AMATH 383
Introduction to Continuous Modeling

Course Projects and Term Papers
Proposal Due Date: Oct. 24, 2003
Writing Credit Draft: Nov. 26, 2003
Final Project Due Date: Dec. 10, 2003

Course Projects

As part of this modeling course, you will develop a course project and write a term paper on that project. Your term paper is to be turned in on the last day of lectures. The research for the project may be done individually or collaboratively (in groups of two or three students). Every student, however, must write and turn in their very own written project report.

Please do not worry excessively about this project. I know that this is the first such project for many of you. This handout gives some pointers on how the proposal and term paper for this project should be structured. Please see the instructor if you have questions.

The purpose of the project is that you learn to tackle a mathematical modeling problem with the following features:

1. It should be a problem of interest to you that is fun to investigate.
2. The project should use mathematical techniques that you have studied in this class. You may need to learn about a class technique in greater depth. It is also fine if you use techniques that go beyond what we have done in class.
3. This should be a real modeling problem and not a cut-and-dried homework problem with pat answers. Ideally, you will need to decide what to consider or ignore, how to express the problem mathematically, and how to interpret the mathematical solution. **Creativity counts!**
4. It may (or may not) be necessary for you to collect or analyze some real data to build or test the model.
5. You will be expected to use the library to identify relevant references in books and journals for this project. You should also look at journals in the library to see how papers are formatted. Much useful information and data can also be found on the web. (However, there is also much nonsense out there. Remember that anyone can publish anything on the web and that the web is not subject to the usual editorial control of books or journals.)

The responsibility for finding a course project is yours, but we will be happy to give you feedback on ideas and some help in locating resources. We will also help to match people into groups, if necessary, but it is best if you can do this on your own.

Proposal

The purpose of the proposal is to ensure that students are beginning work on their projects. You should choose a topic of interest to you, and identify the quantities that are important to this topic. In addition, you should identify the interactions that you believe are significant to modeling. The proposal should state the problem on which you wish to work, the quantities involved, and the assumptions you are making. In addition, you should show some indication of how you plan to work on your project. The proposal needs to be type-written and double spaced.

University Writing Credit

You may use this term project as a way to fulfill a University writing credit. In order to obtain that credit, you must meet two additional course requirements. The first is that you must hand in a complete draft of your project report. The instructor will read the report and make suggestions for either corrections or for improvement. Then you incorporate these suggestions into your final draft. The second requirement is a minimum length requirement, in that the writing must consist of at least 10 pages.

Term Papers

The lengths of project papers will vary, but we are expecting that you will need 8 or 10 pages of double-spaced text to describe your project. You may also want to include figures, data, and/or computer programs. This means that we are talking about 10 to 20 pages. To get writing credit, you must have at least 10 pages worth of text, not counting graphs, figures or tables.

The formats of papers will also vary, but here are some key components of most papers:

1. **Abstract** This is a short overview of the paper, a miniature version of 100 words or so. Someone reading the abstract should get a good idea of what problem was tackled, what techniques were used, and what solution was found. Most professional papers start with an abstract. It is valuable for the potential reader, to help decide if the paper is of interest and, if so, to get an overview of the whole picture before starting to read the details.

2. **Problem description** Present the problem that you are attempting to solve. Give some background. Explain why it is important or interesting. Outline the questions that you would like to answer.

3. **Simplifications** You will probably need to simplify the problem in order to obtain a model that is appropriate for this project. Explain the ways in which you simplified the original problem and outline the assumptions that underlie these simplifications. Justify the assumptions, if possible, or discuss the limitations that are imposed on your model by your assumptions and simplifications.

4. **Mathematical model** How did you turn the simplified problem into a mathematical model? Is there a standard mathematical paradigm that you are using, e.g., calculus of variations or Newtonian mechanics? Or is it a problem of a different sort? How does it relate to standard problems? Define your variables, explain your notation, etc.

5. **Solution of the mathematical problem** What techniques did you use to solve the mathematical problem? Were you able to use standard techniques, e.g., linear analysis for differential equations? Did you need to develop a new analytical method and/or algorithm to solve the problem? Did you use a technique from the literature that we havent discussed in class? Explain in detail.

6. **Results** What did you conclude from your mathematical model? How are these results interpretable in terms of the original problem? Are the results reasonable? If not, what are the failings of the model that led to poor results? If your model is to diffi- cult to solve, is there some simpler model that still gives reasonable results?

7. **Improvements** How can you improve the model or solution technique so as to yield better results? How easy or difficult is it to implement these improvements.

8. **Conclusions** Summarize what you have done and what you have learned.

9. **References** Please include a bibliography if you have used any references, e.g., books, journal articles, web pages. Put a citation in the paper if you refer to a reference.

Please type the paper. You can use any word processing system that you like, and write in mathematical equations if necessary. Final term papers should be printed on paper and turned in at the last class of the quarter. Do not (!) email me term papers to look at unless you can email them as compact PDF files or as plain ascii text.

I will keep the final copy of your project. Please be sure to xerox your final project (before turning it in) if you want to keep a copy.

Students often ask for more guidance in selecting a term project. Sometimes they ask to know what other students have done in the past. Many students select projects that have at least some relationship to the material that we directly discuss in class. This is often a good idea on where to look for ideas, but it then becomes important that you extend what we did in class rather than just copy the course development. The following list collects some thoughts and warnings I'd offer based on past projects. Please don't assume that projects must relate to this list, however.

1. Traffic Flow Problems

   - What are some possible situations that arise? (Congestion, starting, stopping)
   - Do you model individual vehicles, traffic density or some other measure?
   - Some really interesting questions are best analyzed using tools we might only discuss during the last week of class. Get some advance help.
   - What question are you asking? Is a differential equation appropriate? (If not, change the question.)

2. Population Problems (including competition and predator-prey)

   - Caution! Simple models that mirror the development in class do not fare well unless they add a significant development. This may be by introducing a new type of interaction not already discussed (but it must be justified by the modeler and not just proposed as an interesting mathematical exercise).

- Try to put in context of real system (although you should not always necessary).

3. Combat Models

   - Attempt to fit historical data to a simple model (we will look at Battle of Iwo Jima as an example).
     - Needs reasonably detailed data about army sizes, and over extended time
     - It may be appealing to try current events, but do we need to address change in combat styles?
   - Computer games – be sure that a differential equation is appropriate. Make some effort to test the model.

4. Epidemics and Spread of Disease

   - Need to be careful about what is the surrounding population: world, city, nation, peer group
   - How is disease spread? Are simple assumptions reasonable?
   - Be careful of how you use data. Let the model do the work, and use the data to estimate parameters.
   - Estimating parameters may be analogous to combat models and what we do with Iwo Jima.

5. Finances

   - We will discuss dealing with interest and deposits/withdrawals in class. Projects involving money need to involve more than just these principles.
   - A popular request is to model something like the stock market. This is quite problematic as the growth law for stocks is not deterministic but involves random fluctuations. This is outside the scope of the course. But if a student wanted to explore simulations of such a problem, they might talk with me on how to proceed.
   - If you want to study finances, you might try to look at other money-related interactions than just investment.