MIT Spring 2008
Course Information 18.086
Computational Science and Engineering II

Benjamin Seibold

1 General Information

Lecturer: Benjamin Seibold, 2-346, 324-2614, `seibold@math.mit.edu`
Office hours: Wednesdays, Fridays 2:00-3:00

Textbooks: The lecture is designed along the following books:

- required: Gilbert Strang, *Computational Science and Engineering*, Wellesley-Cambridge Press, 2007
- recommended: Randall J. LeVeque, *Finite Difference Methods for Ordinary and Partial Differential Equations – Steady State and Time Dependent Problems*, SIAM, 2007

Course web page: `http://www-math.mit.edu/18086/`

Lectures: 2-132, Mondays, Wednesdays, Fridays 1:00-2:00

Grading: Grading will be based on homework and course projects.

Problem sets: On average one problem set every two weeks, with exercises on theory and programming (50% of work load).

Course projects: To be worked on over the whole term, starting in second week. See Section 3 for more information (50% of work load).

Exams: There will be no exams.

2 Syllabus

Initial Value Problems Stiff problems, wave equation, heat equation, Airy equation, convection-diffusion, conservations laws, front propagation, Navier-Stokes equations, Fourier methods, finite differences, consistency, stability, covergence order, Lax equivalence theorem, CFL-condition, leapfrog method, staggered grids, shocks, upwind, Lax-Wendroff, finite volume methods, level set method

Solving Large Systems Applications yielding sparse matrices, elimination with reordering, iterative methods, preconditioning, incomplete LU, multigrid, Krylov subspaces, conjugate gradient method

Optimization and Minimum Principles Weighted least squares, duality, constrained minimization, inverse problems, calculus of variations, saddle point problems, linear programming, simplex method, interior point methods, adjoint methods

3 Grading Policy

The grading will be based on homework (50%) and a course project (50%). The project consists of intermediate report (20%), final report (60%), and presentation (20%).

Homework exercises There will be a problem set every two weeks (on average) with two weeks time to work on. Exercises will be both theoretical and programming. Some exercies will be more involved, so you are advised to start immediately when the problem set is out. A typical feature of numerical analysis is that there is seldom a unique best method for a given problem. Discussions with classmates and inside office hours are encouraged. However, each participant has to submit his/her own solution.

The obvious rules apply, i.e. copying of solutions is illegal, late submits have to be granted in advance, submitted program codes have to run without errors for grading, etc.

Course projects Over the course of the lecture time, each participant works on an extended problem related to the content of the course. You are allowed to choose a project which is related to your thesis work, however, the following restrictions apply:

- The project must focus on computational aspects related to the lecture topics.

- It is illegal to "reuse" a project from another course or thesis work. Your 18.086 project must cover specific questions and goals, which are not to be identical with the questions and goals of your thesis. For instance, you can investigate a specific computational aspect of your work, and investigate this aspect deeper than you would in your thesis work.

Of course, you can also choose a topic unrelated to your other work. You can consult the list of projects of previous years on the course web page `http://www-math.mit.edu/18086/`.

Any course project has to be agreed on by, and is under the supervision of the lecturer. The following deadlines apply:

Till second week (02/19): Submit project proposal (see below)

Before spring break (03/21): Submit intermediate report on project

Last weeks of lecture time: Give short talk on project

Till beginning of last week of classes (05/12): Submit final report on project

Note that no extensions can be given to these deadlines due to grading requirements.

3.1 Project Proposal

Email your project proposal to `seibold@math.mit.edu` with the following information:

Project title

Project background Does it relate to your work in another field (e.g. your thesis)? If yes, briefly outline the questions and goals of your work in the other field.

Questions and Goals Briefly descibe the questions you wish to investiate in your project. What are your expectations?

Plan Which language do you plan to program in? Do you intend to use special software? Does your project work relate to the work of other people at MIT?