Updated April 7, 2008

Physics 401/801 Spring 2008

Computational Physics

Mondays 1:30 PM–4:20 PM NMC Classroom in 107 Architecture Hall

The purpose of Physics 401/801 is to help the student develop the skills to reformulate physics problems so they can be solved on a computer and obtain physically significant results.

Lecturer: Professor Aaron Dominguez

- Office hours: 4:00 PM - 6:00 PM Tuesdays, or by appointment
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Course Description

This course combines physics, numerical analysis, data analysis, and programming. Students will learn to take a physics problem and analyze it using computers. This will involve the following: learning statistical analysis techniques; Monte Carlo techniques for simulation of physics processes, statistical analysis, as well as numerical integration; numerical techniques for solving differential equations from physical situations; and controlling the numerical errors that might arise from these various numerical techniques.

The course is designed as a laboratory course for undergraduates seeking to improve their skills in computational physics. It complements Physics 311 and is recommended for students who have taken or are currently taking that course. Some background in computer programming, especially C or C++ is assumed.

Course Webpages

- UNL BlackBoard Learning System: `http://my.unl.edu`
- Click on the course "COMPUTATIONAL PHYS PHYS401 SEC 001 SPRING 2008"
- All course material (pre-lecture questions, lecture notes, homework, exams, grades) will be on this website
- Some homework problems will also be submitted by the students via this website

Computers

We will be using the computer lab in the classroom in the NMC Classroom where we meet each week. This classroom is not available for public use outside of class.

You should arrange to have access to a Mac OS X or linux computer for your use outside of class. There are two linux boxes available for public use which have ROOT installed; they are located in Brace 303. We will also setup several linux boxes in the new South Stadium offices for the Research Computing Facility (Schorr Center) if you need a computer outside of class. These are located in the "Cluster Computing Classroom" in the Schorr Center.

The source and binaries for ROOT can be found on the ROOT home page: http://root.cern.ch. It runs on linux, Mac OS X and on Windows if you have Cigwin installed.

You can also ask me for the CDROM's for all the above and I can make a copy for you.

Textbook

- Required text: *Numerical Methods for Physics*, Alejandro L. Garcia.
- Recommended text: *ROOT User's Manual* and *ROOT Reference Manual*, both of which are free and can be found at http://root.cern.ch.
- Optional texts:
  - *Statistics for Nuclear and Particle Physics*, Louis Lyons.
  - http://www.cplusplus.com/doc/tutorial. Please go through this, it is very helpful.
  - *C++ for Dummies*, Stephen Randy Davis.
  - *The C++ Programming Language*, Bjarne Stroustroup.
  - *Scientific and Engineering C++*, John Barton and Lee Nackman.
  - *Numerical Recipes in C++*, William H. Press *et al.* Also see http://www.nr.com.

Academic Integrity

- The UNL Student Code of Conduct and Academic Integrity pamphlet can be found in the "Course Documents" section of the course webpage and at the Student Judicial Affairs Website http://www.unl.edu/sja. The Code is also printed in the back of the Undergraduate Studies Bulletin.
- Please read Section 4 of the Student Code of Conduct regarding cheating and academic integrity.
- **The first violation of academic integrity will result in at least a failing grade for the assignment (exam, homework etc) and notification of university officials. More action maybe taken depending on the particular case. Any subsequent violations will result in removal from the course with a failing grade along with notification of university officials.**
- To avoid situations which lead to cheating, plagiarism, copying and academic dishonesty, please start your work early and ask questions immediately if something is unclear.

Homework, Pre-Lecture Questions & Final Project

Homework

The course has reading assignments, paper-and-pencil problems and computer problems. The problems will be collected and graded by the instructor.

CodeLab

We will be using an online, web-based system called CodeLab to help us learn the basic syntax of C++. The exercises are part of the homework. To register or login, go to http://www.tcgo1.com.

Pre-Lecture Questions

Before many lectures on Monday, there will have been a pre-lecture question posted online at the course webpage at least 24 hours before it is due. **These pre-lecture questions are due one hour before class** and are not difficult, but do cover material that will be discussed during lectures. This is part of your grade and will require that you read the chapter before arriving at lectures.

Final Project

There will be a final project on a subject chosen in consultation with the instructor and their fellow students. The project will involve a computer program, a written report and an oral presentation to the class.

Grading Rubric

The course grade will be based 2/3 on the problem assignments and 1/3 on the final project. Failure to complete the final project will result in a failing grade.

Students are encouraged to discuss the homework problems with the instructor and their fellow students. The solutions to the written homework should be sufficiently clear and complete that an instructor or another student can see what the problem was and how it was solved. (A brief restatement of the problem in the student's own words is needed.)

Computer programs are expected to be well documented in English. A list of computer commands without documentation is not a satisfactory program.

In physics, the answer to a problem is only half the task; the other half is presenting it clearly.

Lecture Syllabus

Jan 14 Intro to computational physics. Basic elements of C++ programming, intro to ROOT

Jan 21 Martin Luther King Jr Day, no class

Jan 28 Round-off error, truncation error. More ROOT basics

Feb 04 Euler algorithm, projectile motion, pendula

Feb 11 Taylor series with error estimate, Midpoint & verlet algorithms, two point interpolation

Feb 18 Verlet algorithm revisted. Runge-Kutta

Feb 25 Adaptive Runge-Kutta method, orbital motion. Final project suggestions. method. **No lab**

Mar 03 Monte Carlo methods I

Mar 10 Monte Carlo methods II

Mar 17 SPRING BREAK! No class ;(

Mar 24 Data analysis I: least squares fitting, statistical methods of error estimation

Mar 31 Data analysis II: likelihood fitting, optimization of analysis

Apr 07 Matrixes, linear systems of equations. Mechanical equilibrium. Final project selection due.

Apr 14 Eigenvalues, eigenvectors, orthogonal matrixes

Apr 21 Nonlinear matrix equations or Artificial Neural Networks

Apr 28 In-class peer editing of final project papers

May 06 Oral presentation of projects, final project papers due

Supplemental Materials

In addition to the optional texts above, I will be making extensive use of the ROOT project's website: http://root.cern.ch. The class library, user's manual, tutorial and mailing lists and discussion boards can be found there. You should plan on accessing this site frequently and taking advantage of the online community associated with it. *You should all register for the ROOT forums where you can post basic questions about ROOT and get very quick feedback from other users and the developers themselves.*