# Physics 320 – Computational Physics – Fall 2024

Course Time: Monday and Wednesday, 1-2pm

Room: SLC 132

Instructor: Nathan Moore, PhD

Final Exam: the last regular class period, 2024-Decemer-4

Office hours: TBD, by appointment, and whenever my door is open

**Course Texts**:

1. Computational Physics, Newman, 2012 <https://www.amazon.com/Computational-Physics-Mark-Newman/dp/1480145513>
2. All Systems Red: Murderbot Diaries, Wells <https://www.amazon.com/All-Systems-Red-Murderbot-Diaries/dp/0765397536>

In addition to these books we'll draw on tutorials hosted by the Software Carpentry organization. See <https://software-carpentry.org/lessons/>

**Why is this course required?**

There are lots of physics problems that you can’t solve by hand. The math is too hard, too big, or too repetitive to be approached on paper. For example, how does the frame of a car deform when it runs into a moose? This is a common question in Sweden, and it is solved by modeling the frame as 0.5cm blocks which interact with constant force over 1us timesteps. Similarly, the weather is predicted with a fluid mechanics model that breaks the atmosphere into 1km blocks. How many blocks does it take to simulate the continental US? Many problems are like this in modern science and computers are an improvement (over humans) in performing these repetitive calculations.

Additionally, it isn’t hard to collect thousands of experimental measurements in a short time. By the end of Physics 333 (for example) it should seem like a normal thing to measure the temperature in the room every second for 2 days with an Arduino and an SD card. Plotting and analyzing more than about 10 measurements by hand isn’t really a good use of a person’s time when a computer can implement it much faster and more accurately than a human.

Finally, and least well appreciated, is the function of computers in repeatability and audit in science. If you can’t get the same result twice from an analysis, the analysis may not be valid. When plots, fits, and calculations are structured as computer instructions, the work is implicitly documented. Understanding how you came up with a number 6 months ago is a huge time and credibility saver that well-documented computer code can provide.

**Why are we using python as the main programming language?**

Many computer programming languages are used for this course across the country. The most common choices include Fortan, C, C++, Java, Matlab, and G (Labview). Each of these languages has its own advantages, and as a young professional, you will likely work in whatever environment is used by the group you join. Learning a second (programming) language is much easier than learning a first, and python is a good first language. Why?

1. Python is popular (Fortran is not. Knowing enough python to put it on your resume may help you find internships or jobs. Python is a common development language at Google, NASA, and the CIA.)
2. Python is free (A professional Matlab license costs $2000+. A professional Python distribution from Anaconda is free.)
3. Python is easier to pick up than other common languages. (Fortran, C, C++, Java)

**What are the course goals/outcomes?**

Physics 320 is a *Physics* course, and thus the goal is to develop enough computer programming skill to solve *Physics* problems. At the end of the term, I want you to feel (and be) capable of writing a computer program in Python to solve a problem that's too difficult to do by hand (on paper).

**Specific goals:**

1. Develop familiarity and capability with the shell computing environment. (connecting to remote machines, editing text, sorting/searching files, navigating directory structure, shell scripting.)
2. Develop familiarity and capability with version control systems (git/github) to document and track the development of a software project. Ie, science done with software should be clear and repeatable!
3. Develop familiarity and capability with the basics of the Python computer language (variables, assignment, looping, control statements, modules, File I/O).
4. Write a program that will read data from file, create a plot from a subset of that data, create a fitline to that data, and generate a publication-quality figure with the data and fit.
5. Write programs to numerically solve differential equations (eg kinematics, electrostatics, etc)
6. Write programs to probabilistically solve Physics problems (eg random walk, Markov, Brownian, or Monte-Carlo style processes).
7. Explore other avant-garde computational techniques.

**Grades**

Class assignments will include weekly problem sets (about 10), occasional quizzes (2-3), and a final exam/project. Students are expected to write their own code. Plagiarism of code will result in a zero for that assignment.

## How should we treat each other in this course?

You may have heard of the psychologist A. Maslow’s “Hierarchy of Needs[[1]](#footnote-1),” which describes the attention people pay to their surroundings. According to the theory, humans first need air, water, food; then safety and shelter; and then love, intellectual curiosity, etc. Learning Physics is fairly high up in this hierarchy, and if you’re hungry, have to go to the bathroom, or fear for your safety, it is difficult to impossible to concentrate on learning something abstract.

Over the course of the semester, we (students and instructor) will form a community. We all benefit from the involvement of everyone in this community - learners and instructor. I am committed to creating a friendly and respectful place for learning, teaching and contributing. Everyone in the class is expected to show respect and courtesy to others.

To make clear what is expected, everyone in the class is required to conform to the following Code of Conduct, which applies to all spaces related to the course, including, but not limited to, the classroom, lab, email lists, online forums, and office hours.

If you believe someone is violating the Code of Conduct I ask that you report it to me, Nathan Moore. If you feel I have violated the code of conduct, please let the department chair, Andy Ferstl (Pasteur 146, [aferstl@winona.edu](mailto:aferstl@winona.edu)), know and he will anonymously relay your concerns to me.

### Code of Conduct

This course should be a welcoming and supportive environment for all people, regardless of background or identity. However, we recognise that some groups in our community are subject to historical and ongoing discrimination, and may be vulnerable or disadvantaged. Membership in such a specific group can be on the basis of characteristics such as such as gender, sexual orientation, disability, physical appearance, body size, race, nationality, sex, colour, ethnic or social origin, pregnancy, citizenship, familial status, veteran status, genetic information, religion or belief, political or any other opinion, membership of a national minority, property, birth, age, or mac vs pc. We do not tolerate harassment of participants on the basis of these categories, or for any other reason.

Harassment is any form of behaviour intended to exclude, intimidate, or cause discomfort. Because we are a diverse community, we may have different ways of communicating and of understanding the intent behind actions. Therefore we have chosen to prohibit certain forms of behaviour in our community, regardless of intent. Prohibited harassing behaviour includes but is not limited to:

* written or verbal comments which have the effect of excluding people on the basis of membership of a specific group listed above
* causing someone to fear for their safety, such as through stalking, following, or intimidation
* the display of sexual or violent images
* unwelcome sexual attention
* nonconsensual or unwelcome physical contact
* sustained disruption of talks, events or communications
* incitement to violence, suicide, or self-harm
* continuing to initiate interaction (including photography or recording) with someone after being asked to stop
* publication of private communication without consent

Behaviour not explicitly mentioned above may still constitute harassment. The list above should not be taken as exhaustive but rather as a guide to make it easier to enrich all of us and the communities in which we participate. All class interactions should be professional regardless of location: harassment is prohibited whether it occurs on- or offline, and the same standards apply to both.

Enforcement of the Code of Conduct will be respectful and not include any harassing behaviors.

Thank you for helping make this a welcoming, friendly community for all.

This code of conduct is an adaptation of the one used by the Software Carpentry Foundation, <https://software-carpentry.org/conduct/>. Note that it is very similar to WSU’s statement on Inclusive Excellence, http://www.winona.edu/diversity/estatement.asp

1. [https://en.wikipedia.org/wiki/Maslow's\_hierarchy\_of\_needs](https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs) [↑](#footnote-ref-1)