Introduction to Mathematical Modeling, Fall 2015
APMA 0200

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Class Meeting Times: MWF: 10:00-10:50
Class Location: Salomon Center 202

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Office Hours: W: 4:00-5:00, TH: 11:00-12:00

Prerequisites: Single-variable calculus equivalent to **Math 0100.** All other techniques from differential equations, linear algebra, numerical methods, probability and statistics will be introduced in class.

Textbook: The course will be self-contained and all lectures will be supported by handwritten lecture notes posted on my website. Some material will be drawn from the **optional textbook:**

An introduction to mathematical modeling, Bender, Edward A. (2012).

This book was originally published in 1978 and as such is dated and in particular lacks emphasis on numerical methods. However, the book gives a concise, informative and interesting introduction to mathematical modeling and the gaps will be supplemented by my lecture notes.

Another book which you might find helpful for learning Matlab is the following concise book:

MATLAB guide, Higham, D. J., & Higham, N. J. (2005).

Course Description: This course provides an introduction to the mathematical modeling of selected biological, chemical, engineering, and physical processes through a series of case studies. This course will be project based with equal emphasis on problem identification and formulation, teamwork and the reporting of results in the form of written reports and oral presentations. Equal time in the course will be devoted to lectures and group projects.

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. One purpose of this course is for students to 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. A second but equally important purpose of this course is to introduce students to 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.

Course Goals: Upon completion of this course students will be able to do the following:

1. Develop and interpret mathematical models.
2. Analyze mathematical models using techniques from linear algebra, differential equations, probability, and statistics.
3. Use computational programs such as MATLAB to simulate mathematical models.
4. Read, write and orally present research in applied mathematics.
5. Critically reflect on the scientific merits and mathematical accuracy of their work.

Class Delivery: The course material will be delivered through an equal mixture of lectures on specific topics and group discussions. Group discussions are a core part of this course and consist of teams of students developing mathematical models with the assistance of the instructor. These models will then be analyzed by the students.

Course Policies:

✦ **Grading:**

Your grade will be based on:

- Weekly Homework: 25%
- Group Discussions: 5%
- Midterm: 10%
- Final Project: 40%
- Final Exam: 20%

✦ **Homework:**

Homework is an essential part of this course and should be taken seriously. Homework will be assigned most weeks on Wednesday and will be due Friday of the following week. The assigned homework problems will be posted on my website. Typically, homework assignments will be open ended in the sense that you will be asked to develop and analyze a mathematical model. Your solutions to these problems must be written in clear sentences that illustrate the methods you used to solve the problem. For an applied mathematician, being able express your thoughts in a way that can be understood by others outside of your field is an essential skill. By writing up your solutions to homework assignments you should present your work in a clear and organized fashion. In addition, writing solutions to problems will provide you with a deeper understanding of the concepts discussed in class.

✦ **In Class Group Discussions:**

Once a week teams of students will develop mathematical models of problems introduced by the instructor. These models will then be analyzed by the students. Evaluation of each student's performance will be based on participation, correctness of mathematics used, and interpretation of the models results in terms of the original application.

✦ **Exams:**
There will be one midterm and a comprehensive final in the course. All exams will be in-class.

✦ **Final Modeling Project:**
A significant portion of the student's progress towards completion of the course goals will be evaluated through a final group modeling project. The project will apply apply techniques from the course to a particular problem of interest. The complete project consists of a group term paper and a final group presentation. The term paper should be written using a professional typesetting program such as LaTeX and the final presentation should done on a computer. Sample LaTeX and presentations will be provided by the instructor. Past examples of projects include:

1. Modeling synchrony in complex networks.
2. Modeling the relationship between malaria and sickle cell anemia.
3. Modeling the spread of information.

List of Topics Covered:

1. Dimensional analysis and scaling (1 week).
2. Introduction to MATLAB (1 week).
3. Modeling population growth (2-3 weeks).
4. Modeling traffic flow (3-4 weeks).
5. Modeling the spread of infectious diseases (1-2 weeks).
6. Monte Carlo simulations (2 weeks).
7. Modeling uncontrolled arms races (1-2 weeks).

(The above topics are subject to change depending on students interests and instructor preference).

Important Dates:

1. October 14: Midterm exam.
2. December 2 and 4: Group presentations.
3. December 7: Group term paper due.
4. TBA: Final Exam