Physics 410: Computational Physics: Suggested Term Projects

---

*Note that all term projects must be approved by the instructor. Term project outlines are due **Oct 19** and the projects themselves are due **Dec 2** (last class day). Contact the instructor for more details concerning any of the topics listed below.*

Some on-line resources which may be useful sources for term project ideas are listed **HERE**.

Charges on a Sphere

Simulate the dynamics of n identically charged particles confined to move on the surface of the sphere. Incorporate dissipation so that the charges eventually come to rest in an equilibrium configuration. Determine and describe the equilibrium configuration(s) for interesting values of n.

Students undertaking this project should find the following visualization software useful:

- **xfpp3d**

The Game of Life

Write a simulation of the Game of Life, a two-dimensional cellular automaton.

Students undertaking this project should find the following visualization software useful:

- **xflat2d**

Solitons

Solve a non-linear wave-equation which admits solitonic solutions using finite-difference techniques. Study the propagation of single solitons as well as the interaction of two or more solitons. Reference: *Solitons and Nonlinear Wave Equations*: Dodd, Eilbeck, Gibbon and Morris.

Students undertaking this project may find the following handouts useful:

- Solution of Nonlinear Systems using Newton's Method: Summary Notes: (PS)
- Problem handout (PS) from PHY/CAM 381C (1997, UT Austin). The second problem involves the solution of the KdV equation.
- Problem set 6 (PS) and key (PS) from PHYS410 (2000). This homework involves solution of non-linear systems of equations, question 2 is particularly relevant.
- Problem set 5 (PS) and key (PS) from PHYS410 (2000). This homework involves treament of equations via finite difference techniques, question 3 on the solution of the wave equation is particularly relevant.

Students undertaking this project should find the following visualization software useful:

- **xvs visualization server**

Schrodinger Equation

Write a program to solve the time-dependent Schrodinger equation in one-space dimension for an arbitrary potential V(x). Some hints for this project are available: (PS) or (PDF).

Students undertaking this project should find the following visualization software useful:

- **xvs visualization server**

The demonstration program **democomplex.f**, which illustrates some of the basics of complex arithmetic with Fortran 77 may also be of use.

Chaos

Simulate and study the behaviour of one or more low-dimensional systems which exhibit chaos: examples include the Lorenz model or the billiard problem.

The Rings of Saturn

Write a program to study the dynamics of a large number of test particles in orbit about a massive body with one or more massive satellites. Study the impact of various satellite properties (mass, orbital radius, orbital eccentricity etc.) on the dynamics of the test particles.

Students undertaking this project should find the following visualization software useful:

- **xfpp3d**
- **IRIS/NAG Explorer**

Traffic Simulation using Cellular Automata

Use a cellular automata model to simulate multi-lane traffic flow.

Moon Landing

Design and implement a simulation of a rocket ship with a main booster and attitude control rockets. Implement an interactive interface to allow a user to attempt to land the rocket ship on the surface on a planet.

2D Ising Model

Write a Monte-Carlo algorithm to simulate the two-dimensional Ising model with external parameters T (temperature) and H (magnetic field). Use your algorithm to study the phase-space structure of the model. Investigate the nature of your results as a function of lattice size.

Students undertaking this project should find the following visualization software useful:

- xflat2d

Dissipative Gas Simulation

Simulate the dynamics of a collection of hard spheres which dissipate some fraction of their kinetic energy when they collide. Work in two-dimensions and determine typical long-term behaviour of the system for a range of dissipation parameter.

Students undertaking this project should find the following visualization software useful:

- xflat2d

Particle Physics Simulations

Reaction-Diffusion Equations

Toda Lattices

Neural Networks

Genetic Algorithms

Simulated Annealing

Pedagogical Java Applet

Design and implement an interactive Java applet which illustrates and/or "demos" some physical principle or set-up of your choosing.

Quantum Computation

Write an essay on the rapidly evolving field of quantum computation.