COMPUTATIONAL PHYSICS

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Tuesdays and Thursdays 12:30-1:45 in Meyer 333

Course Outline

This is a *physics* course, in which we will use computational techniques to solve problems in physics. There will be no exams, grades will be based on homework. You will need to (or learn how to) program (e.g. C, Fortran, IDL, Mathematica, MATLAB), use LaTeX and plotting software.

There is no formal textbook that I will follow, although *Numerical Recipes*[1] by Press et al can be very useful. Other useful books include *Computational Physics* by J.M.Thijssen and *Computational Gasdynamics* by C.B. Laney. They are available at the NYU bookstore if you are interested. Lecture notes are available at the course's website.

1. Basics of Numerics (2 weeks)
   - Numerical Math: Roundoff error, representation of numbers, etc
   - Interpolations and Approximations
   - Computing Derivatives and Integrals
   - Random Number Generators
2. Ordinary Differential Equations (2 weeks)
   - Basic Methods: Euler, Runge-Kutta
   - Implicit Methods
   - Stiff ODE's, Stability.
   - Applications: Resonances in the Solar System, Planetary motion in GR, Chaos
3. Spectral Methods (3 weeks)
   - Random Gaussian Fields, Power Spectrum, Correlation Functions
   - Fast Fourier Transform
   - Windowed Fourier Transforms, Wavelets
   - Applications: Spatial and Temporal Distributions: Analysis and Generation
4. Partial Differential Equations (3 weeks)
   - Finite Differences
   - Grid Methods: FFT, Relaxation, Multigrid
   - Lax, Lax-Wendroff, Staggered Leapfrog, Galerkin Methods
   - Methods of Characteristics
   - Applications: Water Waves and Tsunamis, KdV Solitons, Traffic Problems
5. Renormalization Group and Monte Carlo (3 weeks)
   - Basic Ideas of Renormalization Group
   - Random Walks, Monte Carlo, Markov Chains
   - Applications: Ising Model, Phase Transitions

[1] http://www.nr.com