The course website will be at [http://www.albany.edu/physics/phy577.shtml](http://www.albany.edu/physics/phy577.shtml)

**A PHYSICS 577, class# 4998: Computational Methods, Spring 2016 (3 units course credit)**

Mon-Wed-Fri 09:20-10:15 AM  Physics Bldg, Rm 229

Professor Matthew Szydagis, [mszydagis@albany.edu](mailto:mszydagis@albany.edu), Physics 312, [albany.edu/physics/mszydagis.shtml](http://albany.edu/physics/mszydagis.shtml), with TA Sean Fallon, [srfallon@albany.edu](mailto:srfallon@albany.edu)
Office Hours: 10:30 – 11:30 A.M. MWF, in PH 312, and by appointment.
TA Office Hours: Tuesdays and Thursdays 9 – 10 AM, Physics 323

**Text:** None. All of the needed information and documentation will be provided during class and on the course site, which will also include links to other sites, serving as references for computer programming examples, additional explanations of algorithms, and the vocabulary.

**Course Description and Prerequisites:** Applications of modern computational methods to current topics in physics. Basics of coding and use of standard software packages. Prerequisite PHY 507 or permission of instructor.

**Course Objective:** Students completing this course will be able to write functioning code in C / C++ to accomplish a wide variety of goals, including numerical solutions to problems unsolvable analytically in closed form, and Monte Carlo simulations for making predictions of outcomes in stochastic (random) processes.

Your grades (A through E with +/-) will be calculated according to this rubric:

- **Homework coding**  60%  Weekly at-home programming projects, which must function
- **Final Project**  30%  As class computer-based no exam. Self-chosen code project
- **Class participation**  10%  Regular attendance; participation in discussion of concepts

Homework is comprised of code that must be emailed to the teaching assistant and instructor. It is due on the date specified in class and/or on the course website when assigned, typically a week later. It is not accepted late under any circumstances and, although discussion with your fellow students for help is not only permissible but encouraged, the final product must be your own work*. The program must compile, run, and produce the result(s) specified for a particular assignment. There is a zero-tolerance policy for plagiarism (failure results) which for this type of class would mean turning in (near-)identical code comparing line by line, with names of variables, etc.

Prior knowledge of some programming language is not required, but it is highly recommended. The necessary knowledge and skills to write code in C and C++ will be imparted via in-class lectures and group discussions. Homework can be accepted in other different languages, however, via prior arrangements with the professor and the TA, as long as one or both of them know it. The focus of this course is upon learning various algorithms and techniques, and not on one language. If following along in our official languages you will need a (free) gcc or g++ compiler installed on your OS.

* This includes a prohibition against downloading complete programs from the Internet, which should be a source of help but not of full answers.
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All students are required to have their own personal computers (laptops must be brought to class) they can use for in-class work and homework, as well as a C compiler (or the software for compiling or interpreting their alternative code of choice) and access to the internet to be able to see and use the course materials. If you don't have your own laptop, you will have to follow along as best you can with a school-provided desktop computer outside of class time. Come to see me*

Extra Credit: You can earn bonus points by adding additional features considered to be particularly challenging to implement into your code and program as specified in the homework assignments. The maximum possible credit to earn is 5% of your final grade.

I understand a medical emergency and personal or family difficulties can sometimes prevent you from attending class. Unless something occurs literally on the day of class, please speak with me *ahead of time, if at all possible*. University policy: http://www.albany.edu/health_center/medicalexcuse.shtml

The following is a tentative chronological list of topics that will be covered in this course. Based on an informal verbal survey I will conduct on the first day of class, the pace will be adjusted according to the average level of programming knowledge. I'll also count on those with greater experience to help fellow students with less; the largest roadblock will be getting set up to program while well-versed in a word processor within which to code.

- Introduction to Programming in the C or C++ Languages: the old and new
- Including header files, compiling your 1st code (Hi world), Googling errors
- Variable Declarations; Multi-dimensional Arrays/Matrices
- Integers and Floating Point Numbers; Computational Precision
- Plotting results (Excel, OpenOffice, hand-drawn if necessary)
  - Scatter plots versus histograms, and determining correlations
  - How to digitize data from public figures: http://plotdigitizer.sourceforge.net
- Random Number Generation: Uniform, Gaussian, Exponential, Custom
- “Toy” Monte Carlo Simulation examples from different fields of physics
- Methods for Numerically Solving Differential Equations (ODE, PDE, CDE)
  - Euler, Euler-Cromer, and Runge-Kutta algorithms
- Numerical Limits and Integration (Riemann, Von Neumann sampling)
- Minimization, Maximization, and Optimization Techniques
  - The Newton-Raphson Secant and Conjugate Gradient methods
- Analyzing and Fitting to Data to Validate a Theory/Model
  - Chi-squared, log-likelihood, p-value; discovery claims, classic results

Should there be sufficient time, we may cover Fourier analysis and neural networks. Examples will be taken from all areas including but not limited to orbits, a large-angle pendulum, the expansion rate of the universe, simulating particle detection, relativity.

PARTING COMMENT: IN THIS CLASS, E-MAIL COMMUNICATION IS KEY

* If multiple people in the class are in this situation, then we will move to a computer room.