Math 164 / CS 144 - Scientific Computing

Visiting Professor John M. Neuberger - Spring 2005

Contact: neuberger@math.hmc.edu (john.neuberger@nau.edu), Olin 1263.
Time and place: Olin B143 (Scientific Computing Lab), TR 1:15 - 2:30.
Office hours: T 11-Noon, W 1:30-2:30, R 2:30-3:30, and by appointment.
Graduate Assistant lab hours: To Be Announced. Mike Sheffler from CGU will hold several lab hours per week (programming assistance).
Grader(s): Trevor Pickering and/or Mike Sheffler.
Required text(s): None. It is reccomended that you have programming and/or reference guides for MATLAB and/or C. Most students will find it very useful to have access to a standard Numerical Analysis textbook; for this, I reccomend Burden and Faires.
Web Page: http://www.math.hmc.edu/~neuberger
Grading: Grades will be calculated with the following weights:

- 10%: Daily Grade
- 30%: Group Projects
- 15%: Final Project
- 20%: Midterm Exam
- 25%: Final Exam

Daily Grades will be computed from class presentations, and quizzes/turned-in homework, as needed. All turned-in written material is to be neat and complete, adhering to a professional standard. The lowest homework and quiz scores will both be dropped. Late or impproperly formatted turned-in assignments may be returned ungraded or with a substantial point deduction. An excellent guideline for formatting homework can be found at:
http://www.math.hmc.edu/~orrison/teaching/homework/.
All HW, quizzes and midterm, and corrections should be placed in a notebook; this notebook may count as a substantial portion of the daily grade.

Group Projects are to be done in groups of 2-4 students. Members should participate evenly; it is the group's obligation to enforce this, removing underperforming group members if need be. The instructor can help mediate disputes, if absolutely necessary. Guidelines for performing and reporting a group project effort can be found at the bottom of this document. The Final (solo) Project topic will be chosen by the student, with instructor approval.

Topics Covered: We will use computers to Numerically Investigate (and Theoretically Understand) the Mathematics of Calculus, Ordinary and Partial Differential Equations, Linear Algebra, Nonlinear Analysis, and/or Scientific Applications.

- Newton's method: real-valued and complex-valued functions, fixed-point iteration, higher ordered nonlinear systems, basins of attraction, and applications to differential equations.
- ODE solvers: first and second order initial value problems, boundary value problems, phase diagrams, bifurcation diagrams, and applications.
- Linear Algebra: solving linear systems, computing eigenvectors and eigenfunctions, and using libraries.
- PDE solvers: Parabolic, Hyperbolic, and Elliptic solvers with linear and nonlinear terms. Applications. PDE will be the major focus of the course.

Additionally, we may consider Fourier series, least squares, optimization, and various other topics from calculus, linear algebra, and differential equations.

Technologies used:

- MATLAB - our primary tool.
- C and/or FORTRAN - our secondary tool.
- LAPACK/BLAS libraries - see netlib.org; linear algebra subroutines called from C and/or FORTRAN.
- ARPACK - see netlib.org; find eigenvalues for large sparse systems.
- MPI - a brief introduction to parallel computing.

Schedule:

- Homework: As assigned, Quizzes: Most Thursdays.
- Group Projects: 2/8, 3/1, 3/29.
- Final Project: due 4/19, Presentations 4/19, 4/21, 4/26, 4/28.
- Midterm: 3/3.
- Final: Monday 5/9, 2-5 p.m.

Honor Code: All exams are strictly individual; no cooperation is allowed. Though cooperation on homework assignments is certainly allowed, students are expected to write up their own solutions individually. NO COPYING. Comprehension is the goal, thus each student is expected to understand the solutions being turned in. Group projects will generally concern only collaboration within the group. The final solo projects shall involve no collaborations. It is appropriate to acknowledge the assistance of others, and cite references where appropriate. The HMC Honor Code applies in all matters of conduct concerning this course.

Notebook: Place all Homework in a notebook, on or before due date. If the material was presented in class, the name of the presenter should be indicated. If substantial assistance was used in obtaining the solution, credit the proper person/resource (citing references if need be). The write-ups should be the student's individual work. All quizzes and the midterm should also be placed in the notebook, together with clearly identified corrections. Handouts detailing assigned homework and projects may be placed in the notebook as well, but the project reports and class notes should not be kept here.

I will inspect this notebook during the midterm and final examinations, and if need be, at other times during the semester. The student will receive a notebook grade which may count as a substantial portion of the daily grade.

Project Guidelines:

Plan to produce professional appearing documents. There are many different acceptable formats; the following is more of a suggestion than a rigid rule. Use TeX (or a similar package) to write-up report.

1. Title - suggestive of content, short.
2. Author(s) - in alphabetical order.
3. Introduction - short, mathematical, informative, useful to the reader:
   - Purpose of report.
   - Summary of contents of report.
   - Languages/Platforms used.
   - Key relevant Algorithm/Formulae/Theorem names.
4. Main Body - Label/Identify all objects, refer to appendix as needed:
   - Explanations
   - Formulaes and mathematics.
   - Algorithms, Pseudocode, short code segments.
   - Graphics, Tables.
   - **Freestyle** - do something extra, creative, different! This portion is typically worth a full letter grade!
5. Conclusion - short, mathematical, informative, useful to the reader:
   - Successes/Failures.
   - Discoveries.
   - Proposed future efforts.
6. Appendix - Optional - Longer Code segments, large tables, repetitive data/graphics, glossary, bibliography, index, etc.

Please avoid inclusion of enormous quantities of output data or tedious repetition. An excellent report may be quite short or somewhat long; length has no direct bearing on the quality of the report. Make the effort to include relevant mathematical formulaes and equations, handwritten if necessary.