body problem
  - Fitting ODE's to data
- Probability
  - Probabilistic geometry
  - Markov chains and sports models
  - Zipf's law, Preferential attachment
  - Masters equations
- Simulations
  - Lattice models and Cellular automata
  - Introduction to agent based models
- Games and managing complex systems
  - Public policy and games
  - Policy design
- Extra stuff