Introduction to Mathematical Modeling, Fall 2018
MST-351/651

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Course Website: http://users.wfu.edu/gemmerj/math351-651.html
Office Hours: Tuesday 3-5, Wednesday 1-2, Thursday 2-4
Class Meeting Times: MWF 10:00-10:50
Class Location: Manchester Hall 245

Textbook:

1. *It's a Nonlinear World,* Richard Enns, 2011

Other Texts:

1. *Nonlinear Dynamics and Chaos 2nd Edition,* S.H. Strogatz, 2012
2. *Computational Mathematical Modeling,* Calvetti and Somersalo, 2013

Prerequisites: Linear algebra (MST 121), ordinary differential equations (MST 251). Basic topics from linear algebra and ordinary differential equations are essential. In addition, students should be comfortable with computer programming of numerical algorithms (MATLAB or Mathematica code usually).

Course Description: An introduction to mathematical modeling and modern techniques in the nonlinear analysis of ordinary and or partial differential equations. Specific mathematical topics covered include: dimensional analysis, one-dimensional flows, phase plane analysis, limit cycles, bifurcations and stability analysis. Additional topics covered at the discretion of the instructor can include, but are not limited to: hyperbolic conservation laws, reaction diffusion equations, Fourier analysis, traveling wave solutions to partial differential equations, chaotic dynamics, perturbation methods, calculus of variations. The emphasis of the course will be equal parts theory, mathematical modeling, and computational explorations. The theory will be presented within the context of applications drawn from areas such as population modeling, spread of infectious diseases, chemical kinetics, traffic modeling, collective behavior, as well as other topics from biology, chemistry and physics.

Course Rationale: Often the standard university curriculum presents mathematics as compartmentalized into topics such as calculus, linear algebra, differential equations etc. However, many "real world" problems are multi-faceted and require an interdisciplinary team of individuals to tackle. In such a group, the job of an applied mathematician is to synthesize techniques from various areas of mathematics to develop mathematical models that are on the one hand simple enough to analyze but on the other hand sufficiently sophisticated to capture the core principles of the problem. The purpose of this course is fourfold:

1. Students will learn elementary qualitative analysis of ordinary differential equations.
2. Students will learn the typical ways in which applied mathematicians approach practical applications, from understanding the underlying problem, creating a model, analyzing the model using mathematical techniques and numerical simulations, and finally interpreting the findings in terms of the original problem.

3. Students will learn critical thinking within the context of mathematics and science. In many typical mathematics courses students are taught to solve problems using standard techniques and there is usually a predetermined "correct" approach. In this course students will learn how to assemble basic assumptions to formulate their own solutions to problems and test the validity of their results based on the science of the problem. In this way the student will learn the critical skill of evaluating and reflecting on their own work.
4. Students will learn how to use numerical simulations of mathematical models to understand qualitative behavior of solutions, validate their models, and generate conjectures.

Course Delivery: The course material will be delivered through a combination of lectures and in class group assignments. Evaluation of the students understanding of the material will be assessed through written homework assignments, in-class exams, in-class quizzes, a semester project and a final exam.

Course Policies:

✦ **Grading:** Your grade will be based on:

- Weekly written homework: 10%
- Class Works: 5%
- Two in-class exams: 30% (15% each)
- Term paper proposal: 5%
- Term paper: 15%
- Final presentation: 5%
- Final Exam: 30%

You are guaranteed the following grades if your final percentage lies within the following ranges:

90-92.9: A-	**93-100: A**	
80-82.9: B-	**83-86.9: B**	**87-89.9: B+**
70-72.9: C-	**73-76.9: C**	**77-79.9: C+**
60-62.9: D-	**63-66.9: D**	**67-69.9: D+**

✦ **Written homework:** Written homework will be assigned most weeks on Thursday and will be due Friday at the beginning of class the following week. The assigned homework problems will be posted on the course website. Late homework will not be accepted under any circumstances. However, I will drop the lowest homework score from your grade. Written homework must consist of solutions that show all steps, be your own work and be written clearly using complete sentences as appropriate (see homework policy).

✦ **Group work:** Throughout the course there will be several unannounced "class works". These consist of structured group assignments that will be completed during class time. These assignments will generally be exploratory allowing students to learn a new concept through a "hands on" approach.

✦ **In-Class Exams:** There will be two in-class exams and a comprehensive final in the course.

✦ **Modeling Project:** A significant portion of the student's progress towards completion of the course goals will be evaluated through a modeling project. The project should apply techniques from this course to the student's field of interest. The student should select a research paper to read in detail, reproduce some of the results in the paper and produce results of their own by modifying or extending the paper. The project consists of a proposal, term paper and final presentation. The proposal should be a rough sketch of the topic the student has selected. The term paper should be written in the form of a research article with all mathematical details fully written out. The term paper should be written using a professional typesetting program such as LaTeX and the final presentation should done on a computer.

Tentative Course Schedule:
1. Introduction to nonlinear systems (2 weeks).
2. Phase plane analysis (2 weeks).
3. Bifurcations (2 weeks).
4. Limit Cycles (1-2 weeks).
5. Nonlinear maps (2-3 weeks).
6. Nonlinear partial differential equations (3 weeks).

Important Dates:
1. September 28: Exam 1.
2. November 2: Exam 2.

The Honor Code: At Wake Forest, we expect you to behave as honorable citizens of the class, the university, and the world as a whole. When you complete an assignment with your name on it, you are representing that everything you are turning in is your own work. That means that you do not copy from other students, textbooks, or websites. If at any time I become aware of cheating or plagiarism in this course, I will submit the information to the honor council.