THE UNIVERSITY OF IOWA

Introduction to Mathematics Research

A Survey of Applied Mathematics

Documentation and Evaluation

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Fall 2007

Introduction to Mathematics Research
A Survey of Applied Mathematics
22M:096
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Esprit de Course

Introduction to Mathematical Research provides an opportunity for undergraduate students to gain experience working with a variety of areas relating to current mathematical research interests. The 'applied mathematics' section of this class introduces five different applied topics through the course of one semester. Students learn how to build mathematical models from fundamental principles, such as conservation laws, and implement their models for computational simulation.

Our goal in developing this course is to provide students with hands-on experience using mathematics. To this end, we created a modular course structure, divided into 5 three-week modules. Within each module, we allot time for lecture, discussion, and computer lab work. By presenting materials in different forums and challenging the student to implement their models, we attempt to engage students and encourage a deeper understanding of the material.

This course was designed to be administered by one faculty member and two graduate student assistants. The faculty role is intended to be primarily supervisory, while the roles of the graduate students involve lecturing, leading discussions, and preparing and grading homework assignments. Additionally, the graduate students are encouraged to design and develop modules in areas of their own interest. This structure is beneficial for several reasons:

- Three instructors can provide a broad range of mathematical expertise and alternate viewpoints.
- Pairing an advanced 'senior' graduate with a 'junior' creates a 'master-apprentice' framework for course continuation.
- Graduate students gain valuable upper-level teaching experience.
- Faculty gains direct interaction with advanced undergraduate students interested in further mathematical study without the pressure of a full course load.

Part I. Course Proposal and Development

Official Course Proposal

We propose an undergraduate level applied mathematics course focusing on the development, implementation, critique, and analysis of mathematical models. This course is intended to be listed under the title "22M:096 – Introduction to Mathematics Research" and run opposite to the existing course of the same title.

This course is intended for undergraduate students with a strong background in calculus, specifically those students having earned an A or B in Calculus II. We feel that the applied nature of this course will appeal to a variety of students. As such, we expect this course to generate interest from students in mathematics, engineering, and the natural sciences.

Under our proposal, the course would be run by a supervising faculty member and two graduate students. Two additional graduate students may observe/assist with the goal of running the following year's course. Additional teaching and mentorship support can come from an advanced undergraduate student who has previously taken the course.

We believe that such a course would benefit the department by filling an existing void in the departmental curriculum, providing upper level teaching experience for graduate students, and encouraging students in math related fields to pursue a math major or minor. Furthermore, we feel that the proposed course structure allows for mentorship opportunities between all levels of mathematicians:

- Professorial/Graduate Instructor—course development and administration
- Graduate Instructor/Graduate Trainee—course development and administration
- Graduate Instructor/Undergraduate student—offer perspective on research opportunities in applied mathematics
- Undergraduate RA/Undergraduate student—former students may serve as RA for course, offering undergraduate perspective

We suggest that this course run during the fall semester of each school year. This avoids conflict with the existing pure math undergraduate research course, which is offered during spring semesters. In addition, by offering the course in the fall, we create an opportunity for summer training of future course managers and development of new curriculum modules.

Course Description

Introduction to Mathematics Research (22M: 096) explores how mathematics is currently being used to interpret and solve real-world problems. The one-semester course is composed of five independent modules, each focused on the development, implementation, critique, and analysis of a model relating to a particular area of current research interest. For example, previous topics covered in one semester were: collisions, subsurface fluid flow, traffic flow, epidemiology, and financial option pricing. Despite substantial differences in subject material, each module is approached using the same methodology. A typical three-week module is presented in the following manner:

1. Motivation for understanding and solving the problem
    a. Determine parameters of importance.
    b. Establish appropriate assumptions.
    c. Agree upon significant output values.

2. Mathematical formulation
    a. Derive a governing equation.
    b. Introduce a technique for solving the equation.
    c. Develop an implementation plan (create the model).

3. Model assessment and reassessment
    a. Observe challenges and limitations of the initial model.
    b. Strengthen the existing model.
    c. Discuss current and future research goals in the area.

Successful completion of Calculus II or consent of instructor is required. Grades are based on class participation, homework, mini-projects (with presentation), and a final group project (with presentation). The course is taught by a faculty member and a mathematics graduate student.

Course Development Summary

The department of mathematics at the University of Iowa offers a wide array of courses at the undergraduate level for students interested in math. In addition to the standard calculus and linear algebra courses, there are introductory courses in real analysis, abstract algebra, and point-set topology. Noticeably absent from this curriculum are courses focusing on the application of mathematics outside of academia. In order to address this shortcoming, we proposed a new undergraduate course focused specifically on the modeling of real-world phenomena using mathematics.

In order to provide students with a broad understanding of the types of problems they can solve and the techniques they can use to solve them, we decided to break the course into five isostructural modules. Each module is composed of several introductory lectures, followed by computer simulation and experimentation, classroom discussion, and ultimately group projects and presentations. This modular format also allows for dynamic course content between offerings, as modules are designed to be interchangeable.

This course was first offered in the fall semester of 2007 as a section of "Introduction to Mathematics Research." Topics covered included areas of active applied mathematics research within our department, such as collision modeling, traffic flow, subsurface fluid flow, epidemiology, and financial options pricing. The course was supervised by Professor David Stewart.

Student reaction to this course has been very positive. At the end of each module, students were asked to complete an anonymous online survey regarding the content of the module and the framework of the course. Overwhelmingly, students found it very beneficial to dedicate class time to discussing models with classmates and instructors. Additionally, many appreciated the time spent on computer implementation of the models. In general, students felt better prepared to approach mathematical models in either research or in industry.

At present, this course is scheduled to be offered again in the spring of 2009. The current head of the department of mathematics has requested funding from the College of Liberal Arts and Sciences to make this course a permanent part of the undergraduate mathematics curriculum. Professor Stewart has agreed to retain a supervisory role, and preparations are being made to include several new modules in the next offering.

Module Summaries

Collisions Module

Accurately simulating the behavior of systems of physical bodies involves determining how the bodies react when they make and break contact. This amounts to calculating impact forces using Newton's Laws of motion. A difficulty in modeling collisions is that they inherently lead to instantaneous changes in velocities and accelerations, making it difficult to apply continuous methods.

In this module we introduce a simple complementarity model for collision resolution. We begin with rigid bodies and observe that either the objects are not in contact (and exerting zero force on one another) or are exerting forces on one another (with zero distance between them). Thus, the product of the 'gap' between objects and the contact forces they exert on one another is always zero. We extend this intuitive complementarity condition to rigid bodies in three dimensions. We also address simulation issues, such as collision detection and solution of large linear systems of equations.

Traffic Flow Module

Management of traffic flow in urban environments is important in order to allow for efficient and safe transportation. Understanding how cars interact with one another and how different road conditions affect the flow of traffic can help planners develop efficient and robust traffic networks.

In this module, we examine a continuous model for traffic flow derived from the fundamental principle of conservation of cars. We derive a simple differential equation to describe the variation of traffic density over time. This equation can be solved analytically or numerically for traffic density, and then used to determine traffic volume, average flow rate, and total throughput. We extend our basic model by including a "two-second" rule, through which we require drivers to maintain a safe two-second distance between cars.

Subsurface Flow Module

Fresh water is essential for life on Earth. Since the majority of the Earth's fresh water stores are found underground, understanding subsurface flow is vital in determining the viability and the sustainability of water resources. The application of subsurface flow models, however, is not limited to water; contaminant remediation, waste storage, and land usage are just some of the additional issues subsurface modeling can address.

In this module we introduce fundamental hydrology terminology and concepts and use them to derive a three dimensional transient fluid flow equation. Assuming knowledge of material flow parameters, such as hydraulic conductivity and specific storage, we use finite difference methods to solve for hydraulic head (pressure head) at each 'node' on a predetermined grid. We continue to explore the subject by defining advection and hydrodynamic dispersion in a mathematical context in order to derive the advection-dispersion equation for contaminant flow. Once again, we use a finite difference approach to determine contaminant concentration throughout a region of interest.

Epidemiology Module

The study of disease propagation has very practical applications in today's world. With biological threats including avian flu and tuberculosis and the potential for bioterrorist attacks, it is important to understand not only how diseases spread but also what combination of quarantine and vaccination can be used to prevent or slow the spread.

In this module, we introduce a standard SIR epidemiological model. This involves partitioning the general population into separate compartments: Susceptible (S), Infected (I), and Recovered (R). We derive a system of differential equations detailing how individuals move from one compartment to another. For simple cases, this system has an analytical solution. As we introduce more compartments (for instance, infected but not yet contagious), the system can only be solved numerically.

Financial Options Pricing Module

Financial options are investment vehicles that have value based primarily on an underlying asset. Similar to traditional traded stocks, options can be bought and sold for purely speculative reasons. But unlike stocks, options allow investors to minimize their portfolio risk because the pricing method is entirely deterministic.

In this module, we first develop a stochastic differential equation to model underlying stock (asset) prices. Using this equation and Ito's lemma we derive Black-Scholes partial differential equation for option pricing. After exploring the effect different boundary conditions have on solutions to the equation, we choose to approximate the result (option value) using finite difference methods. We further investigate the topic by introducing applications of Black-Scholes equation to areas such as equity valuation of a company, building of a manufacturing site, or determining the value of a product patent.

Module Template

Day 1: Introduction to Problem/Solution Technique

- Couple introduction with a presentation and working model.
- Introduce fundamental equations and ideas for subject.
- Introduce fundamental ideas of modeling technique.
- Motivate the need for a model.

Day 2: Full derivation of applicable equations (mostly independent of technique).

Day 3: Algorithm and numerical method development.

- Propose and develop a numerical method.
- Auxiliary code structure should be available here.

Day 4: Computer lab experimentation.

- Allow students to experiment with several different methods (plug 'n' play coding)

HOMEWORK ASSIGNMENT 1: Analysis or comparison of method(s).

HOMEWORK ASSIGNMENT 2: Implementation of numerical technique for computational simulation.

***Students should be prepared to begin a mini-project over the material presented so far

Day 5: Discussion of results from computer experimentation.

- Intuitive interpretation of what should have happened.
- Explanation of why differences were observed.
- (as time allows) Objective methods for model comparison.
- Lead-in to day 6: improvements/necessary modifications to model.

Day 6: Necessary extensions of basic model to more general (useful) situations.

Day 7: Survey of current open research questions and issues.

Day 8: Computer lab.

- Student computer exploration with addition of model improvements.

Day 9: Discussion/student presentations.

Part II. Survey Summaries

Following the conclusion of each module, students were asked to respond to several questions via the ICON online survey tool. The following sections summarize the responses offered by students. Full student responses appear in the appendices.

Collisions Survey Summary

This survey was given at the end of the collisions module. Students were asked to anonymously complete the following questions on ICON. Results appear below exactly as they were entered online. Raw responses appear in Appendix A.

Eight of eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**0**	**1**	**6**	**1**
The level of programming that was required for the homework and projects was reasonable.	**0**	**2**	**1**	**4**	**1**
Class discussion was well directed.	**0**	**0**	**2**	**2**	**4**
Class discussions contributed to my understanding of the material.	**0**	**0**	**1**	**3**	**4**
I feel comfortable speaking in discussion.	**0**	**0**	**1**	**2**	**5**
I feel comfortable asking questions in lecture.	**0**	**0**	**1**	**3**	**4**
Group work cramped my style.	**2**	**4**	**1**	**1**	**0**
Everyone in my group was able to contribute to the project.	**0**	**4**	**0**	**4**	**0**
Lecture prepared me for the homework assignments and labwork.	**0**	**2**	**2**	**3**	**1**
I am worried about my grade in this course.	**0**	**3**	**3**	**2**	**0**

2. What went well during the first module? (i.e. what should we continue to do in the next few modules)

Discussions were very popular with students. Most felt that being able to interact with instructors and other students was very helpful. Others found that the mixture of class formats (lecture, discussion, lab) was effective. Although some students had difficulties programming with Matlab, others found Matlab to be a very helpful tool.

3. **What didn't go well during the first module? (i.e. what should not do anymore?)**
   The most notable problems in this module had to do with Matlab programming requirements and group projects. Many students didn't feel adequately prepared to complete the programming aspects of homework and projects. Additionally, most students felt that they could have accomplished much more (with respect to projects) had they been given more time.

   Several other students felt they would have benefitted from a more intuitive or visually motivated approach rather than a theoretical mathematical approach.

4. **Does having three instructors strengthen or weaken the format of the course?**
   It is very helpful to have three instructors available as resources. Students generally appreciate being able to get multiple explanations from different points of view. Also, having more people involved allows students to more freely ask questions during lab periods.

Instructor Response

It is important for us to provide students with more guidance in future programming assignments so that they are not overwhelmed by issues not directly related to the module. We hope to assign homework slightly earlier in the future modules so that students can complete it before beginning on projects. We'll also have to try to design lectures and homework assignments to complement each other.

The general response to the module format has been good. Students seem to like seeing material in lecture, then implementing models on computer and talking about it in class. Also, the miniprojects seem to provide both closure (with respect to the material presented) and motivation for further study (with respect to the larger family of problems presented).

Traffic Flow Survey Summary

This survey was given at the end of the traffic flow module. Students were asked to anonymously complete the following questions on ICON. Results below have been summarized from students' responses. Raw responses appear in Appendix B.

All eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**0**	**0**	**9**	**2**
The level of programming that was required for the homework and projects was reasonable.	**0**	**1**	**1**	**7**	**2**
Class discussion was well directed.	**0**	**0**	**0**	**6**	**4**
Class discussions contributed to my understanding of the material.	**0**	**0**	**4**	**3**	**4**
I feel comfortable speaking in discussion.	**0**	**0**	**2**	**4**	**5**
I feel comfortable asking questions in lecture.	**0**	**0**	**2**	**4**	**5**
Group work cramped my style.	**5**	**2**	**2**	**1**	**1**
Everyone in my group was able to contribute to the project.	**0**	**1**	**0**	**8**	**2**
Lecture prepared me for the homework assignments and labwork.	**0**	**0**	**3**	**7**	**1**
I am worried about my grade in this course.	**0**	**7**	**3**	**1**	**0**

2. What went well during this module? (i.e. what should we continue to do in the next few modules?)

The most popular addition to this module was the introduction of supplemental handouts. Students benefitted from having materials to which they could refer when working on their own. Many students also liked having extra class time to work on their homework and projects. Also, several students thought that the simulator materials helped them understand the model.

3. What didn't go well during this module? (i.e. what should not do anymore?)

Homework assignments and projects need to be better defined before they are given. Additionally, it would be helpful if all simulator code was written in Matlab instead of Matlab with C++.

4. **What can we do to make the homework go more smoothly?**
   Many students thought that homework went relatively smoothly. As mentioned above, it is important to clearly define homework requirements and expectations before assigning it. Also, providing guidance on how to use software would be helpful.

5. **How are the miniprojects helping (or hurting) your understanding of the material?**
   The group miniproject assignments provide students with the opportunity to learn from their peers. Almost every student commented on how these projects helped tie together key ideas from lecture and homework. A few students liked how the miniprojects complemented the homework assignments.

   Several students suggested that more time be devoted to miniprojects, or that a greater divide be made between homework assignment deadlines and project start dates so that students could complete their homework (entirely) before beginning a more complex problem.

6. **How did this module (traffic flow modeling) compare to the last one (collision modeling)?**
   Most students thought that this module was better organized and presented. Several mentioned that the handouts and presentations helped them understand the material better than the lectures in the collisions module. A few students commented on how the math in this module was more difficult, but the programming was less intensive.

Instructor Response

Homework assignments continue to be a concern for students. Expectations for homework assignments need to be better defined in the future. Programming also remains an issue, but it seems that the handouts we've provided have helped students gain confidence in their coding abilities.

The adjustments we made from the first module appear to be helping students adjust to this course format. Almost all students participate in class discussion, and group projects have become a very popular part of the course (although students still want more time).

Subsurface Flow Survey Summary

This survey was given at the end of the subsurface flow module. Students were asked to anonymously complete the following questions on ICON. Results below have been summarized from students' responses. Raw responses appear in Appendix C.

All eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**1**	**0**	**6**	**4**
The level of programming that was required for the homework and projects was reasonable.	**0**	**1**	**2**	**5**	**3**
Class discussion was well directed.	**0**	**0**	**1**	**4**	**6**
Class discussions contributed to my understanding of the material.	**0**	**0**	**1**	**6**	**4**
I feel comfortable speaking in discussion.	**0**	**0**	**1**	**5**	**5**
I feel comfortable asking questions in lecture.	**0**	**0**	**2**	**3**	**6**
Group work cramped my style.	**5**	**5**	**1**	**0**	**0**
Everyone in my group was able to contribute to the project.	**0**	**1**	**2**	**8**	**0**
Lecture prepared me for the homework assignments and labwork.	**0**	**0**	**3**	**3**	**5**
I am worried about my grade in this course.	**1**	**6**	**4**	**0**	**0**

2. What went well during this module? (i.e. what should we continue to do in the next few modules?)

Students continued to voice their appreciation of handouts and supplemental materials, especially those made available online. The homework assignments complemented the projects and each other. Lecture and discussion were well organized and focused.

3. What didn't go well during this module? (i.e. what should not do anymore?)

As mentioned in the previous two surveys, students would like more time to work on miniprojects and homework. Also, several students feel unprepared to complete the programming portions of assignments.

4. **How did the handouts help (or hinder) your understanding of the material and your ability to do the homework?**
   Most students found the handouts to be good references for use outside of lecture. A few mentioned that it was helpful to be able to listen to lectures without having to 'scramble' to write notes. Some students thought that the handouts could be improved by including material to help them with their Matlab coding.

5. **How are the miniprojects helping (or hurting) your understanding of the material?**
   Again, students appreciate the projects, but would like more time and more programming experience.

6. **How did this module (subsurface flow modeling) compare to the last two (collisions and traffic flow)?**
   Most students felt that this module was more difficult (or more demanding) than the previous two modules. Even so, many students listed this as their favorite module of the three. Also, many students liked this module because they were able to produce working simulator within the three week time period.

Instructor Response

This has been (to date) the most effective module. Students were excited to see material that could be directly applied in areas they've already studied (many students are currently studying civil engineering). Handouts were produced with greater consistency, and students are becoming much more capable of mathematical programming (though they still lack confidence in their abilities).

It is difficult to gauge how much time students will require on homework assignments and projects. Based on the surveys, it is clear that this is the greatest student concern. We've discussed changing the course offering times (for the next semester) to include a dedicated computer lab so that students have the time they need.

Epidemiology Survey Summary

This survey was given at the end of the subsurface flow module. Students were asked to anonymously complete the following questions on ICON. Results below have been summarized from students' responses. Raw responses appear in Appendix D.

Nine of eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**0**	**1**	**7**	**1**
The level of programming that was required for the homework and projects was reasonable.	**0**	**1**	**0**	**6**	**2**
Class discussion was well directed.	**0**	**0**	**0**	**7**	**2**
Class discussions contributed to my understanding of the material.	**0**	**0**	**2**	**7**	**0**
I feel comfortable speaking in discussion.	**0**	**0**	**1**	**5**	**3**
I feel comfortable asking questions in lecture.	**0**	**0**	**1**	**6**	**2**
Group work cramped my style.	**3**	**4**	**2**	**0**	**0**
Everyone in my group was able to contribute to the project.	**0**	**1**	**0**	**6**	**2**
Lecture prepared me for the homework assignments and labwork.	**0**	**1**	**1**	**6**	**0**
I am worried about my grade in this course.	**1**	**1**	**2**	**4**	**0**

2. What went well during this module? (i.e. what should we continue to do in the next few modules?)

The presentations were well organized and students seemed to have an intuitive understanding of the material. Using compartmentalization (and drawings of compartments) helped emphasize the main ideas of the model. Definitions were clear and available in handout form.

3. What didn't go well during this module? (i.e. what should not do anymore?)

This module was very rushed. We completed this module in eight days instead of the scheduled nine. Also, the day scheduled for 'sensitivity analysis' used mathematical techniques that the students didn't feel comfortable with.

4. How are the miniprojects helping (or hurting) your understanding of the material?

Most students felt that the miniprojects helped the overall understanding of this topic. Some thought that their project was easier than others, while others thought theirs was very difficult. Balancing the relative difficulties of the miniprojects was somewhat of a concern.

5. **How did this module (epidemiology) compare to the last three (collisions, traffic flow, and subsurface flow)?**

   Students felt that this module was easier to understand most of the material, but certainly noticed the cramped timeline. The application of this module to real-world situations was more apparent than the previous modules.

Instructor Response

As with the subsurface flow module, students were really able to intuitively understand this module. The handout 'cheat-sheets' with important definitions and sketches of the compartments in the model were very helpful for students. We should consider making these available in other modules.

Due to a scheduling miscalculation, we only had eight days (instead of the scheduled nine) for this module. We were able to cover all of the material we wanted to, but students definitely noticed the time crunch. Also, the difficulty of the miniprojects caused some concern amongst students. It should not be difficult to rebalance the projects so that all are equally challenging.

End of Course Survey Summary

During the last week of the fall semester, students were asked to complete a survey on the course ICON web site. Questions were targeted towards specific areas determined by the instructors, mentioned by students in conversation, or outlined in the initial course proposal. In what follows we give a brief summary of the comments received from student surveys for each question. Complete (raw) comments are given in Appendix E.

Section 1. VIGRE related questions

The Department of Mathematics recently received a grant intended to help us "vertically integrate" our department —to encourage interaction between faculty, post-docs, graduate, and undergraduate students. The funding for this course was provided through this grant.

1. **Did this course help you 'vertically integrate?'**
   Students felt that they were able to interact very closely with Dr. Stewart and with both graduate teaching assistants. The discussion format of the course allowed for "a high degree of communication between the professor, the [graduate student instructors], and more than average [communication] amongst the students themselves."

2. **One suggestion has been to include an upper-level undergraduate 'teaching assistant' in the course to help with assignments and programming. Do you think this would help, hurt, or not make a difference?**
   As long as there are two graduate students involved directly with the course, there doesn't seem to be any need for another assistant. However, students generally agreed that if an undergraduate assistant were to be included, s/he would need a substantial programming background and prior experience with Matlab.

3. **Do you feel prepared to begin working on problems related to the ones we examined in this class?**
   Every survey respondent feels prepared to *begin* working on related problems, but the extent to which they feel they could independently succeed varies. Most students seem to be ready for more complex models, given appropriate guidance. Several students noted that this course emphasized the modeling process as much as any particular model, and were therefore more confident in their abilities.

4. **Has this course increased your interest in math in general?**
   Perhaps "broadened" would be a better word than "increased." Students who enrolled in this course were generally already interested in studying math. Several math majors appreciated the applied nature of this course as a complement to the theoretical courses they'd already taken. On the other hand, a few of the engineers found the subject matter to be much more theoretical than what they'd seen in their engineering courses.

Section 2. Likert questions

In this section, students were asked to respond to each statement with a choice varying from "Strongly disagree" to "Strongly agree." Many of the statements chosen for this section were drawn from the standard end of term evaluations issued by the department of mathematics.

5. Please select the option that best describes your opinion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This course is organized well.	0	0	0	**7**	**4**
Concepts are presented in a manner that helps me learn.	0	0	**1**	**7**	**3**
My work is evaluated in ways that are helpful to my learning.	0	0	**2**	**7**	**2**
The instructors seem interested in teaching this course.	0	0	0	0	**11**
The instructors communicate well.	0	0	0	**2**	**9**
It is clear what the instructors consider important.	0	0	**1**	**7**	**3**
Class presentations are well organized.	0	0	**2**	**7**	**2**
Important points are clarified with good examples.	0	**1**	**2**	**5**	**3**
The instructors present materials clearly.	0	0	**1**	**6**	**4**
The instructors are effective in teaching the subject matter of this course.	0	0	0	**6**	**5**
Assignments contribute to my learning.	0	0	**1**	**5**	**5**
I have acquired a basic understanding of the subject area of this course.	0	0	0	**6**	**5**
I have been encouraged to think for myself.	0	0	0	**2**	**9**
The instructors are available during office hours.	0	0	0	**3**	**8**
The amount of work in this course was appropriate.	0	0	0	**4**	**7**
The level of programming that was required for the homework and projects was reasonable.	0	**2**	**4**	**3**	**2**
Class discussion was well directed.	0	0	0	**5**	**6**
Class discussions contributed to my understanding of the material.	0	0	0	**6**	**4**
I feel comfortable speaking in discussion.	0	0	**1**	**4**	**6**
I feel comfortable asking questions in lecture.	0	0	**1**	**4**	**6**
Lecture prepared me for the homework assignments and labwork.	0	**2**	0	**8**	**1**

I am interested in taking more math courses.	0	**2**	**1**	**3**	**5**
I would recommend this course to classmates.	0	0	**1**	**3**	**7**
I would recommend these instructors to classmates.	0	0	0	0	**11**

Section 3. Directed Questions

In this section we pose questions aimed at improving the course structure and content for future sessions. These questions were developed by the instructors.

6. **Our intent in this course was to present a variety of topics in applied mathematics, develop basic models for those problems, and give you the opportunity to experiment with the models. Our goal was to give you the fundamental preparation to address these types of problems in industry (your future jobs) or in academia (as potential independent research projects).**
   Do you feel prepared?
   As reflected in question 3, students generally feel prepared to approach similar mathematical problems, but are unconfident in their abilities to do so on their own.

7. **In designing each module, we tried to follow a set framework when deciding how much lecture, lab, and discussion should be included. (You may have noticed that the first three days of each module were always lecture, followed by a lab day and a discussion day.) Was this effective?**
   The general class structure seemed effective. On the positive side, students appreciated the introductory lectures we prepared to introduce them to new topics, and they found the discussion to be valuable. However, there wasn't always a smooth transition from lecture to homework, and almost all students would have liked more time in the computer lab.

8. **In preparing for the course, we planned for three weeks to cover each module. Was this enough time? Would you have liked to have seen more topics in less depth, fewer topics in greater depth, or did we do okay?**
   By and large, students felt that the amount of time spent on each module was appropriate. A few students would have liked to spend more time on each module in order to go into greater depth.

9. **If you were to suggest prerequisites for this course, what would they be? (i.e. what do you wish you had taken before you took this course?)**
   The current prerequisite for this course was two semesters of calculus. Students felt that this calculus background was adequate. In addition, many students suggested that some sort of programming background would have been helpful, and several students found their background in differential equations beneficial.

10. What could we do to get more students like you interested in this course?

Publicizing this course early is essential. Most students feel that recruiting students from other majors (engineering, physics, biology, economics, etc.) would be effective. One student suggested emphasizing the applied nature of the course, while another suggested emphasizing the lack of exams.

11. Would you be interested in taking more courses in applied mathematics?

There were very mixed results for this question. Several students showed particular interest in applied math courses, while a few others tended towards pure math. Other students showed no further interest in math courses.

12. How did homework assignments and group mini-projects contribute to your understanding of class materials?

The homework assignments and group projects helped to reinforce the concepts discussed in lecture. Most students felt they learned the most from actually experimenting with and implementing models. As in several previous responses, students would have liked to have more time to work on homework and projects, and occasionally felt underprepared for the programming aspects.

13. Which module(s) do you feel you understood most clearly? Why?

Each of the five modules presented this semester was listed as 'understandable' by several students. The most common responses were epidemiology and traffic flow. In all responses, students felt that the modules were most understandable when they had previous experience with the material (e.g. having been in a traffic jam) or had an intuitive idea of what should occur (e.g. response to a collision).

14. What other areas of applied mathematics would you be interested in studying if you were to take this course again?

This questions makes it apparent how unfamiliar students are with applied mathematics. Many students responded by saying that they don't know any other areas to which math can be applied! Some suggestions for modules included biological models, sound and soundwave propagation, resource management, more financial topics, and physics or astrophysics.

15. What did we do well this semester?

Most students thought that the availability of the instructors outside of class and the relaxed atmosphere of the class were very helpful. Presenting the materials in an organized and structured manner contributed to the learning environment.

16. What did we do poorly this semester?

The biggest problem voiced by students was the inadequacy of the preparation for Matlab programming. Additionally, some students felt that there was a gap between where lecture left off and where homework assignments started. As seen in previous questions, most students felt there was insufficient class time dedicated to programming homework assignments and mini-projects. Other students felt that certain mathematical derivations occurred too quickly during lecture.

17. How do you feel we responded to your needs/requests?

Students felt that we responded "promptly and adequately." Several mentioned the effectiveness of the post-module surveys.

18. Which class meeting type (lecture, presentation, discussion, lab) helped you the most? the least?

Discussion and lab meetings seemed to be the most helpful, while lecture was the least helpful. Students consistently reported that they learned the most by actually implementing models rather than by listening to how the models were derived.

19. What did you think of the pacing of the course?

Pacing seemed to be at or slightly above the comfort level for most students. As we approached the end of the semester, the pace quickened in order to cover the allotted material. People seemed to like the three-week format with gradual acceleration from day 1 to day 9.

20. How does the format of this course compare to other math courses you've taken?

This class format was different from the formats of most courses students had taken. Students appreciated the different presentation formats (lecture, discussion, lab, presentations). "This format is more conducive to learning because of the time spent working in the lab on real topics."

21. How does the content of this course compare to other courses you've taken?

Students "really enjoyed implementing models to depict real life problems and real life events." "The mathematical depth that this course goes into far exceeds that of my other engineering classes and the physical depth far exceeds that of my other math classes. "

22. How did the group projects help (or hurt) your learning?

Group work seemed to be beneficial to all students. Most enjoyed having larger, directed projects to work on, and each student felt capable of contributing to the group project in some way. Projects encouraged discourse amongst the class.

23. How did the handouts help (or hurt) your learning?

The handouts were generally helpful so long as they were provided in a timely manner and were complete. Some students preferred to take notes during lecture and presentations, while others appreciated the supplemental material so that they could "focus more on the speaker and the material."

24. What could be done to better organize the course?

First, explicitly lay out the class format. Students feel they would have benefitted by knowing which days were scheduled lectures, which were scheduled labs, etc. Second, provide more flexibility of lab time so that students can complete their homework and mini-project assignments.

25. If you have any additional comments or suggestions, please communticate them to us in the following open space.

Students had many good comments and suggestions in many different areas. Here are some samples.

- I really enjoyed this class. It was new and exciting material. I liked modeling real life problems...it gave us a chance to see the importance of math and modeling in the real world. Thank you so much for a great semester.
- Great job overall. All instructors were very knowledgeable on the subject which was impressive.
- Keep up the good work, I really enjoyed this class overall, and I am glad to see that you guys are interested in teaching it. This University would be a better place if more classes were staffed by people with your attitudes / enthusiasm.
- This course was a very positive experience. In fact, it was the only class that I enjoyed so much I didn't miss a class all year. That being said, I am skeptical about the long term success of this course because I believe it succeeded due to the superior ability of its professors. Any other math professor that I have encountered thus far would have difficulty in "entertaining" an undergraduate audience with the material of this course.

Refer to Appendix E for complete listing of comments.

Part III. End of course instructor remarks

Based on the results of the anonymous surveys and from our own personal observations, we have identified several common areas of note. Here we list some of the things that went well throughout the semester, some of the things that are causes of major concerns (which must be addressed before offering this course again), and some areas of minor concern (which ought to be addressed before offering this course again). We conclude with our plans to address these concerns.

Highlights

- The modular format of the course provided a good survey of problems in applied math. Three weeks was almost the perfect amount of time for each module.
- The common structure of the modules (presentation, lecture, lab, discussion, lecture, lab, presentation) helped students feel comfortable changing from module to module.
- Visualization and graphics allowed students to interpret results.
- Although late in being listed, the course enrollment was strong.
- The atmosphere of the classroom encouraged student participation.
- Each module addressed material at an appropriate level. Students were rarely overwhelmed by theory.

Major Concerns

- Students need more time to complete homework assignments and projects.
- Programming requirements are (generally) above the skill level of students.

Minor Concerns

- Criteria for quality of homework and presentations needs to be explicit.
- Homework assignments and projects need to be made more concrete.
- In several modules, the final projects varied greatly in difficulty.

Future Plans

In order to address concerns regarding homework and project time, we propose moving the course to a Tuesday/Thursday schedule with a Wednesday class dedicated to lab work. Each module would then be composed of six lecture/discussion periods and three lab periods. Homework could be assigned at the end of the first week and turned in by the end of the second week. Projects would then be assigned by the middle of the second week and turned in on the final day of the module.

We could additionally use the dedicated lab days to assign Matlab tutorial assignments. We plan to develop short tutorials for Matlab that focus on particular skills needed in each module. For instance, the first tutorial might focus on using ‘for’ or ‘while’ loops to prepare students to populate a coefficient matrix needed in the subsurface flow module. In this way, we can ensure that each student is better prepared to do the programming necessary for homework assignments and projects.

One of the problems we encountered this semester was that the homework assignments we developed left some room for interpretation. Since this was the first time the course was offered, we had expected that homeworks and projects would need some refining. Also, many students noted an

imbalance of project difficulties. We hope to spend time revising homework to make the problem criteria more clear and reexamining projects to ensure a proper balance. Additionally, as this is a course in applied math, we would like to add a requirement that homework solutions be written in paragraph form for an audience of educated laypeople.

Even though there are a number of changes that need to be made to improve the course, many of the things we tried this semester were well received by students. First, we plan to keep the modular structure of the course and the general module schedule template. Students liked being able to focus on a particular subject in depth for three weeks, then look at something new. As instructors, we also appreciated being able to look at a variety of models throughout the semester, as it provided a natural framework in which several people could lecture. Next, we think that the group miniprojects at the end of each module are effective in challenging students. The homework assignments gave an introduction to the fundamental techniques needed to create a simulator, while the projects built on the homework to force students to extend the models beyond what we discussed in class. Finally, we believe it is important that, whatever topic is being discussed, we provide either visual or intuitive motivation for the approach we choose to take. Students reported feeling most comfortable with material in modules where the approach matched their intuition. The subsurface flow and collision modules were examples of where intuition was helpful, while the continuous model of traffic flow was counterintuitive.

Part IV. Appendices

Appendix A. Collisions Module Survey Results

This survey was given at the end of the collisions module. Students were asked to anonymously complete the following questions on ICON. Results appear below exactly as they were entered online.

Eight of eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**0**	**1**	**6**	**1**
The level of programming that was required for the homework and projects was reasonable.	**0**	**2**	**1**	**4**	**1**
Class discussion was well directed.	**0**	**0**	**2**	**2**	**4**
Class discussions contributed to my understanding of the material.	**0**	**0**	**1**	**3**	**4**
I feel comfortable speaking in discussion.	**0**	**0**	**1**	**2**	**5**
I feel comfortable asking questions in lecture.	**0**	**0**	**1**	**3**	**4**
Group work cramped my style.	**2**	**4**	**1**	**1**	**0**
Everyone in my group was able to contribute to the project.	**0**	**4**	**0**	**4**	**0**
Lecture prepared me for the homework assignments and labwork.	**0**	**2**	**2**	**3**	**1**
I am worried about my grade in this course.	**0**	**3**	**3**	**2**	**0**

2. What went well during the first module? (i.e. what should we continue to do in the next few modules)

- I like the time spent in the computer lab with the 3 instructors circulating, it gives me a chance to work on the problem, get immediate results from the software, and get immediate help from the instructors.
- I liked the overall flow of the section. First learning the math in discussion and then doing individual homework to kind of play around with the idea and finally moving on to a bigger group project.
- The first module was well organized and help was easy to come by. The course is a definite winner so far.
- The discussions were very informative and valuable. They cleared up questions that I had and brought up interesting theoretical questions.
- I thought that the level of discussion was interesting and new. Most of the classes I have taken have little or no discussion. It was exciting to hear ideas from my peers and to see what they

were thinking about on this topic. The modeling gave a good illustration of something very real--such as collisions.

- just about everything seemed to go well. the lecture/labwork/discussion mix worked very well for me.
- I have a very theory based math background and no programing experiance, I thought this module was just the right amount of programing for gettng my feet wet and showed one more practiacl side of math, that someone could go out and get a job doing this. I thought it was interesting, I like meeting in the computer lab to get us going on the programming stuff. I also liked how broad the subject was, it really allowed for many different ideas of how we could improve on or make more complex the basic ideas.
- Working with matlab was good. This gave me the opportunity to get back into programming after about a year. Discussions on the topic of modeling were helpful also. This helped me get a better understanding as to what type of input a programmer will need when creating a model. Pairing us non math folks (aka engineers) together with those who have a better grasp of this stuff was a great idea. Otherwise the entire class would have suffered.

3. What didn't go well during the first module? (i.e. what should not do anymore?)

- I feel like I just barely understand some of the math involved (not that it is too difficult, I am just slower than most people), maybe add more step by step explanations if it does slow things down too much. I personally didn't contribute much to the group project because I couldn't quite make the connections so quickly, Dana pretty much carried us step by step. We DEFINITELY needed more time to complete the mini-projects.
- Its not so much something we did that didn't go well but something I felt was left out that could really help get the message across. When we're in the first part of the module and one of you guys are trying to show us the straight math, I really think it would help to have just a brief visual like with a powerpoint or a short video clip. I don't know if its just me but I sometimes get lost in all the equations and have a hard time seeing what is actually going on. Every once in a while if there was a pause just to visually show the events I think that would be nice. I think this could be especially helpful with this upcoming traffic flow module.
- It may be helpful to present the "bigger picture" before beginning the analysis of the ball, floor collision. Looking back on the analysis it is more clear, however, in class I was pretty lost to as to exactly what we were trying to arrive at.
- The programming was rather hard to get into with the way that information was presented at first. Some guided programming would have been helpful. The group work was difficult to coordinate.
- I don't think that if the group project was suppose to be the main focus of the module that it was given the most about of time. I thought and my group as a whole thought that the 3 or 4 days we were given to work on the projects was not necessarily sufficient time. It could be that we had a harder topic to illustrate and maybe we weren't suppose to have the main focus be on the group projects.
- Nothing significant.
- I didn't think we had enough time to meet wiht our groups, we sat together the day it was assigned and thought about it for a little bit, then not all of us could make the office hours to work on it, and people were busy over the weekend so the rest of our colaboration was done by email, until three of us got together be for class monday. It worked out allright, but I think we could have come up with even more if we had had another chance to meet all together. I think it might go better the next time to assign which group to which project ealier, that way we can at least think about it a little deeper befor we get together and it would be more reasonable to

have at least a week from the time it's assigned to when we present in order to work out a good time work all together.

- My biggest problem with this first module was the fact that I was playing catch up with mat lab from the start. I assumed we would spend a few days reviewing basic inputs for matlab. This would have placed the class more on an even footing from the start. My weakness in matlab put me at a disadvantage when in the group setting, which meant that I was not able to contribute my fair share to the solution. It seems to me that having more reference material to look over would have been helpful to me also. Particularily concerning the basics of modeling. If there were a way to give us material to access over the internet so that we could refer to this when working on homework would have been ideal. Putting it over the net would also take care of having to buy books for the course.

4. Does having three instructors strengthen or weaken the format of the course?

- STRENGTHEN! Dr. Stewart provides great insight and he is a good lecturer, and Ben and Ted are great at interpreting what he said into my level of processing. Great job to you all. I look forward to future modules.
- It helps so much. Everytime I got stuck last module there was was always someone to give a hint in the right direction. And its also helpful to have different people saying the same thing. I know at least a couple of times I struggled to understand what one of the instructors was saying and then another one helped clear it up.
- It is very beneficial having three instructors for this course. It is evident that each instructor has his own strengths. It is great as a student to utilize the expertise of all three.
- It helps that there are more resources to ask questions to.
- I think have three instructors strengthens the course. It gives more one-on-one time with students. It also allows there to be three qualified voices in the class. Each instructor may have a different perspective of the modeling and can give the class that individual insight.
- i think having three instructors strengthens the format. it's helpful to have three great resources to answer questions.
- Unlike a more traditional or theoretical math course, this material seems to have several different ways, if not infinitely many, of aproaching it, so I think having three instructors who, while they share many ideas, inevitably have differing ways of thinking about the subject, is positive. It also increases availibility to us to get outside of class help to have three potential people to field a question via email, ect.
- I think this is a great concept, especially since the class is so small. Having 3 instructors allows the class to get different viewpoints on how to attack a problem.

Appendix B. Traffic Flow Module Survey Results

This survey was given at the end of the traffic flow module. Students were asked to anonymously complete the following questions on ICON. Results appear below exactly as they were entered online.

All eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**0**	**0**	**9**	**2**
The level of programming that was required for the homework and projects was reasonable.	**0**	**1**	**1**	**7**	**2**
Class discussion was well directed.	**0**	**0**	**0**	**6**	**4**
Class discussions contributed to my understanding of the material.	**0**	**0**	**4**	**3**	**4**
I feel comfortable speaking in discussion.	**0**	**0**	**2**	**4**	**5**
I feel comfortable asking questions in lecture.	**0**	**0**	**2**	**4**	**5**
Group work cramped my style.	**5**	**2**	**2**	**1**	**1**
Everyone in my group was able to contribute to the project.	**0**	**1**	**0**	**8**	**2**
Lecture prepared me for the homework assignments and labwork.	**0**	**0**	**3**	**7**	**1**
I am worried about my grade in this course.	**0**	**7**	**3**	**1**	**0**

2. What went well during this module? (i.e. what should we continue to do in the next few modules?)

- lecture exlplanations provided obvious direction and made everything easier to understand.
- I liked that we were able to get help working through the miniprojects. I also liked the discussion about how to theoretically change the models at the end of the unit.
- It was very encouraging to have an extra couple of days to properly evaluate and create our project. I thought my group especially was much better prepared to present to the class its findings. I also felt that programming experience did not affect the understanding of the module. Having little programming experience, I wasn't overwhelmed this module.
- Everything went fine.
- hand outs are good
- I really liked having the powerpoint slides shown in class during the first few days we got into the topic. This allowed me to see what was going on underneath all the straight math.
- There were many great things about this module. First, it was very well taught. Second, the class as a whole is more relaxed now as people have come to know each other a little better. I think this has contributed to a very conducive learning environment. Finally, even though I was struggling with the second homework, I was able to find help with very short notice. Thanks.

- Handouts were much more useful and informative. During this block I was able to go to the notes and handouts to help me get started. You guys should definitely continue with the handouts/printouts.
- I thought the group projects went well. We all had interesting subjects to thing about and they were less of a programing challeng than the previous module. Also I felt like we had more time to meet with the group so we colaborated much better this time. I also liked the first asignment being written and not programing. The simulator we had could help for scetches but I did mine without it. I liked haveing a mix of computer and written work to do. Also I think the post miniproject rap up was excelent as it allowed us to see how complex the subject can get, in fact in both modules thus far it has been clear to me how a person of a team of people could devote hour and hours to making more coplicated modles, or for that matter how almost infinitly complex modles can get.
- The Matlab simulator was quite helpful...charts and graphs in general are good.
- format/schedule

3. What didn't go well during this module? (i.e. what should not do anymore?)

- The only thing that didnt go well for me was the partial differential equations. Nothing you guys can do, just the first time I have dealt with stuff like that.
- I would have liked to have time to work on all of the homework before the miniprojects. I thought that the day we decided on the miniprojects was going to primarily be used for hw2 and so I didn't have as much of a chance to work with the group on the miniproject.
- I really can't pinpoint one thing that went wrong during the module. Although it takes a few days for me to begin grasping the material in the lecture style classes, I can usually understand the ideas presented in class after some time.
- As with the previous module, I didn't feel like we were able to spend enough time to complete the project.
- I can't think of anything, the class is interesting and engaging, good job guys.
- The programming part for homework 2 wasn't very hard once it was explained how to open and run all the files, but it was almost impossible to do by yourself. I think the programming part helps a lot and should be kept in but there should be a better explanation of how to do it.
- For homework two of this module the computer program was difficult to implement. You could comment the matlab code or show us exactly how to use the software.
- Perhaps a few more examples of what it is you guys want for homework. Sometimes it's hard to get started on the work if we don't know where to begin
- I can't think of anything that stands out. I guess there were a couple of days when I wasn't sure if the second homework was due or not. Sometimes you guys tell us we are ready to do a homework but not when it is due, however, you seem rather flexable so it might not be much of an issue. It hasn't burned me where I didn't get something in on time and got penalized for it maybe its not an issue.
- The miniproject requirements were a bit unlcear.
- not much

4. What can we do to make the homework go more smoothly?

- I feel comfortable with homework right now.
- It would be nice to get a little more comfortable with the math before we have to do the homeworks. Maybe if we reviewed and highlighted the key equations after deriving them so that we would know which parts we will need for the homework. I sometimes had trouble following the derivations, but when we were shown the final equations I understood what was going on. If we could review the key equations one more time, it would be very helpful.
- I'm not sure. Sometimes it just takes some time and guidance to understand the material.
- Have more class time to work on them
- sometimes I don't understand what specifically to do to solve the problems. I guess give more thorough questions, not bad overall though.
- Like I said before just a little more clarity with the programming.
- The first homework was a very good assignment in that it greatly furthered my understanding of the topic. The second homework was very frustrating because I had no idea how to use the software.
- see above
- I think its gone smoth enough.
- Provide some kind of outline or starter during class.
- n/a

5. How are the miniprojects helping (or hurting) your understanding of the material?

- The miniproject discussions within our groups help understand the material a lot. Then actually speaking adds to comprehension (or provides reality of not understanding).
- I think the miniprojects help, but they seem to take away a little from the homeworks. I found the miniprojects especially helpful to understanding actual applications of the models and i enjoy thinking about the problems. It was nice to be able to focus on the concepts this time and not have to worry about programming the miniprojects.
- The miniprojects seem to be the final say in the modules, allowing me to either finally grasp the material or to finally show how little I understand. The miniprojects are exciting when you understand the material and what needs to be done to present accurate findings about the project we were assigned.
- The miniprojects allow everyone in my group to bounce ideas off of each other, and then proceed in a direction that everyone agrees with, which makes our understanding of the concepts more concrete.
- I like them, I think it is good to work with other people on tough problems.
- In order to complete the homeworks I feel you have to really kind of know whats going on. The miniprojects are good because after you get a good grasp on things, they push to the next level and make you think about new questions and possibilities. Even if these don't exactly get answered, I like thinking about new ideas.
- The miniprojects are great. However it may be beneficial to assign projects that are easier to implement in a simulation. For instance, our group had the "traffic loop" problem and although it is a very plausible problem, writing any sort of code to simulate a traffic loop was probably far beyond our capability.
- The projects give us a feel for what needs to be looked at when modeling a problem. For example, we need to come up with assumptions and parameters and implement these into out model.

- As long as your guys are satisfied with the miniprojects presentations and level of completion I think they are very helpful. They've gotten us thinking about more difficult problems using what we have allready learned and without us beating are heads against the wall trying to get functioning programs.
- They help round out the discussion by presenting different aspects of the topic.
- helps expand ideas about the material

6. How did this module (traffic flow modeling) compare to the last one (collision modeling)?

- I felt like I understood where things were going and how to get there in the traffic flow module. Though once we made it to the 4 equations in collisions everything kind of clicked.
- I thought that this module went more smoothly and I understood more of the material.
- The traffic flow model was much more organized and efficient. I felt that I understood the material much, much better. Programming was not a major focus of the model and we were given more time to complete the miniprojects. Overall, I liked the traffic module much better than the collision module.
- This model was easier than the last one, because everyone in my group was at the same level of understanding
- I found it easier to visualize to patterns, but harder to forsee characteristics and graphs
- I liked how things were explained as far as the powerpoints and examples went. I really just didn't find this module very interesting to be honest. It seemed like if you were actually trying to model a traffic flow the equations could get to be infinatly hard. The collisions one kept my attention much better and I'm really looking forward to this subsurface fluid flow module. This is probably because all my other classes are studying this too. For collisions = dynamics/physics. For fluid flow = thermodynamics. Something different is never bad though.
- This module was more challenging. I liked the first module a little better, as it pertains more to my field of study, mechanical engineering.
- I felt like I understood this module a little more. The fact that we had something to use as a reference was very helpful.
- I've found both equally interesting and challenging topics. You guys did a better job of giving us more time to meet with our groups so in that respect I liked the traffic flow modeling better.
- The math was much hairier.
- over-all much smoother and less daunting

Appendix C. Subsurface Flow Module Survey Results

This survey was given at the end of the subsurface flow module. Students were asked to anonymously complete the following questions on ICON. Results appear below exactly as they were entered online.

All eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**1**	**0**	**6**	**4**
The level of programming that was required for the homework and projects was reasonable.	**0**	**1**	**2**	**5**	**3**
Class discussion was well directed.	**0**	**0**	**1**	**4**	**6**
Class discussions contributed to my understanding of the material.	**0**	**0**	**1**	**6**	**4**
I feel comfortable speaking in discussion.	**0**	**0**	**1**	**5**	**5**
I feel comfortable asking questions in lecture.	**0**	**0**	**2**	**3**	**6**
Group work cramped my style.	**5**	**5**	**1**	**0**	**0**
Everyone in my group was able to contribute to the project.	**0**	**1**	**2**	**8**	**0**
Lecture prepared me for the homework assignments and labwork.	**0**	**0**	**3**	**3**	**5**
I am worried about my grade in this course.	**1**	**6**	**4**	**0**	**0**

2. What went well during this module? (i.e. what should we continue to do in the next few modules?)

- Practical applications and visual references = good
- We had an extra day to work in class.
- lectures helped understanding of material
- I really liked the addition of handouts. Also it seemed like the material was structured very well before it was presented to the class.
- I liked how much there was posted on ICON so that if I needed to refer back to something it was no problem. The powerpoint presentations that Ben had also were good visual help during lecture. I also really thought the homework built off eachother nicely. The first one really helped me to understand the second. I also liked how the last group projects were actually doable. In the previous ones the projects have been so hard that no one really finished but this time most of the groups were able to come up with a solution.
- everything
- The module continued to enhance my interest in modeling. It was interesting to actually see a model of something so important as groundwater. I think continuing the over set-up or structure of lectures and discussions should be continued.

- the handouts helped a lot, especially because they made sure we had the equations when we programmed. it was good to get help when on the programming to make sure we have the right code
- I enjoyed the visualization we had for this module. It made the ideas easier to grasp.
- I thought everything went well. The subject wasinteresting and practical, the homework contributed to understanding, and the projects gave us an impression of real world applications of the subject, however complicated they may be.
- Group projects went well.

3. What didn't go well during this module? (i.e. what should not do anymore?)

- Mini-projects are enjoyable, but we need more time to work on them, and understand the concepts fully. Maybe make the M-P's due a week later, but go ahead and start the next module (a day earlier to account for the presentation day), that would give us time to work on them.
- My partners and I didn't have time outside of class that we could meet to work together.
- a lot of programming, but works with help in office hours
- I don't know.
- The only thing I didn't really like were the printed packets that were handed out in class. All of that info was online so if you needed it you could always get it. And during class Ben had the same exact packet up on screen. I didn't really mind it much its just that I didn't really use them.
- nothing in particular
- I thought that my level of programming was not good enough to complete this project. I did not have enough time due to other classes to put in hours of outside class time to complete the code necessary to properly model the groundwater and wells.
- we could have used more time to program
- Better deployment of programs and data that we'll need to use in our miniprojects.
- Nothing stands out in my mind.
- Needed a little more background on programming matlab

4. How did the handouts help (or hinder) your understanding of the material and your ability to do the homework?

- Hand outs = good Two sided printing = awesome Not having to write, listen, read and understand simultaneously... priceless
- The handouts were extremely helpful, I couldn't have done the assignments without them.
- handouts helped understanding by allowing more visualization of tasks
- The additional handouts were definitely appreciated. They helped because I could focus less on taking notes and more on trying to understand the topic during lecture.
- Didn't really help or hinder either way only because they were online and I just looked there.
- helped immensely to have the class notes hard copy
- The handouts seemed to improve my overall understanding of the material, but the handouts did not completely help me in writing code for the model. The handouts did give overall help but not specific examples and aid for finishing the code and homework.
- the handouts were very helpful. the equations were sometimes hard to figure out but the handouts help
- The handouts were invaluable as a reference to the underlying math.
- The handouts were helpful, espesially after the first day's presentation was undermind b y the fire alarm.
- Handouts were good, they could have used more info on programming, though.

5. How are the miniprojects helping (or hurting) your understanding of the material?

- I like them (again, more time) otherwise working with the equations for a while helps me understand them more, only after time due you really see the connections
- The miniprojects makes the material sound in my mind. After the homeworks I don't really fell like I know what is going on, but after the projects I feel pretty confidient that I know what is happening.
- miniprojects help understanding, programming a bit confusing
- The miniprojects went very well. The great thing about the second project was that it strongly related to the group project. This made the group project pretty painless.
- The miniprojects really help bring everything together. I thought these mini projects were all interesting.
- miniprojects help to visualize all the mathy-ness
- The miniprojects are definitely helping my overall understanding of the material. While sometimes the miniprojects are not completed perfectly and can bring frustration, the miniprojects are interesting and exciting to work on.
- The miniprojects help a little, but it might help to walk us through them a little more
- I found our miniproject to be helpful. It built on the steady-state case, and extended it into the transient case, which improved my overall understanding of the model.
- I like the miniprojects, they get me thinking about actually using what we've learned to solve real problems or at least were to begin.
- mini projects are helpful in the sense that our we can get a great amount of help from others in our group.

6. How did this module (subsurface flow modeling) compare to the last two (collisions and traffic flow)?

- It more directly visual than traffic flow, collisions was also, this was my favorite module yet.
- This module was a little more difficult than the other two. The more difficult the problem is, the better I feel when I get it accomplished, though. I think I enjoyed this modele the most so far.
- i think this module was a little more in depth than the other two in terms of material throughout and the all homeworks and miniprojects directly related to work (not that others didnt but it was easier to see where we were going with the material).
- This module was great in that it a good portion of the class had working code in the end. It makes the project more gratifying when you are able to attain a concrete model.
- It was my favorite topic out of all three. I think this was because it actually seemed like this model could actually be used in everyday problems. Unlike the traffic one that just seemed to have infinetly many factors to take into account.
- this module was da best
- This module seemed to require a lot more programming then the previous modules. While I still get an overall grasp on the different modules, this previous module was frustrating when I was unable to complete the code.
- This one seemed somewhat better than the previous ones
- Even though the math was similar, I found this module much easier to get a handle on than the traffic flow. Probably since it was less abstract and more easily visualized. The math was more familiar than the complementarity stuff in the first module, though I enjoyed that one a lot, too.
- All three have been good, this time and in the traffic flow you gave us more time wtih our groups which was an improvment from the collisions.
- This module was much more programming intensive. I found this module to be one of the most demanding.

Appendix D. Epidemiology Module Results

This survey was given at the end of the subsurface flow module. Students were asked to anonymously complete the following questions on ICON. Results appear below exactly as they were entered online.

Nine of eleven students completed this survey.

1. Please select a value reflecting the extent to which you agree with the statement given.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of work in this module was appropriate	**0**	**0**	**1**	**7**	**1**
The level of programming that was required for the homework and projects was reasonable.	**0**	**1**	**0**	**6**	**2**
Class discussion was well directed.	**0**	**0**	**0**	**7**	**2**
Class discussions contributed to my understanding of the material.	**0**	**0**	**2**	**7**	**0**
I feel comfortable speaking in discussion.	**0**	**0**	**1**	**5**	**3**
I feel comfortable asking questions in lecture.	**0**	**0**	**1**	**6**	**2**
Group work cramped my style.	**3**	**4**	**2**	**0**	**0**
Everyone in my group was able to contribute to the project.	**0**	**1**	**0**	**6**	**2**
Lecture prepared me for the homework assignments and labwork.	**0**	**1**	**1**	**6**	**0**
I am worried about my grade in this course.	**1**	**1**	**2**	**4**	**0**

2. What went well during this module? (i.e. what should we continue to do in the next few modules?)

- Overall, it went ok. There was some good discussion and understanding.
- I thought it pretty much all went well. The topic was interesting. The real world applications of research in the area is clear, which is something I enjoy about this and all the topics we have examined.
- material was applicable and understandable, the "boxes" explained the formulas well, good module topic due to high "understandability"
- It is helpful when the main points of the lectures are emphasized. I felt that I could understand the key points of the lectures about the models even though I had trouble following all of what was being gone through. Summarizing at the end of lecture helps.
- The programs were easy to write
- definitions for each box were explained well.
- the programming in the homework was a lot more understandable than previous modules
- just about everything

3. What didn't go well during this module? (i.e. what should not do anymore?)

- It seemed rushed...more time could have been taken to discuss the sensitivity of the variables. The lecture by Profesor Stewart seemed rushed and not very relavant to the material. There were too many variables and writing and rushing through things. I really didn't understand Professor Stewart's lecture.
- I thought the last day of lecture, when Prof. Stewart ran through the math needed to solve the SIR model's varibles' sensitivities explicitly was a little fast. Furthermore, it might have been more useful to have seen the miniproject choises before that lecture. I understand that their was alot of math to get through and it was only a small part of the topic, and only directly applied to the one gorup's project but having that topicin mind before the lecture would have made the direction and purpose of the lecture easier to understand.
- I can't say that I followed Prof. Stewart's lecture on the matrix of Taylor expansion of something... It was impressive, but way over my head.
- The sensitivity method that Dr. Stewart derived was horribly difficult to follow during class. I was hoping we might get a chance to discuss some of the other methods to model epidemics or the other variables that are normally taken into account.
- There wasn't really any time to go to office hours for the miniproject since it was assigned right before break, and they were due right afterwards.
- We could always use some dancing girls (and more handouts)
- the only thing that didnt go very well was our project. the sensitivity model was tough to deal with "presentation-wise." Everyone was able to understand the project but presenting it in a manner understandable to class was difficult.
- nothing comes to mind

4. How are the miniprojects helping (or hurting) your understanding of the material?

- The miniproject didn't really seem to help my understanding of this module's material. The miniproject didn't really click with our group and it was hard to get concrete results without just guessing and checking.
- I think the mini projects are great. They let us dive a little deaper with out piling on the work and gives a scence of how much more complicated, (by that I also mean realistic,) the subject can get.
- They help. keep doing them, I'm not sure why I feel that way though
- The miniprojects seem to take some time that might be better spent making sure the concepts are thoroughly understood. They generally do help by making us think more deeply about the matter. Some of the miniprojects are especially difficult though and are hard to get a lot out of.
- The miniproject seemed like it was just another homework this time.
- give good understanding of the subject
- sensitivity was tough but understandable
- it's nice to be able to investigate the different specifics in the miniprojects... it definitely enhances understanding of the material

5. **How did this module (epidemiology) compare to the last three (collisions, traffic flow, and subsurface flow)?**
    - This module seemed rushed and cramped for time. It didn't seem as throughouly discussed as the other ones.
    - I thought the work amount was equivalent and the subject was ias nteresting.
    - This was another good topic due to applicability, though all of them have been understandable, this one has connections that are visible and readily apparent. keep this module for future classes!
    - It was somewhat difficult just because of how rushed it was. Ifelt that we didn't get a chance to ask many questions on the homework because we had advanced to the miniprojects before the homework was fully understood.
    - This model seemed easier to understand
    - this went better
    - good module, amount of work was appropriate, was not too difficult to understand
    - I thought this module produced some really cool graphs

Appendix E. End of Course Survey Results

Section 1. VIGRE related questions

The Department of Mathematics recently received a grant intended to help us "vertically integrate" our department —to encourage interaction between faculty, post-docs, graduate, and undergraduate students. The funding for this course was provided through this grant.

1. **Did this course help you 'vertically integrate?'**
   - Yes. This course has allowed me to have personal contact with faculty and graduate students more than any other course I have taken as of yet.
   - yes i think that the information coming from different viewpoints, including bed, ted, and prof. stewart, allowed for verical integration because of the different levels of thought processing and information presentation.
   - Yes..I was able to interact with graduate students and faculty.
   - I'm an undergraduate and I was able to get to know Ben and Ted very well. Also I felt very comfortable talking to Dr. Stewart. So yes this did help.
   - Yes, this one close to, if not the, most disscusion intensive mothematics course I've ever taken. Rather than strictly lecture, we offten had back and forth conversations between the students and the instructors as well as Prof. Stewart. This is also the only mathematics class I'd ever had with group projects and presentations, which gives a large back and forth between the instructors leading the class and the students leading the class.
   - This course helped me to interact with graduate studens and undergraduates more. By doing miniprojects with the same partners over and over allowed me to get to know them better, and divide the workload of the miniprojects according to the capabilities of the partners.
   - Absolutely, many levels of students were involved, and the different heirachies (sp?) of instruction were beneficial for overall subject comprehension
   - Yes, it was great to get to know my professors. This was made possible by the small class size and a project based curriculum.
   - The class was certainly very interactive between the instructors and students. Yes I felt vertically integrated (but still felt vertically challenged).
   - Yes, my other math courses have been stricktly lecture based with very little discussion behond clarification questions in this course we had a high degree of communication between the professor, the grad students instructing it, and more than average amongst the students them selves.
   - I do believe this course helped encourage interaction between faculty, post-docs, graduate, and undergrad students. this semester i talked to more prof's, t.a.'s etc. more than all previous semesters.

2. **One suggestion has been to include an upper-level undergraduate 'teaching assistant' in the course to help with assignments and programming. Do you think this would help, hurt, or not make a difference?**
   - Of course having another person in the class that knows the material well and is available to help would improve the class. If the assitant would be able to help wih assignements and programming, that would be very helpful.
   - I dont think it would make a difference unless this person had office hours different from the ben and teds scheduled office hours. It may help with certain aspects of the homework, but I dont think it would be particularly necessary.
   - This would definitely help as the course requires some programming experience
   - As long as someone like Ben or Ted was teaching this class I don't think that would be needed. They care enough about the students and are willing to help so a teaching assistent would just get in the way.
   - I don't think it could hurt. If nothing else, there would be four people, instead of three, walking around to help us on working days. Also, this TA might more closely understand the limits of another undergrad's programing ability.
   - An upper-level undergraduate "teaching assistant" would allow for more resources for the stuednts, and would probably help greatly with the assignments and programming, but the teaching assistant should not give out the answers, which could be hard for an undergraduate to do.
   - It would always be good to have more help with coding and homeworks
   - I think this would only help the course because the students seem to be of a variety of backgrounds. Many have strong programming skills while others are more firmly rooted in "pure math". Adding a TA would help alleviate some students' weaknesses.
   - There are two answers to this question:
     1) a TA would not be needed if office hours and accessibility to the instructors is kept at the same level as now.
     2) If the instructors restrict the availability for some reason, I believe a TA could benefit this course.
   - I think it would help, if the student is a proficent programmer. In that case there would be another body to work the room during work days for one, and second, assuming he or she were closer to the students experiance level in math and programming experiance (s)he might trouble shoot some problems before they arrise in the classroom.
   - This could help a lot, but I thought Ben and Ted were more than enough help on assignments and programming. Maybe if they wanted to lessen their workload...

3. **Do you feel prepared to begin working on problems related to the ones we examined in this class?**
    - I feel that I have a good idea of all of the concepts and approaches that we examined in the class but I don't feel that I have retained the specific mathematical skills to work on problems such as these without some sort of brush up. I think I am significantly more prepared to work on problems such as these than other problems that we have not examined.
    - Because of the phrasing of the question, yes. I would feel comfortable to begin working in a certain subject area, but I think more experience in the programming area would be necessary for me personally.
    - Yes I feel better prepared to create models for everyday things
    - Yes. This is part of the reason I joined the math club. I have gotten used to analyzing problems from a mathematical point of view.
    - Yes, absolutly, and I find myself thinking about other situations that are close to or related to the ones we have examined, and how the methods we used might coorespond to these.
    - I fell very prepared to work on simular mathematical modeling problems. If it weren't for this class, I would think about participating in the math modeling competition.
    - Yes, I feel prepared to BEGIN. This class has taught me what goes into setting up a mathematical model. Obviously, more training would be good, but I better understand the process now.
    - Yes, however a brief review at the beginning of the semester of the theory used throughout the course would be greatly appreciated.
    - I feel more prepared for certain modules (like traffic flow and epidemiology) but not prepared for others (like finance and collisions)
    - I do. I think that I could go on to learn about and work with higher or more exspanded problem levels with the subjects we looked at. Also, as we used ideas from the subsurface water module to approach the financil modul, I think I have a sertain number of tools developed with which to start my thinking if presented with a new topic.
    - Prepared enough to kind of know what's going on. or what some expected results might be.

4. **Has this course increased your interest in math in general?**
    - Maybe broudent would be a better word. I've always been interested in math but this class definatly exsposed my to some more practial and stimulation application out side of almost pure theory which has comprized my studies in the past.
    - my math interest has probably stayed the same, but it definitely showed me some of the cooler aspects of math.
    - I don't know if it has changed my interest in math a whole lot. It has changed my opinion of how mathematical problems are solved though and has made me appreciate the effort that has to go into solving mathematical application problems.
    - I have always been interested in math. I think what this course did in general was allow me to think about different problems from a new mathematical perspective.
    - Yes it has increased my interest somewhat
    - To be honest it made me glad I was an engineer. I like math, I find it interesting, I just prefer actually working with real materials and situations. But this class helped me realize that.
    - The majority ofmy math background has been theoretical, and while that can be interesting for me it was satisfying to study something more practical. I think a healthy mix of both is nessisary, so yes my interest has grown. Furthermore I think looking at some of the specific areas to study in math can give a better reason for a student to study math in the first place.
    - I was always very interested in math, but this course has shown me that I although I undrestand everything that we have done, I enjoy doing work in pure math more than applied.
    - Yes, prior to this couse, all of the math that I had leaned was very mechanical, this course made some of that knowledge applicable.
    - Yes!
    - Most certainly.

Section 2. Likert questions

In this section, students were asked to respond to each statement with a choice varying from "Strongly disagree" to "Strongly agree." Many of the statements chosen for this section were drawn from the standard end of term evaluations issued by the department of mathematics.

5. Please select the option that best describes your opinion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This course is organized well.	0	0	0	**7**	**4**
Concepts are presented in a manner that helps me learn.	0	0	**1**	**7**	**3**
My work is evaluated in ways that are helpful to my learning.	0	0	**2**	**7**	**2**
The instructors seem interested in teaching this course.	0	0	0	0	**11**
The instructors communicate well.	0	0	0	**2**	**9**
It is clear what the instructors consider important.	0	0	**1**	**7**	**3**
Class presentations are well organized.	0	0	**2**	**7**	**2**
Important points are clarified with good examples.	0	**1**	**2**	**5**	**3**
The instructors present materials clearly.	0	0	**1**	**6**	**4**
The instructors are effective in teaching the subject matter of this course.	0	0	0	**6**	**5**
Assignments contribute to my learning.	0	0	**1**	**5**	**5**
I have acquired a basic understanding of the subject area of this course.	0	0	0	**6**	**5**
I have been encouraged to think for myself.	0	0	0	**2**	**9**
The instructors are available during office hours.	0	0	0	**3**	**8**
The amount of work in this course was appropriate.	0	0	0	**4**	**7**
The level of programming that was required for the homework and projects was reasonable.	0	**2**	**4**	**3**	**2**
Class discussion was well directed.	0	0	0	**5**	**6**
Class discussions contributed to my understanding of the material.	0	0	0	**6**	**4**
I feel comfortable speaking in discussion.	0	0	**1**	**4**	**6**
I feel comfortable asking questions in lecture.	0	0	**1**	**4**	**6**
Lecture prepared me for the homework assignments and labwork.	0	**2**	0	**8**	**1**
I am interested in taking more math courses.	0	**2**	**1**	**3**	**5**
I would recommend this course to classmates.	0	0	**1**	**3**	**7**
I would recommend these instructors to classmates.	0	0	0	0	**11**

Section 3. Directed Questions

6. **Our intent in this course was to present a variety of topics in applied mathematics, develop basic models for those problems, and give you the opportunity to experiment with the models. Our goal was to give you the fundamental preparation to address these types of problems in industry (your future jobs) or in academia (as potential independent research projects). Do you feel prepared?**
    - I think, again, with more programming experience I would feel prepared. I was able to understand almost all of the straight math concepts, but it was the link between the math and actually creating a functioning program that I struggled with.
    - Yes I feel prepared to at least attempt to solve problems or do research on these topics. This course did a good job of at leaslt attempting to give everyone a taste of math modeling.
    - I definatly feel more prepared than before I took this class. I had no idea some of the ways problems were analyzed. I found it interesting to get the math point of view instead of only and engineering point of view which is all I get.
    - Yes. It is obvious that any specific field wuold require an amount of familiarizing with the underliing mathematical theories but I feel confident in my ability to be tough those and then to use them to solve poblems.
    - As I mentioned somewhere earlier, I do feel prepared to do more modeling problems, and will most likely participate in the upcoming math modeling competition. If it weren't for the class, I would have had no clue how to approach similar problems. Now I feel like I could formulate a reasonalble plan of action to solve some future problem, whether it would be correct or not is a different story. Learning more math will fix that.
    - Yes, I am now much more prepared than I was before this class.
    - Yes
    - I feel that I have a general understanding of the topic but would not be confident taking on certain modules on my own without more practice.
    - Yes. I could work deeper in either work or research with these subjects and I also think I would have a practiacl starting point with which to approach new topics.
    - I feel a lot more prepared in the aspect that I know what to expect. I know the basic process for modeling different problems, and the approximate amount of work and collaboration required to get a good start.
    - I do not know if I feel prpared to look at more complex problems yet, but I do think that the course has prepared me to utililze mathematical models and continue examining new mathematical strategies. I feel far more comfortable developing strategies for models than actually making programs.

7. **In designing each module, we tried to follow a set framework when deciding how much lecture, lab, and discussion should be included. (You may have noticed that the first three days of each module were always lecture, followed by a lab day and a discussion day.) Was this effective?**
    - I think that lectures could be shortened to give more time for the homework or perhaps a homework could be cut out of each module in order to make sure that concepts are fully understood. A little more emphasis on general ideas and methods would make things clearer than dealing with variables and equations so much during lecture.
    - The schedule was effective for the most part. I think the first days of the modules (while it was nice to take a short break to intro new subject) would be better spent integrated with the next two and then spending an extra day or half day in the lab.
    - Sort of... I thought that more time could have been spent in the lab.
    - Yes. I think you have to have the first couple days just to get everyone familiar with the topic. I liked this.
    - Yes. Corresponding to my previous answer, first the groud work of the area of research must be layed to give us a starting point. I particullaly like the first day of each module when we list what we think would be inmortant to have in a model for the problem type we will be looking at. SImilarly it seemed like the last day of each module we talked about some of the other applications or dirrections posible of the things we were studying, and I thought that was positive.
    - Given the number of modules and the number of weeks, this was the best way to do it. In each of the modules I felt like we could have used another lab day or two inorder to ask questions and get things going before the miniprojects. Unfortunately, my group was always still working on the homework when we were down in the lab for the schudled day to be working on the mini-projects, so it became increasingly difficult to find time where we could work as a group on the mini-projects.
    - Yes, the format was effective. Sometimes the transition from lecture to homework was too abrupt. I would have liked a bit more explaination about how to actually squish reality into the derived equations and vice versa.
    - Yes, I liked the structure of the course.
    - following a framework is a great idea but I felt like we should have spent more "hands on" time in the lab.
    - It was, it might be more effective to tell the next class that up front so they have a better sense of how where each lecture it moving them and when to exspect ot be in the lab.
    - This was a pretty effective way of organizing the classwork... I can't think of any ways to improve on it, other than maybe an extra lab day. or like a "discussion" type section of the class that focuses on the ever-popular matlab portion of the class.

8. **In preparing for the course, we planned for three weeks to cover each module. Was this enough time? Would you have liked to have seen more topics in less depth, fewer topics in greater depth, or did we do okay?**
    - I think that the amount of time on each project was ok, but things seemed very rushed toward the end of the modules when homeworks were due and presentations had to be made. If 1 unit was cut out that would ease things a bit. Otherwise a little reorganizations of the modules could fix it to.
    - For the most part, I think there was enough time for everything. I would have liked to have some more time on a few of the projects and I think there were a few days in lecture where we may have gone too in depth for my complete understanding.
    - I think for the first 3 modules the time spent was the right amount of time. The last 2 modules seemed rushed and I felt that not as much time was spent going in depth on these modules. The idea of 3 weeks for each module is about right. Time to lecture, discuss and then implement
    - For each of our topics, an entire semester could easily have been spent on just that one. I like how they only allowed three weeks for each topic. It kept stuff from getting way too complicated.
    - I don't think that more topics would be better, becasue we really didn't dive terribly deep as it was. However I also think that having a varriety of topics was positive, as a survey of the many tyopes of research in mathematics. Thus I think five modules was just right.
    - I think you did ok. It would have been interesting to go more in depth, but not everyone undersatands or likes the same topics, so maybe one fewer topic would be helpful in giving a few extra days on the other modules in the lab. Presenting more topics in less depth would make it harder to fully understand what was going on. In each module, the mini-project was what made me feel like I understood what was going on.
    - It was ok, I would have preferred maybe 3 or four topics in more detail (or at least more time -in class- to work on the assignments and projects.
    - I would have like to see less topics in more depth. I think it is more beneficial to fully divulge into a given topic in order to fully understand it rather than graze over several topics. Often it seemed like we had difficulty in moving on to a new topic because people were still working out the kinks in a different topic.
    - this seemed to be the right amount of time.
    - It was, I thought it was perfect. I certainly don't think that more topics in less depth would be positive. We took the subject to a first and second step with the homeworks and then to a brouder third with the projects and I wouldn't sugest any less. On the flip side I enjoyed the veriety, it kept things interesting. If someone happend to be completley stumped we would move on every three weeks, unlike in a traditonal class where day one leads to day two leads to and so on to the last day where missing one idea can continue to be detramental the rest of the class. Not that the skills we developed early didn't help us latter. If anything doing four modules would be acceptable for a little more depth and for not crunching the last one, but I by no means am suggesting that.
    - i think the time spent and the depth was just about perfect for the modules. i think i would have started getting really lost if we saw fewer topics on less depth and i probably would have gotten bored or just overloaded if there were more topics in less depth.

9. **If you were to suggest prerequisites for this course, what would they be? (i.e. what do you wish you had taken before you took this course?)**
    - I felt that I would have been more prepared for the course if I had had some previous background in the strategies we used to solve some of the problems. I had no idea what the finite difference strategy was and I felt sort of thrown into the units that relied on it because the math behind it was difficult to understand.
    - Calc 2
      programming of some sort (even though i took eps2 i was still a little lost on a lot of the programming because the work we did in class was more abstract than anything learned from basic programming)
    - Some more programming courses...there was more programming required than I thought would be
    - Definatly Calc 2. and probably Differential Eqns. are too good ones to be very familiar with. As well as Matrix Algebra.
    - It might have been easier if I had had more programming before this class but I don't really think a programing class should be a pre req. because it would narrow the field of students that might take the class to much. I wouldn't have taken the course if this were the case, and I feel like I have learned some programming along the way. A better question might be, what classes below this one in the math department should have tought more matlab coding. Other than that, if they weren't allready, calc I-III or equivelent and matrix algebra are a must.
    - It was helpful for me to be taking an ODE class at the same time. Otherwise, just some calculus and maybe a programming class or two.
    - differential equations, and some sort of intro to programming in matlab or C. I had taken programming, and took diff eq simultaneously, and found that my programming experience helped alot. I began to understand the math more once we got farther along in diff eq (so I definately think diff eq should be a pre-req)
    - Through differential equations.
    - A dedicated programming course (not EPS 2) along with differential equations.
    - I felt ill equiped programming wise, but I got through it, and requireing a programming clas might be eccesive and to limiting to the people interested in the class. I realize its beyond the reaches of this survey but I think the best resolve would be better teaching basic MATLAB in calc. Its admitedly been year sense I had it, but we mearly through matlab up occationaly to graph something, and the instructor did the coding so we really weren't forced to learn the program.
    - any course that was matlab intensive

10. What could we do to get more students like you interested in this course?

- It would be helpful if the class had some sort of theme each time it was taught. Engineering, biology, or business problems could be emphasized in seperate semesters. THis would attract students from these ares. Otherwise the course is going to naturally appeal more to math students.
- The only way would be to explain the full benefit of the course. Such as...this course offers deviation from normal math courses and thought processes that go along with them. This course will count toward a math minor, and no tests are required.
- I'm not exactly sure...as an engineer I saw it as a good way to be on a higher math level and to earn credit for a math minor...that could be an advertising idea
- I really don't think it would be that hard. I know you could get a ton of engineering students to sign up for it if it was made known that this class counts towards your math minor.
- Honestly I would have taken this course before now if I had had the chance.
- The class should be advertised more, and maybe push the fact that there are only projects and no exams.
- There are no other students quite like me. Dancing girls would help, otherwise continue to tell engineering students that they will learn how to apply all of the math they have been studying (and that they can get a math minor), That was a big factor for me.
- Recruit some engineering. The freshmen or sophomore engineering seminar might be a good place to look.
- I think you could get more students interested if you highlight the fact that this is an applied research class, and continue to focus on real life topics (perhaps study models that apply to college age students such as sports or entertainment?)
- I think a summer on isis that is specific and suggests the practicallity of the class of theory would be enough.
- hand out fliers?

11. Would you be interested in taking more courses in applied mathematics?

- I probably will not take any more classes in applied mathematics because I will not have room in my schedule and the types of problems examined probably will not relate to my areas of study. If I do decide to take more math, it will probably be applied as opposed to pure.
- I would with more matlab programming experience.
- Yes...depending on what prerequisites were required and what experience and knowledge of programming and higher mathematics.
- No. This class was interesting but just not for me. I much prefer physics related stuff.
- Yes, even having a second semester set up the same , but with five different modules would interest me.
- I am interested in areas of applied math, and will most likely take more classes, but I am more interested in pure math courses.
- Possibly, based on my experience with this class. Yet...probably not, based on the fact that I have been taking math classes for years, and I am actually in school to study engineering (no offense ;-)
- No, I look forward to focusing in on engineering courses.
- Yes
- Absolutly.
- possibly

12. How did homework assignments and group mini-projects contribute to your understanding of class materials?

- They helped us see visually what goes on within a model, however at times the course felt a litle too much like a programming course. The pseudocoding was especially helpful in that it made us look at the problems systemaically.
- The assignments and projects acted as extensions of the lecture into the more intricate process of actually obtaining a solution, and I think the whole process helped my understanding.
- They seemed to work well in bringing everything together. I thought more time could have been spent on the projects and clearly understanding the material for those. But overall they did a good job in testing the material learned in lecture and bringing in the lab and getting results.
- They really are what got the points across to me. Lecture was great and all but in order to really grasp the whole concept I had to work through it.
- The homework made us put into practice what we had been learning and in a way similar to how a reel reasearcher would be looking at these problems, jsut at an introductory level. I thought the mini-projects were the best part. They allow us to take what we have learned and apply it towards grander problems, especially when the actually programming is unpractical, at least we have ideas about it, approaches, and disscuss them as a class.
- If it weren't for the homeworks or miniprojects, I never would have fully grasped why we were doing the model, and what was important about it.
- Applying the material that we have been learning is always good, making graphs come to life helps understand the mechanisms behind them
- The individual homework assignments were much more beneficial to me. They seemed structured very well and were excellent in pointing us in right direction for our group projects. I think more individual homework assignments would help the students grasp the material better in the future.
- I learned more from group assignments because I was able to get help from my classmates as well as the instructors. Homeworks were sometimes difficult, which made it tough to gain anything from them.
- Well. Ususally the first homework was well layed out by the lectures, then we had to build on it with a little more independent thinking, then the mini-projects called for even more, but also were flexable enough to bypass our programming short comming and just talk about and speculate how a bigger problem chould be tackled.
- those both helped a lot... it's one thing to hear someone explain the class material, it's a whole different ball game to actually apply it yourself. the mini-projects were especially beneficial to work with others closely and bounce off ideas

13. Which module(s) do you feel you understood most clearly? Why?

- I felt that I understood the epidemiology model very well. This is because there was an easy way to visualize what was happening. THe flow chart and corresponding inputs and outputs was very helpful to my understanding. SOme of the other modules were a bit more difficult to interpret and the math behind them was difficult to understand and remember at times. The epidemiology model allowed us to refer easily back to the math at any time.
- I think I understood collisions and subsurface flow the most because I was able to pick up the math behind the bigger ideas alot faster than some of the other modules.
- I felt I understood the traffic flow module the best. It did not require as much programming as the others. It seemed to be easier to understand what the model was saying than the others. It may be an isolated thing that maybe traffic flow just was more interesting to me.
- The Epidemiology one. The concepts were equally as difficult as the other topics but at the same time they could be simplified back to SIS or SIRS. For some reason, just having this starting point helped me to visualize things better.
- The epidemiology. It might just simply be because it was the last one, becasue I didn't seem to have so many issues in programming, and all mine and our models were very clear and practical. This module also related about the best to real situations that I can not only immagine but I have lived through every fall/winter sense I was born; the cold season.
- I understood the Epidemology model the most, because it was just solving a differential equation and matlab has this neat ODE solver that made the programming easy to deal with.
- groundwater flow, epidemiology, and stock options; I guess because I can understand the underlying patterns fairly easily
- I understood the collisions module most clearly probably because it is very easy to visualize. Everyone has some intuition of what is likely to happen when two objects collide. It was a great first module.
- Traffic flow. I felt like this was the easiest to understand, perhaps because of the obvious real life situations concerning this module. I was able to visualize more with this topic than any other.
- Epidemiology. It might very well be becasue it was the last full module, and my skills were the better developed going into it than in the past three, but I also found it extremly easy to relate to, and imagin in practical terms. Everybody deals with catching this or that, half the students in the class probably had cold as we sat disscussing it. Not that most of us can't relate to traffic jams either but, while I am not saying I disliked any of them, groundwater, collisions, and stock options his a little less close to home.
- traffic and collision - they were subjects that i was most familiar with

14. What other areas of applied mathematics would you be interested in studying if you were to take this course again?

- I would be interesed in developing some biologically significant models and perhaps some human resource management models.
- I would actually like to go more into the finance area. Even though I am still having trouble getting my homework finished (...programming), the fact that I am learning about the math concepts behind making money is intriguing.
- I'm not sure about what other areas of applied mathematics there are.
- I would personally like to see something dealing with sound and soundwaves. Either how they travel or how new technology can focus them into beams.
- I think population modeling could be interesting, both of people and animals. A module of some basic actuarial science might be interesting as well.
- I have no idea what other areas of applied math would be interesting. Focusing on some area of computer science would be intersting.
- I could learn more about stock options and groundwater flow, otherwise, predicting winning lottery numbers, forecasting elections, etc. seem interesting
- Animal or bacterial population modeling
- unknown
- I think population growth, or decline could be intersting. Or perhaps actuarial studies, insurance rates or probability based life expectancies, ect. Furthermore physics or astro physics would both be facinating topics.
- i don't know enough about applied mathematics to know any other areas

15. What did we do well this semester?

- I thought the best thing about the clas was the personal attention that was available to all students. It was good to have wel prepared visual presentations.
- The best thing you guys did during the semester was the extra help in office hours which allowed to accomplish the homework and understand the material a lot more than what I would have.
- You did a great job of answer questions and being excited to teach this material. I felt like you really wanted me to understand the modules and did the best you could to see that we understood them
- Everytime I needed help there was someone there to help me. The hands-down best part about this class was that there were three professors that all spoke English and they all could communicate well. I think without that, this class would have been almost impossible. The instructors are what made this class work.
- The subjects were appropret and stimulating, and the instructores seemed very interested and excited about everything.
- You presented the material in a structured and clear manner. You were available and enthusiastic about helping me during office hours.
- One thing I really liked was the relaxed attitude of this class, if more classes were like that, I would enjoy college more. I also liked the three-professors aspect, more veiwpoints are always good
- All three professors seemed to enjoy coming to class and talking about each topic. This positive attitude was definitely contagious.
- Explaining the traffic flow module went well. I was able to grasp most of what was said which proved helpful during the programming excercise. Ben proved to be very knowledgeable on the subject of finance which was very impressive, unfortunately the time period we had to cover this subject was not enough. All instructors were very willing to take the time to explain what was being taught.
- I liked the class set up, I liked the topics, and I have complained aobut programming but the truth is I am a better MATLAB programmer now than when I started and I appreciate that.
- the layout of the course, the module topics, the lectures
  these were all great, i thought.

16. What did we do poorly this semester?

- Sometimes the math and goal of the module got muddled and it was easy o end up confused. I felt a little thrown into the homeworks.
- I think sometimes you would get carried away in some of the in depth lectures. Not that what you were talking about was bad...just hard to understand.
- I felt that programming was a bigger part of the course than I anticipated. I felt that more time needed to be spent on the miniprojects than in the room lecturing and discussing
- Sometimes the programing was a little rediculous. haha. Oh Ted. But even when it was, someone was there to help me figure it out.
- Sometimes things seemd a little disorganized but I don't think there was nay huge problem, just small things that would probably dissapear if you teach the class again, in fact from the first to the last module the class improved. Also, sense we don't have any test, and most of our homeworks are handed in through icon, I would have like to have a better idea of where I stood grade wise. I assumed I was doing well but I didn't know for sure. Here's hoping!
- I never felt like we had enough time in the lab to do the homeworks, the miniprojects, the final project and this last survey. This survey is going to take an hour to fill out.
- Smooth out the segue between abstract lecture, and applying the material on homeworks. Some of us still have our math training wheels on, and require slow tedious transitions when setting up initial equations. I usually had the theory, and understood the assignment, I just often had a hard time seeing how to modify the theory interpret its meaning, then apply it to our given problem (even though you often walked us through it).
- The derivations of the models could have been broken down further. Reintorducing the some of the math used in the derivations would have helped.
- I did not fell adequately prepared for programming in Matlab. It would have been helpful to have taken one day to cover at least the very basics of Matlab early on in the course. Also, I thought we could have used more examples of what type of program we were to write. There were times when some folks did not have a clue on how to begin the programming.
- Some times things seemed a little disorganized but considering it is the first time the course was tought I imagine it will be better in the future. Getting the homeworks and mini projects up sooner so we can have the problems in mind, even if we don't know which one we will be working on, during some of the latter lectures would have been helpfull in a couple of the modules.
- i don't think there was anything i would classify as "poorly" i always thought that the matlab was a little too advanced for me to do by myself. so maybe having almost all the assignments have to do with matlab could be considered a little bad.

17. How do you feel we responded to your needs/requests?

- just fine...example...extra time on last homework (especially after ice storm)
- I felt like you did a good job of responding to the surveys we filled out. You tried to fix or do things differently to the best of your abilities when we requested them
- Great. Even from one module to the next. I remember asking in the first module if there could be much more visual stuff presented. This was implemented immediatly in all the rest of the modules.
- Very well, the surveys at the end of each module were excelent. Our feed back on the class, to me seemed well paced this way giving you guys time to adjust, and I can't think of any specific reoccuring problems form one module to the other.
- You responded as best you could given that this is the first time this class is offered. For some of the mini-projects notes were not available, and sometimes the lectures covered the material too quicly.
- Very well (although we're still waiting for the dancing girls)
- Awsome! Either Ben and Ted were always helpful on short notice and were very accessible at their office hours.
- the response was noticeable.
- Well. It was clear that you guys were reading out surveys after each modules and consciously trying to improve and succeding at that.
- promptly and adequately

18. Which class meeting type (lecture, presentation, discussion, lab) helped you the most? the least?

- Discussiong washelpful because it let us ask questions when we needed to. Lab ended up beeing a little frusterating since 1 hour did not seem like enoughtime to get a good start on the projects and get to the point where questions could be asked.
- discussion and lab helped the most for the required tasks because we actually had to deal with the problem at hand during these times.
- Lecture = least....harder to understand the modules through words and equations.
  Lab = most...able to see the model working in real life and what the equations were meant to produce and show to us
- Its really hard to say for this. For some of the modules I learned best when I was with my group, for others it was lecture, and sometimes when another group was presenting it made something click.
- I can't say, I thought the mix was important and well propotioned.
- The lab meetings were the most valuable for me. During the lectures I knew the lest, but lab would not have been very helpful without it. I don't think there was a least helpful part of the class.
- lab and discussion, I learn by doing, then learn more by seeing what I did wrong. Other students often had interesting ways of solving problems. The group work was good in this class (some classes it makes things worse, but it really helped in this one)
- Definitely the lab. It gave us opportunities to think about our model, make mistakes and corrections, and eventually iron out the details of the model.
- Lab helped me the most because I am more of a hands on type of person.
  least was presentation, although this was fun.
- I couldn't say, I thought it was well balanced, and I wouldn't want to see any of them cut in favor of more of another.
- most - presentation
  least - lab
  not that lab is bad, just that lab means matlab and that means i get lost

19. What did you think of the pacing of the course?

- I think the course moved a little slowly at the beginning of each module and was a litle fast at the end. I don't know exactly what can be done to fix this.
- The pacing was fine for the time allowed...see #8
- The pacing was good until the end of the semester when things began to feel rushed and hurried.
- Fast, but not too fast. I liked the pace because if you really didn't like a module you only had to deal with it for 3 weeks. Anyone can deal with something like that for 3 weeks.
- It was well paced it moved quickly, but becasue it didnt' exactly have costantly mounting matierial, where day one leads to day two ...right to the last day, it was ok to more fast. If a student didn't 100% get the last day of the traffic module it didn't reduse his or her chance of getting the finance homework done.
- The pace was a little quick, but we knew that was going to happen. Again, a couple more days in the lab would be very helpful.
- It was OK, I would have liked to spend more time analyzing the material that we covered. So, less modules, with more time on each, but not necessarily more detail, just more discussion of it.
- It may have been too fast (or it may just seem fast with all the work I have in other classes). I would have liked to break down each model and totally grasp it before moving on.
- pacing is fine, as stated above, you should allow for one day to cover programming basics.
- It was nice. Some times things moved quickly but sense the latter and harder issues were attacked by groups and becasue we started new topics quicly too, I don't think people were getting left behind.
- i thought the pacing was pretty spot on for the depth we ventured to in each module.

20. How does the format of this course compare to other math courses you've taken?

- I like the format of this class because it is more relaxed, allowed for questions and personal help, and didn't bring the stress of exams. It was more easily juggled with otehr classes since it was flexible.
- Completely different because the rest of the math courses that I have had were the basic progression of learning a new type of math, while this course helped apply the math.
- It is new and interesting. I really liked the change of scenery from lecturing to in the lab to discusssing. It gave a new way to learn and understand math.
- I loved it. For Matrix Algebra, Calc, Diff EQ, ..., I learned how to work problems but never had a clue as to what they were used for or good for. For this class it was the concept that was taught first followed by the math. I have never taken a math class at Iowa where I could actually understand and communicate with my professor. It was awesome to finally have someone who could teach.
- It's very differn't but I think that is positive. The day after day lecture of most math classes is nessisary for many subjects but research isn't about resighting theory, its about getting new, helpful, and accurat results and thats the path we were on.
- I haven't taken any other math courses that have done projects, or modules. However, I have taken Computer Science courses that did sections in a similar manner.
- It is way better, it does not even compare. most math classes are too mechanical and formulaic (pun intended)
- The format of this course is very different from any other class I have ever taken in that it was very project oriented.
- This format is more conducive to learning because of the time spent working in the lab on real topics like traffic flow and finance.
- Unlike any others I've taken. I'm not cursing my classes of almost pure theory but most classes are just that, and dabbled with short examples of applications. Here we are given only the theory we need to get started than we are right on to realistic problems. Having both theory and practice is important, both in this class and in a coriculam. I think this class more than anyother gave me ideas of what I could do with my education in job or in research.
- completely different, and quite enjoyable.
  a nice change

21. How does the content of this course compare to other courses you've taken?

- the content in this was different in that it was a lot more hadns on and pertained to specific problems whereas other courses focus on general princples. This couse focused on case studies.
- This course offers a new way to look at problems that we have faced in other courses.
- It is very new and interesting and exciting. I really enjoyed implementing models to depict real life problems and real life events.
- Some of it like the collisions module and the fluid flow module were similar which was good because I could relate to them. The other ones like the Epidemiology module I have never had anything like that but that was interesting too.
- We didn't som much produce answers, we produced stradigies for producing answers. Other classes expect students to learn the latter while doing the former, in this course it was dirrect.
- The content of this course is similar to some Computer Science courses I've taken in that we do small modules throughout the semseter and each module is independent of the others.
- It is actually applicable
- The mathematical depth that this course goes into far excedes that of my other engineering classes and the physical depth far excedes that of my other math classes.
- content was interesting
- The types of math used spanned many classes contents, algebra, geometry, calc, and differentials, more probably if I thought about it long enough. The applications of these to realistic problems was unique.
- way more interesting and easier to try to learn

22. How did the group projects help (or hurt) your learning?

- The group projects hurt the ability to focus on the homeworks, but they did give us experience doing some of the more complex problems that we may be faced with in the future if we continue math research.
- The group projects helped my understanding unless the project was something that we had no hope of accomplishing. A few of them were a bit to in-depth for the time allowed.
- The group projects definitely helped our learning...giving us a chance to better understand the module and to put everything together in what you guys wanted us to understand. It allowed us to go more in depth and see the models working on more intricate and detailed problems. It was difficult at times to see how important the group projects were because not as much time was spent on them.
- I liked how the same groups were kept the whole semester. By the end everyone knew what everyone else was good at and we could really get stuff done. Just ideas over with other people really helped me to learn.
- they are extremly helpful. they give us a chance to approach hader uses of what we learned even if we can't acctually finish the problem.
- Group projects helped my learning, but working with my partners wasn't always benificial. I think that in the future if groups do not have an even number of people working in them, then either the group with the least number of people should have the simplier project, or people should be rotated so that one group is not always stuck with less people doing more work.
- I liked them, each student seemed to have strong and weak points, so all were able to help all
- It was great to be able to apply the model and to get something tangible out of it.
- I enjoyed the goup projects because I was able to learn from my peers as well as the instructors
- They helped. They got us thinking about larger applications of what we had learned with out limiting us to any one persone short commings or to our overall limits of programming or math.
- they helped by being able to work together and have peers explain ways that they interpret things

23. How did the handouts help (or hurt) your learning?

- The handouts helped a lot because they gave us something to refer back to. This way difficult equations were always at our disposal. It would help if they contained more general information on programming and had less emphasis on the difficult equations.
- the handouts offered a good reference point while doing the homework or projects.
- The handouts really didn't help or hurt learning...they maybe reinforced this talked about in class and on the homwork
- I was not a fan of the handouts. I would much rather have someone present and then write down the key equations or concepts when appropriate.
- In the epidemiology module we were given a handout that listed what all the veriables where and some of the equations and I thought it made the homework easier having it right beside my notes as I flipped around. If posible I would make a similar hand out for each unit. The programing basics was helpful and you couldn't go wrong by exspanding on it a little. We didn't always need the powerpoint handouts. I'd say putting them online would be good enought.
- The handouts were extremely helpful. Without the handouts, I whouldn't have been able to do the homeworks or mini-projects because taking notes in class wasn't always possible due to how quickly the lectures were going.
- They were good (and two sided, awesome)
- The handouts were greatly appreciated. I could focus more on the speaker and the material by simply notating the handouts.
- Handouts were lacking in many respects. First, I thought there should have been more examples of programming or derivations in each module. Second, it would have been helpful to have references in the handouts.
- They were certainly never harmful. I liked the handout in the epidemiology module that had a layout of all the variables and some of the asic equations on one side of one sheet. I had it out and beside me every lecture and always while I was working on the comp. Making a sheet like that for every module would be great. As for the notes, I don' thin it was nessisary to print them out if you can get them up on icon before we start on the homework they apply to. We don't need them during the lectures on powerpoint, or even before. We can pay attention and take notes then when we start on the homework we can pull up the notes as we need. A slightly exspanded volume of the programming basics might be productive.
- handouts were helpful in just being able to follow along and write notes right on the class notes

24. What could be done to better organize the course?

- I liked the general organizaion of the class. A little experimenting could determine the specific changes that would be helpful to each module.
- I think the most important thing would be to allow for an extra day in the lab when necessary, b/c when you dont have enough time to spend on homework and struggle to finish, it really hinders understanding of the material
- I think more time could be spent on projects and homework...rather than spending the majority of the time on theory and equations...spend more time on implementing and visualizing and showing the actually models in action.
- I would like to see the homework and projects graded faster but thats about it.
- I think telling students up front the format of three lecuterday then a lab day ect. would be good, so they have a scense of where things are going even if it is slight, thus we know when to exspect to start working on homework and when, even if it isn't due yet, we need to have something done on the homework so we can disscus it in class.
- I feel like the course was organized very well. We always knew what was coming next.
- dancing girls with huge syllabusses (that way we all know the schedule)
- Four modules may be a more appropriate number to shoot for rather than five
- better references, better examples, a quick intro to programming.
- Laying out the internall day by day exspectations of the modules might help, so the student can say to them selves this is the last day before we will be in the lab, I better know what the first homework is so I can be thinking about it during the lecture.
- I think the only thing i would have liked better was an extra meeting time "discussion section" if you will that focused on specific topics in matlab that would help with homework. or something along those lines.

25. If you have any additional comments or suggestions, please communticate them to us in the following open space.

- Good job teaching the course! The only thing that could be worrisome to someone taking the class in order just to gain more exposure to math research would be grading. The class seems most effective when it feels like a seminar and it may discourage people who aren't very math proficient from taking it if they are going to be taking 3 graded credit hours. I really enjoyed being exposed to such a diverse aray of stuff. My friends were all really impressed by the types of topics that we examined when I told them!
- dont buy google...its bound to crash sometime
- I really enjoyed this class. It was new and exciting material. I liked modeling real life problems...it gave us a chance to see the importance of math and modeling in the real world. Thank you so much for a great semester.
- Thanks for everything Ben, Ted, and Prof. Stewart. I really enjoyed your class.
- If in the future no additional undergrad TA is added I think the course shold be limitted to aprox. the number of students we had, orthe neighborhood of 12-15. I think many more wold have worked against the vertical integration and would have made assistance during work days scarse.
- This survey took too long to fill out. If it was broken up into two surveys that were given out on different days, then I fell like I could have answered the questions better, or more completely. Otherwise, I think I have mentioned everything.
- keep up the good work, I really enjoyed this class overall, and I am glad to see that you guys are interested in teaching it. This University would be a better place if more classes were staffed by people with your attitudes / enthusiasm.
- This course was a very positive experience. In fact, it was the only class that I enjoyed so much I didn't miss a class all year. That being said, I am skeptical about the long term success of this course because I believe it succeeded due to the superior ability of its professors. Any other math professor that I have encountered thus far would have difficulty in "entertaining" an undergraduate audience with the material of this course.
- Great job overall. All intructors were very knowledgeable on the subject which was impressive.
- Grades a little sooner may also have been helpful to indecate the level of work you exspected. I turned in all the homework and figgured I was doing well, and each mini project I figured was equivalent of how succesful we were as the one before, but if my group was doing B- work on the first module I had no way of knowing, and continued at the same level, without being able to say, hey guys and gals we need to step it up here. However, if that were the case, i figure you guys would have said something to indecate it.
- making math interesting is a good thing!

Appendix F. Supplemental Materials

Syllabus

Introduction to Mathematics Research
Course Syllabus
22M:096
3:30-4:20 MWF—room 118 MLH—Fall 2007

COURSE SUPERVISOR: David Stewart
Office: 325B MLH
Office Hours: To Be Determined
Phone / e-mail: 335-3832 / dstewart@math.uiowa.edu

INSTRUCTORS: Ben Galluzzo & Ted Wendt
Offices: 225N MLH (Ben) and 25N MLH (Ted)
Office Hours: Monday & Wednesday 1:15-2:15 (or by appointment)
Phone / e-mail: 335-3767 / bgalluzz@math.uiowa.edu and
335-3719 / twendt@math.uiowa.edu
course website: http://icon.uiowa.edu (login with hawk-id and password)

Course Materials: There is no required text for this course. Lecture notes, in-class presentations, and computer programs will be made available to students as needed on the course website (ICON). Class assignments may require student submission of a MATLAB computer program. MATLAB is available for student use in the Math Department's computer lab (room B5 MLH, located in MLH basement) as well as by remote access through a student math department account. A student version of MATLAB (Release 14) for use on a personal computer is available for purchase at the IMU bookstore for $99 (NOT REQUIRED).

Course Description and Prerequisites: This is an applied mathematics course designed to introduce students to current methods of real world math modeling by focusing on the development, implementation, critique, and analysis of mathematical models in a topic-by-topic setting. Planned topics include modeling collisions, groundwater flow, traffic flow, spread of infectious disease, hub optimization, and (potentially) mathematical finance. Each topic will serve as the focus of a three week module. This course is intended for undergraduate students with a strong background in calculus, specifically those students having earned an A or B in Calculus II.

Course Work and Grading: Within each module there will be two homework assignments and one group mini-project. A final group project will be presented in class at the end of the semester. Semester grades will be based on the following distribution:

Class Participation	**30%**
Individual Homework	**30%**
Group Assignments	**30%**
Final Group Project	**10%**

- Due to the importance of class participation in determination of a final grade, it is very important that you notify the course teaching staff of any planned absences in advance.
- All programmed homework and group assignments must be submitted electronically to the ICON "Dropbox" by **12:00 noon** on the day it is due.

This course is given by the College of Liberal Arts and Sciences. This means that class policies on matters such as requirements, grading, and sanctions for academic dishonesty are governed by the College of Liberal Arts and Sciences. Students wishing to add or drop this course after the official deadline must receive the approval of the Dean of the College of Liberal Arts and Sciences. Details of the University policy of cross enrollments may be found at:
http://www.uiowa.edu/~provost/deos/crossenroll.doc

Important Notice: Information concerning Student Rights and Responsibilities (including Student Complaints about Faculty Actions and Academic Misconduct) can be found in the CLAS Student Handbook (http://isis.uiowa.edu). If a situation arises where you and your instructor disagree on some matter and cannot resolve the issue, you should see the Course Supervisor. However any problems concerning the course should be discussed FIRST with your instructor.

Disabilities: Please see a member of the course teaching staff either after class or during office hours if you have a disability which may require some modification of seating, testing or other class requirements so that appropriate arrangements may be made.

Sexual Harassment: Sexual harassment is reprehensible and will not be tolerated by the University. It subverts the mission of the University and threatens the well-being of students, faculty, and staff. Visit http://www.sexualharassment.uiowa.edu/ for definitions, assistance, and the full University policy.

Tentative Course Schedule

Date	Module
Weeks 1-3	**Collision Modeling**
Weeks 4-6	**Traffic Flow**
Weeks 7-9	**Subsurface Fluid Flow**
Weeks 10-12	**Hub Optimization**
Weeks 13-15	**Epidemiology**
Week 16	**Present Final Projects**

NOTE: This schedule is only tentative. Changes to the syllabus, if necessary, will be announced in class and posted online.

Listed Final Exam Time: 9:45 Wednesday, December 19, 2007