PHY 211: Computational Methods in the Physical Sciences and Engineering

Fall 2022

Web:	Course Moodle site
Text:	Problem Solving with Python (online, free)
Instructor:	Casey Berger
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Office hours:	TBD and by appointment: **https://calendly.com/caseyberger**
	* zoom or in-person
Office:	McConnell 310A

Course Description

This course provides an overview of commonly used computational methods and their applications to physics problems. Using the Python programming language, we will begin with understanding how programs send instructions to computers on to simple data visualization, error analysis and uncertainty in computational calculations, and then progress on to numerical integration and differentiation, machine learning, and stochastic methods. In each case, we will examine the method's applications to relevant physics scenarios. This course will be project-based, with multiple short projects throughout the semester intended to build the skills and generate a set of modules that can be used as part of a final project applying a computational method to an appropriate physics problem of the student's choice.

Prerequisites: PHY 118 or PHY 119 or permission of the instructor, as well as MTH 112. No prior experience with linear algebra is required, however advanced projects will be available for students with interest and experience with linear algebra

A course schedule will be made available on Moodle, subject to change. The schedule on Moodle will be kept up-to-date, and any changes in the schedule will be announced in class and over email.

Course Logistics

Objectives

By the end of this course, you will be able to

- code using the Python programming language
- store, organize, and visualize data using Python and the pandas toolkit
- translate the mathematics of physical scenarios into the appropriate computational algorithm
- understand and communicate the limitations of numerical techniques
- write a multi-tiered algorithm which calls on multiple functions and incorporates pre-existing packages
- understand and explain the utility of numerical algorithms in answering complex physics research questions

Topics

This course covers the following content:

- The Python programming language and useful packages (such as numpy, scipy, and pandas)
- Computational error and uncertainty
- Numerical differentiation and integration
- Managing and visualizing large amounts of data
- Fitting and machine learning techniques
- Stochastic methods

Course Components

Assignments are broken into three categories: essentials, depth, and effort.

Essentials

There are five essential assignments. These should be your first focus in this class. You must receive an "S" on all essentials in order to pass the class, but remember that you can use tokens to resubmit any assignments you do not receive a satisfactory grade on.

Depth

The depth assignments are things that would be good for you to learn in this class. They are not required to pass, but if you want to deepen your understanding of computational methods, especially if you plan to continue on in scientific computing after this class, they are highly recommended. You must receive an "S" on at least one depth assignment to get above a B- in this course, but you do not have to do them all to get an A.

Effort

Every unit, I will suggest a number of practice exercises, readings, and other enrichment activities. These are all intended to be helpful in improving your skills in this class, but they are not required. You should do whatever you find helpful from those activities, and then you will fill out a form each week letting me know what you worked on (if anything), why you chose those problems (or no problems), and whether you have any questions or feel you're struggling in any particular areas. This homework form will receive a "S" simply for completion. Not turning it in or leaving questions blank will result in a "U."

I recognize this type of grading may be unfamiliar to many of you. I am always open to questions and discussion about this. Please don't hesitate to email me or come by my office hours if you are struggling with content OR with how this grading method works or why I am using it.

Assignment distribution

Essential assignments	Depth assignments	Effort assignments
Project 1: Python basics	Project 1: Error Analysis	WHWs 01-12
Project 2: Fitting data	Project 2: Stochastic Processes	
Visualization project	Project 3: Numerical integration	
Project 3: Numerical differentiation		
Final project		

Deadlines and Extensions: Because you have the opportunity to redo assignments, I strongly recommend staying on top of the due dates. However, I am always willing to be flexible. If you want an extension on any deadline, you must ask me first, but I will almost always grant it. If I don't immediately grant it, I will work with you to figure out an alternative that will help you achieve your goals in this class.

Grading

In this course, I will not be giving numerical or percentage grades to individual assignments.

Your goal in this class should be to learn, and grades do not help with learning. In fact, they steal attention away from the more important feedback that contributes to growth and improvement.

I will be using a form of alternative grading called specifications grading. Using this, every assignment will receive either a satisfactory or unsatisfactory grade, and I will also leave detailed feedback and commentary, in order to help you improve your work.

Your final grade will be determined based on the number of S or U grades you receive in each category, in the following way:

1. You **must** receive a Satisfactory grade on the five essential assignments to pass the class
2. An "S" on only the essential assignments and a "U" on all depth and effort assignments will result in a C
3. To get a B or an A, you must receive satisfactory grades on at least some of the depth and effort assignments

There is a grading sheet provided which can help you see how this breaks down and even test out putting in different grades.

You will be able to re-do any assignments that receive a "U" grade. Each re-do costs one token, and tokens can be earned in a number of ways. The only exception to this is the final project, due to time constraints, but if you meet the scheduled milestones along the way and turn in the final project form, you will receive an "S." No "U" grade is final. The goal is to learn, which means you can always go back and try again!

You can earn tokens in the following way:

1. Responding to the syllabus question/comment form (up to 2 tokens)
2. Filling out the office hours poll before the end of the day on Sunday, September 11 (1 token)
3. Filling out the first day of class poll before the end of the day on Sunday, September 11 (1 token)
4. Scheduling a final project pitch meeting prior to the recommended due date (1 token)
5. Scheduling a 15 minute meeting with Casey to discuss the assignment you want to re-do, where we will create a plan together to help you prepare to re-do the assignment (number of tokens will depend on the plan we come up with)

Community

Land Acknowledgment

We acknowledge that we are on Indigenous land: the territory of the Nonotuck peoples. We are grateful for the opportunity to live, learn, and grow on this sacred land, and extend our respect to citizens of this nation who live here today, and to their ancestors who have lived here for hundreds of generations. We recognize the repeated violations of sovereignty, territory, and water perpetrated by invaders who have impacted the original inhabitants of this land for over 400 years. We know this acknowledgement is insufficient, and does not undo the harm that has been done and continues to be perpetrated now against Indigenous people and their land and water.

Classroom Culture

We will build this part of the syllabus together, and it will serve as our community expectations. How will we protect and support each other in order to make this classroom environment one where we can all thrive?

Our community guidelines here

A general note on emails and availability:

If you email me on a weekday, you can expect a response from me within 24 hours. If you email me on a weekend, you can expect a response from me by class time on Monday (or the first day back if it's a long weekend or holiday).

A general note on COVID-19:

If you are feeling at all unwell, please do not come to class. Not only is rest important for your own health, but it's also important to do all you can to protect your community. Stay home, message me to arrange any accommodations (I will be very flexible!), and contact the Schacht Center to arrange a symptomatic test (413-585-2250).

More information about Smith's COVID-19 response is available at the Culture of Care page.

College Policies

Academic Integrity and Honesty

Honor Code Statement:
Students and faculty at Smith are part of an academic community defined by its commitment to scholarship, which depends on scrupulous and attentive acknowledgement of all sources of information and honest and respectful use of college resources.

Smith College expects all students to be honest and committed to the principles of academic and intellectual integrity in their preparation and submission of course work and examinations. All submitted work of any kind must be the original work of the student who must cite all the sources used in its preparation.

Students voted to establish the academic honor system in 1944. The basis of the Academic Honor Code is articulated in Article X of the SGA Constitution and Article VII of the SGA Bylaws.

Accommodations for Disabilities

I **do not** require a letter from ODS to make accommodations for disabilities. If you would like to work through ODS, I am happy to do so, and you can contact them at ods@smith.edu. You may also just let me know what accommodation you need, and we will work to ensure you are properly supported. You do **not** need to tell me your disability.

Resources

There are tons of resources at Smith to help you succeed in this course and in your college career. If you think of resources I have not included here, please let me know, so I can add them. You can also find this resources page on the moodle site.

- Your instructor! I am here to help you and you are welcome to reach out to me any time.
- Spinelli Center math reviews
- Workshops for time management and managing stress
- Writing help from the Jacobson Center
- Crisis Resources
- Mental Health Crisis Hotline: call or text 988
- Counseling Resources
- Wellness Services
- Gender Identity and Expression
- Where to report sexual misconduct and other forms of discrimination