Computational Physics

Contact Information

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Class Hours:	MWF 13:05-13:55 Howey N210
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References:	A First Course in Computational Physics, 2nd Edition, Paul L. DeVries and Javier E. Hasbun (Jones and Barlett, 2011) Numerical Recipes, 3th Edition, by William H. Press, Saul A. Teukolsky, William T. Vetterling and Brian P. Flannery (Cambridge University Press 2007)
Software:	Matlab

Objective

Applications of numerical methods and computer programming to condensed matter; astrophysical hydrodynamics, gravitational physics, black holes and cosmology.

Topics

Introduction

Solving Non-linear equations

- Bisection method
- Linear interpolation
- Newton-Raphson Method
- Programs: findroot.m froot.m dfroot.m d2froot.m

Solving systems of equations

- Gaussian elimination
- Iterative methods
- Matrix inversion
- Eigenvalues and Eigenvectors
- Non-linear systems

Interpolation and curve fitting

- Polynomials
- Cubic Splines
- Least Squares Fitting

Numerical Integration

- Trapezoidal rule
- Simpson rule
- Romberg integration
- Splines and Integration

Numerical Approximations to Derivatives

- Finite Differences
- Truncation Errors & Convergence
- Richardson Extrapolation
- Programs: deriv.m

Ordinary Differential Equations
Initial-value Problems

- Euler Method: ode_euler.m
- Runge-Kutta Methods
- Stellar Models: stellar.m, stellar_rhs.m, chandra.m

Ordinary Differential Equations
Boundary-value Problems

- Tri-diagonal Solver
- Shooting method: shooting.m, shooting_rhs.m

Partial Differential Equations

- PDEs examples
- Advection Equation: advect.m, advect_rhs.m, euler.m, rk2.m, rk4.m
- von Neumann Stability Method
- Method of Lines
- Burgers Equation: burgers.m, burgers_rhs.m

Time-dependent Partial Differential Equations

- Hyperbolic Equations
- Cosmological Inflation
- Domain Walls: inflation.m

Time-dependent Partial Differential Equations

- Diffusion Equations
- Proto-planetary disks

Schrodinger Equation

- Time dependent using Crank Nicholson
- Time dependent using Iterative Crank Nicholson
- Stationary Solutions

Time-independent Partial Differential Equations

- Successive Over-relaxation
- Poisson Equation

Monte Carlo Methods

- Simple Monte Carlo integration
- Von Neumann Rejection Method
- Maxwell-Boltzmann distribution
- 2D Ising Model

Fourier Analysis

- Fast Fourier Transform
- Convolution and Correlation

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Policies

HOMEWORK: There will be THREE homework assignments during the semester. Homework problems will typically require writing computer programs based on the numerical algorithms discussed in class. Computer programs MUST be written completely from scratch, with the essential steps fully commented. The structure of the program can, however, be based, if necessary, on programs written or discussed by the instructor. The instructor reserves the right to request the student the reproduction of results submitted in homework assignments. Delays in the submission of homework sets will be penalized 2 points per day.

TEAM PROJECT: 2/5 of the course grade is assigned from a project. The project consists of two parts. One of them is an oral presentation the week before dead week. The second part is a written report, between 3 and 5 pages in length, due the day of the final exam. The teams for the projects could have a minimum of 3 and maximum of 5 members. The research project should clearly require the use of numerical methods. All members of each team participate in the oral presentation. At the end of each presentation there will be a Q&A session involving fellow classmates and the instructor. Both, the final report and oral presentation must include:
1) description of the nature of the problem,
2) the numerical techniques used,
3) code testing,
4) results, using scientific visualization where applicable, and
5) scientific implications.

GRADES: The homework assignments are computed on a 0-100 point scale. Their weights are:

Homework 1 (PDF)	20 %	Due February 10, 2012
Homework 2 (PDF)	20 %	Due March 16, 2012
Homework 3 (PDF) magnetic.m magnetic_plot.m	20 %	Due April 18, 2012
Project Presentation	20 %	Due
Project Report	20 %	Due
Total	100 %	

The final letter grade is assigned using the following conversion table. Plus/minus letter grades are used only for borderline cases.

A	100 - 85
B	84 - 75
C	74 - 65
D	64 - 55
F	55 - 0

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Honor Code

The policy on academic integrity as stated in the GIT Honor Code will be fully enforced during this course. In particular: Collaboration during in-class activities is permitted and encouraged unless your instructor explicitly indicates otherwise. Collaboration on homework assignments is permitted and encouraged unless your instructor explicitly indicates otherwise. Such collaboration should have the purpose of sharing an understanding of the principles and general solution techniques, not simply the sharing of answers. Collaboration is NOT permitted during exams. Violations of these rules will be prosecuted as violations of the GIT Honor Code.

Note that the Honor Code formally defines academic dishonesty as *…any act that does or could improperly distort student grades or other student academic records*. If you should have any question regarding the propriety of a particular behavior, you are encouraged to discuss the matter with the instructor.

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