**Math 222 (Introduction to Scientific Computing)** **Fall 2002**

**Instructor:** Rob Manning, rmanning@haverford.edu

**Meetings:** MWF 10:30–11:30 AM, Koshland H012.

**Office:** Koshland H207C, 896-1210.

**Office Hours (tentative):** MWThF 1:30-3, Koshland H207C, or arrange another time with me.

**Prerequisites:** Math 121 or 216 or 215, and experience with Mathematica or a programming language, or permission of the instructor

**Text:** "Numerical Mathematics and Computing", 4th edition, Ward Cheney and David Kincaid (Brooks-Cole, 1999).

**Supplementary Material:** "Numerical Recipes", by Press, Teukolsky, Vetterling, and Flannery, Cambridge University Press. You may find this to be a useful resource for an additional perspective on topics in this course, or for almost any computing problem you may run into. The Science Library has multiple copies, and it also exists on-line at `www.nr.com`, or at `lib-www.lanl.gov/numerical/index.html`

**Course Philosophy:** The goal of the course is to provide a bridge between the theoretical and practical aspects of scientific computing, so that you will understand the mathematical ideas behind several numerical algorithms and also know how to apply them to solve problems in your major. It is not a cookbook course on how to use algorithms, nor is it a class purely on the theory of algorithms. In each unit of the course, there will be a progression from basic conceptual material to more practical implementation issues, culminating in the student computer project at the end of the unit.

**Assignments:** The course will be divided into five units (see schedule). In the middle of each unit, there will be homework on the basic ideas of the algorithms. At the end of each unit, there will be a computer project, often done in groups of two, implementing the algorithms to solve a problem in the natural or social sciences, hopefully tailored to your scientific interests. For each computer project, we will meet once or twice in a computer lab during lecture time to get everyone started on the project, and then it will be completed for homework.

**Exams:** There will be two take-home exams, one due the second week after fall break and one during finals period.

**Grades:** The semester's grade will be based on:

Homework : 20%
Projects: 40%
Exams: 20% each

**Honor Code:** I encourage you to discuss the non-computer homework with other students in the class and/or with me. The actual writing of the homework should be done individually, so that it represents your personal understanding of the problems. For computer projects, you will work with one or more partners and together submit one project report, but you should not collaborate with any one other than your designated partners. There will be no collaboration allowed on the exams.

**Web page:**

`http://www.haverford.edu/math/rmanning/math222.html`

The Web page will contain all handouts, HW assignments, HW solutions, etc.

## Anticipated Schedule

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|---|---|
| 9/2-9/6 | Errors and approximations in scientific computing |
| 9/9-9/13 | Solving linear systems |

**Unit 1: Solving nonlinear equations**

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|---|---|
| 9/16-9/20 | Bisection, Newton's method |
| 9/23-9/27 | Multivariable Newton's method, secant method |

**Unit 2: Optimization**

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|---|---|
| 9/30-10/4 | Newton's method, golden section search, quadratic interpolation |
| 10/7-10/11 | Steepest descent, quasi-Newton methods |

Fall Break

**Unit 3: Monte Carlo methods**

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|---|---|
| 10/14-10/18 | Random numbers, numerical integration or simulation by Monte Carlo |
| 10/21-10/25 | Simulated annealing |

**Unit 4: Interpolation and Approximation**

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|---|---|
| 10/28-11/1 | Polynomial interpolation, splines |
| 11/4-11/8 | Splines, Least squares approximation |

**Unit 5: Differential Equations**

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|---|---|
| 11/11-11/15 | ODE Initial value problems (Euler's method, Runge-Kutta, adaptivity) |
| 11/18-11/25 | ODE Boundary value problems (shooting, finite differences) |
| 11/25-11/27 | ODE Boundary value problems (collocation) |
| 12/2-12/6 | PDEs (finite differences) |
| 12/9-12/13 | PDEs (finite differences) |