CMU Department of Mathematical Sciences
21-369: Numerical Methods
Fall 2007
Course Project

Overview:

Modern science is driven by two necessary components: theory and experimentation. Much of scientific theory can be described or modeled using mathematical relationships, and some experimentation can be reduced to investigating these relationships numerically (scientific computing). In addition, for many areas of science, explicit experimentation is unmanageable or even intractable. In these cases, numerical simulation may be the only way to produce experimental data of the phenomena that is modeled by theory.

With this in mind, this project consists of identifying a scientific problem of interest, learning how numerical methods and scientific computing are used to aid in the research of that problem, and communicating this knowledge to other students and the instructor.

Objectives:

The objectives of this project are:

- To give students an understanding of how numerical methods and scientific computing techniques are used to solve scientific problems of current interest.
- To provide students an opportunity to learn in detail about a scientific problem of interest to them.
- To develop students' technical communication and research skills, and to expose students to the scientific research and publication process.
- To provide the opportunity to collaborate with other students to complete a written technical document and presentation.

Project Requirements:

Students will work in groups of no less than 2 and no more than 4 members. If you have any trouble assembling a group or finding others to work with, please see the instructor before the group deadline (below).

This course project will consist of a written (typed) report and a brief presentation. The report should be around 3-15 pages in length (before references) and contain answers to the questions outlined in the Description section of this document. The presentation should be around 5-10 minutes in length and provide a summary of the report. Both the report and the presentation will be turned in electronically via the Blackboard online course (preferred format is PDF). Cited references are required for the report and optional for the presentation.

Description: The work on the project should, at a minimum, provide answers the following questions:

- What is the problem of interest, and why is it interesting?
- What is the current status of scientific research on the problem?
- What mathematical relationships arise in the modeling of the problem?
- How do scientists employ numerical methods to gain further knowledge about the problem? What kinds of results are obtained?
- How accurate are current numerical techniques for this problem? Are there any stability, solvability, accuracy, or other issues that arise?

In addition, the following optional questions may also be of interest:

- Are published mathematical software packages employed in the research of this problem? If so, what are they and what do they do?
- Can you replicate some published computational experiments?
- Are other numerical techniques for the same problem available? Do you have any ideas about how the research in that field could be furthered?

Milestones: The following dates are tentative, updates will be available on the online course calendar:

- Set Group Members: 9/12/07
- Choose Topic: 9/24/07
- Progress Update: 10/29/07
- Draft Report Due: 11/19/07
- Presentations: 12/3/07-12/7/07
- Final Report Due: 12/5/07

Useful Resources: In addition to your instructor, many resources may be of use. Links to some of these will be posted in the online course:

- Academic search engines, such as Google Scholar, Web of Knowledge, MathSciNet
- Scientific journals (electronic and print) held by CMU Libraries
- Mathematical software repositories, LaTeX manuals/tutorials

Other Comments: * Students are encouraged to use the LaTeX typesetting system for the report as well as the presentation slides. In addition to providing a flexible, elegant way to typeset mathematical expressions, LaTeX is extremely useful when citing references and labeling sections and equations.

* It it usually possible to make certain assumptions and simplifications regarding the problem of interest that will allow you to perform some simple numerical experiments. It may be helpful to your understanding of the problem to try this.