ASTR 5540 Math Meth Fall 2008. Projects.

Do one of the following projects. You should do some background reading, write some code, and compute some results. You will make a 10 minute presentation of your project in class after the Fall Break. You may work alone or in a pair, but I expect the same level of individual effort in either case. If you have a specific idea for a different project, come and talk to me about it.

1. Waves with Fast Fourier Transforms

Write a code that uses FFTs to evolve the wave equation

$$\left(\frac{\partial^2}{\partial t^2} - c^2\nabla^2\right) f = 0 \tag{1.1}$$

in a periodic box. Things to consider:

1. More than one dimension;
2. Various initial conditions;
3. Allowing the sound speed c to vary as a function of wavenumber k;
4. Allow dissipation.

2. Symplectic or implicit integrator

Write a symplectic integrator that integrates a system of planets, or an implicit integrator that integrates a stiff system of equations.

H. Beust, "Symplectic integration of hierarchical stellar systems", Astron. & Astrophys., 400, 1129.
David E. Kaufmann, "Swifter – an improved solar system integration software package", `http://www.boulder.swri.edu/swifter/`.
Miguel Preto & Scott Tremaine, "A class of symplectic integrators with adaptive timestep for separable Hamiltonian systems", `http://arxiv.org/abs/astro-ph/9906322`.

3. Particle-Mesh (PM) code

Write a PM code to integrate a gravitating system of particles in a periodic box. Things to consider:

1. More than one dimension;
2. Setting up initial conditions with the Zel'dovich approximation;
3. Allow cosmological expansion of the box.

Hugh Couchman, "Cosmological simulations using adaptive particle-mesh methods", `http://hpcc.astro.washington.edu/simulations/DARK_MATTER/adapintro.html`.
Nishikanta Khandai & J. S. Bagla, "A Modified TreePM Code", `http://arxiv.org/abs/0802.3215`.
Andrey Kravtsov "Writing a PM code", `http://astro.uchicago.edu/~andrey/Talks/PM/pm.pdf`.

4. Shock capturing code

Write a 1-dimensional shock capturing code.

John Blondin, John Hawley, Greg Lindahl, & Eric Lufkin, "VH-1" http://wonka.physics.ncsu.edu/pub/VH-1/VH-1_guide.html.
Christian Klingenberg, Wolfram Schmidt, & Knut Waagan, "Numerical comparison of Riemann solvers for astrophysical hydrodynamics", http://arxiv.org/abs/0711.4141.
B. Scott, "Riemann Solvers", http://www.crs4.it/HTML/int_book/NumericalMethods/int_book.html.