

# PHYS 220: Computational Physics

Prof. Adi Foord

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Office Hours: T 2-3:00pm

Office: PHYS 316

Class Hours: T/Th 10-11:15am

Class Room: PUP 206

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## Course Description

This course will provide an introduction to computational packages in Python, with particular emphasis on their use in solving physics problems and analyzing experimental data taken in physics laboratory experiments. Applications to problems in mechanics, electromagnetics and wave propagation will be stressed. At the end of the course, you should:

- be able to use a high-level programming language (Python) to write modularized programs and plot simple figures, such as scatter plot, time series, histogram, and 2D contour;
- understand fundamental numerical methods for evaluating integrals and derivatives and solving linear and nonlinear equations;
- write programs to solve physics problems involving ordinary differential-equations (ODEs);
- be able to write programs to solve physics problems involving partial differential equations (PDEs);
- be able to use Monte Carlo methods to simulate and understand random walk problems;
- have a good mastery of basic data analysis methods, such as linear regression, uncertainty analysis, and Fourier analysis.

## Required Materials

Computational Physics, Revised and Expanded

Mark Newman

ISBN 978-1480145511

Sample chapters are available at the author's webpage: <http://www-personal.umich.edu/~mejn/cp/>

## Recommended Supplementary Materials

Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib, Second Edition

Robert Johansson

Computational Physics: Problem Solving with Python, Third Edition

Rubin H. Landau, Manuel J. Páez and Cristian C. Bordeianu

An Introduction to Error Analysis, Second Edition

John R. Taylor

## Important Dates

1. First day of class: Tuesday, 1/28
2. Last day to change/drop a course without a grade of "W" being recorded: Friday, 2/07
3. Project Proposals Due: Thursday, 3/13
4. Take-home Midterm: Thursday, 3/27 (due Thursday, 04/03)
5. Project Presentations: Tuesday, 04/29 – Thursday, 05/08
6. Last day of class: Thursday, 05/08

## Course Structure

### Class Structure

PHYS 220 will be a mixture between instructional lectures and interactive, in-class, activities. Individual reading, and practicing to code at home, will play an important role in being successful in this course. Feel free to ask questions during lecture, whether you have difficulty with a concept, notice an error, or want to hear more details about an aspect of the material. Students are responsible for checking their academic e-mails and the Blackboard page daily for getting updates about the course, grades, homework, and class notes.

### Lecture

In order to be successful in this course, you should attend all classes. Please be attentive and take notes during lectures. **You will need to bring your laptop to each lecture to be able to work through in-class problems.** You are welcome to ask questions to clarify any point that is not clear, either during class or during my office hours.

## Homework

Homework assignments will be available on the course Blackboard page every Thursday and are due by the beginning of class (10 AM sharp) the following Thursday. **Late homework will not be accepted, and any homework turned in after 10 AM on the due date will receive a zero.** One homework assignment can be turned up to one week late without penalty. All other late work will be given a grade of zero. You are encouraged to discuss the material and homework questions among yourselves. However, the homework solution should be your own work, not a group product. **ChatGPT, and other large language models, or AI-based tools, are prohibited (see more details below).** For each graded assignment you will need to include the following: (1) Hand-written pseudocode: An outline of the steps, and their order, that your code needs to include; (2) Code comments: Detailed, personalized comments explaining each part of the code; and (3) Debugging logs: A debugging log (output of errors thrown when running the code), with commentary noting how errors were resolved. No credit will be given for copies. Please cite any resources used to complete homework assignments (including online resources and in-person conversations) at the bottom of each assignment.

## Graded In-class Assignments

Throughout the semester there will be graded in-class assignments (GCAs). You will have approximately half of the lecture to get started on the assignment, and will need to turn in a completed assignment by the EOD (midnight). These assignments will be less rigorous than homework problems, and will be focused on a recent topics taught in class. If you do not attend the lecture where the GCA is handed out, you will not have the opportunity to turn in a solution. The GCAs represent “check-in” points to ensure that (1) you are attending lectures and (2) absorbing the material in class. There will be approximately  $\sim 5 \pm 1$  GCAs. Similar to homeworks, you will need to include hand-written pseudocode, code comments, and debugging logs.

## Exams

There will be one take-home midterm during the semester. You will have one week to complete the midterm (see schedule included at the end of syllabus). If you know that you will be impacted by a foreseeable reason (religious holiday, court date, family event, existing medical problem, etc.), you must make arrangements before the midterm, rather than after. Outside of these scenarios (or the excused circumstances listed in “Class Attendance and Missed Work”), turning in the exam late will result in a zero, with no make-up option.

## Final Project

An independent semester-long final project is a major part of the course. For your final project, you will work in groups of 3, and write a python program demonstrating that you understand the concepts we discussed in class. The project must develop a sufficiently advanced python computer program to solve a problem and use multiple numerical methods related to the course. The final project will consist of a project proposal (due on 3/13), an in-class oral presentation (15 minutes, plus 5 minutes for questions), and a written report (including python source code, program output, and a citation of any related journal articles). The project should be considerably

more advanced than homework problems, independently developed by the student groups during the semester, and not developed directly as part of a student's research group work. In-class project oral presentations will be made during the last couple of weeks of the course with only a limited number of slots per day. Presentations are scheduled on a first-come basis and must be scheduled by 3/27. More details about the Final Project will be shared by the instructor later in the semester.

### Large Language Models (e.g., ChatGPT) Policy

LLMs, or otherwise known as "AI" tools, are not allowed to be used for any **any** work in this class (including homeworks, graded class assignments, exams, or your final project). **Using LLMs misses the point of this class, which is not to produce code but to figure out how to produce code and then successfully write it.** We will be checking all work to ensure that LLMs were not used. Any work that we believe used LLMs will automatically receive a zero.

### Class Attendance and Missed Work

Absences from class and missed work are accommodated (excused) in five circumstances: 1) significant illness, 2) personal instances of distress or emergency, 3) religious observance, 4) varsity athletic participation and 5) required court or legal appearances. For each circumstance, you will need to present to the instructor supporting evidence (e.g. a doctor note). The amount of time that is given to make-up the work will be decided on a case-by-case basis.

### Grading Policy

The grade will count the assessments using the following proportions:

- 30% of your grade will be determined by homework
- 25% of your grade will be determined by the midterm
- 20% of your grade will be determined by the GCAs
- 25% of your grade will be determined by the final project (Proposal 5%, Oral Presentation 10%, and Final Report 10%)

Your letter grade will depend on the total score. If your total grade is:

- $\geq 90$ , your letter grade will be "A"
- $90 > X \geq 80$ , your letter grade will be "B"
- $80 > X \geq 70$ , your letter grade will be "C"
- $70 > X \geq 60$ , your letter grade will be "D"
- $60 > X$ , your letter grade will be "F"

## Material

Topics that will be covered in this course are listed below, with a rough schedule. **The exact topics that we cover will depend on the pace of the course, some material may be excluded or additional material may be included.**

Class #	Date	Topic	Assignment	Due Today
First Day of Classes T, 1/28				
1	T, 1/28	Introduction: Overview of Syllabus Installation of Python, Spyder, and Jupyter Notebook		
2	Th, 1/30	Basic Programming (CP Chapter 2.1-2.4)	HW 1 Posted	
3	T, 2/04	Basic Programming (CP Chapter 2.5-2.6)		
4	Th, 2/06	Plotting and Visualization (NP Chapter 4; CP Chapter 3.2)	HW 2 Posted	HW 1
F, 2/07 Last day to change/drop a course without a grade of "W" being recorded				
5	T, 2/11	Plotting and Visualization (CP Chapter 3.2-3.3)		
6	Th, 2/13	Accuracy and Speed (CP Chapter 4)	HW 3 Posted	HW 2
7	T, 2/18	Integrals and Derivatives (CP Chapter 5.1-5.3)		
8	Th, 2/20	Integrals and Derivatives (CP Chapter 5.4-5.6)	HW 4 Posted	HW 3
9	T, 2/26	Integrals and Derivatives (CP Chapter 5.7-5.9)		
10	Th, 2/27	Dr. Foord traveling Integrals and Derivatives (CP Chapter 5.10-5.11)	HW 5 Posted	HW 4
11	T, 3/04	Linear and Nonlinear Equations (CP Chapter 6.1-6.2)		
12	Th, 3/06	Linear and Nonlinear Equations (CP Chapter 6.3-6.4)	HW 6 Posted	HW 5

Class #	Date	Topic	Assignment	Due Today
13	T, 3/11	Fourier Transforms (CP Chapter 7.1-7.2)		
14	Th, 3/13	Fourier Transforms (CP Chapter 7.3-7.4)		HW 6 Project Proposals
Spring Break 3/15 -3/23 No Classes				
15	T, 3/25	ODEs (CP Chapter 8.1-8.2)		
16	Th, 3/27	ODEs (CP Chapter 8.3-8.4)	Midterm	Presentation must be scheduled
17	T, 4/01	ODEs (CP Chapter 8.5-8.6)		
18	Th, 4/03	PDEs (CP Chapter 9.1-9.2)	HW 7 Posted	Midterm
F, 4/04 Last day to drop from individual courses (you will receive a "W")				
19	T, 4/08	PDEs (CP Chapter 9.3)		
20	Th, 4/10	Random Processes and MC (CP Chapter 10.1)	HW 8 Posted	HW 7
21	T, 4/15	Random Processes and MC (CP Chapter 10.2)		
22	Th, 4/17	Random Processes and MC (CP Chapter 10.3)	HW 9 Posted	HW 8
23	T, 4/22	*Bayesian Statistics (TBD)		
24	Th, 4/24	*Bayesian Statistics (TBD)		HW 9
25	T, 4/29	Final Presentations		
26	Th, 5/01	Final Presentations		
27	T, 5/06	Final Presentations		
28	Th, 5/08	Final Presentations		
29	T, 5/13	Last day of class. No class.		
	W, 5/14	Study Day		
	Th, 5/15 – W, 5/21	Final Exams		

## Course Policies

### Lectures

Please refrain from using computers in class, with the exception of electronic tablets for taking notes. Phones are prohibited during lecture. Eating and drinking are allowed in class but please refrain from it affecting the course.

### Attendance Policy

Attendance is expected in all lectures. Valid excuses for absence will be accepted **before** class. In extenuating circumstances, valid excuses with proof will be accepted after class.

### Academic Integrity and Honesty

*The following content has been created by others and is mandated to be on all syllabi.*

In February 2001, the Faculty Senate affirmed the importance of our values and practices by adopting the Statement of Values for Student Academic Integrity that is placed on most course syllabi:

*Academic integrity is an important value at UMBC. By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal.*

The purposes of higher education are the learning students and faculty undertake, the knowledge and thinking skills developed, and the enhancement of personal qualities that enable students to be strong contributing members of society. In a competitive world, it is essential that all members of the UMBC community uphold a standard that places integrity of each student's honestly earned achievements above higher grades or easier work dishonestly sought.

All members of the UMBC community are expected to make a commitment to academic honesty in their own actions and with others. Academic misconduct can result in disciplinary action that may include suspension or dismissal. The following are examples of academic misconduct that are not tolerated at UMBC:

- Cheating: Using or attempting to use unauthorized material, information, study aids, or another person's work in any academic exercise.
- Fabrication: Falsification or invention of any information or citation in an academic exercise.
- Facilitating academic misconduct: Helping or attempting to help another student commit an act of academic misconduct.
- Plagiarism: Knowingly, or by carelessness or negligence, representing as one's own, in any academic exercise, the intellectual or creative work of someone else.
- Dishonesty: Lack of truthfulness or sincerity when interacting with the faculty member regarding an academic exercise.

To this end, UMBC undergraduate students also adopted the following Undergraduate Honor Statement as it describes the high standards to which everyone in the community will be held:

*I hereby assume the responsibilities of an engaged member in a scholarly and civic community in which academic work and behavior are held to the highest standards of honesty. It is my active participation that affirms these principles and gives them true meaning as well as value in my education. I realize that by committing acts of dishonesty I hurt myself and place an indelible mark on the reputation of UMBC. Therefore, I will not cheat, fabricate materials, plagiarize, or help another to undertake such acts of academic dishonesty, nor will I protect those who engage in acts of academic dishonesty.*

For more information on the topic of Academic Integrity, visit: <http://oue.umbc.edu/ai/>

### Accommodations for Disabilities

*The following content has been created by others and is mandated to be on all syllabi.*

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADA AAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that creates equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at [sds.umbc.edu](https://sds.umbc.edu) for registration information and office procedures.

SDS email: [disAbility@umbc.edu](mailto:disAbility@umbc.edu)

SDS phone: 410-455-2459

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

## Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination

*The following content has been created by others and is mandated to be on all syllabi.*

**UMBC Policy** in addition to federal and state law (to include Title IX) prohibits discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment, or related retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources. The Title IX Coordinator can be reached at [titleixcoordinator@umbc.edu](mailto:titleixcoordinator@umbc.edu) or 410-455-1717.

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in making a report, please use the **Online Reporting/Referral Form**. Please note that, if you report anonymously, the University's ability to respond will be limited.

### **Notice that Faculty and Teaching Assistants are Responsible Employees with Mandatory Reporting Obligations.**

All faculty members and teaching assistants are considered Responsible Employees, per **UMBC's Policy on Sexual Misconduct, Sexual Harassment, and Gender Discrimination**. Faculty and teaching assistants therefore required to report all known information regarding alleged conduct that may be a violation of the Policy to the Title IX Coordinator, even if a student discloses an experience that occurred before attending UMBC and/or an incident that only involves people not affiliated with UMBC. Reports are required regardless of the amount of detail provided and even in instances where support has already been offered or received.

While faculty members want to encourage you to share information related to your life experiences through discussion and written work, students should understand that faculty are required to report past and present sexual harassment, sexual assault, domestic and dating violence, stalking, and gender discrimination that is shared with them to the Title IX Coordinator so that the University can inform students of their **rights, resources, and support**. While you are encouraged to do so, you are not obligated to respond to outreach conducted as a result of a report to the Title IX Coordinator.

If you need to speak with someone in confidence, who does not have an obligation to report to the Title IX Coordinator, UMBC has a number of **Confidential Resources** available to support you:

- **Retriever Integrated Health** (Main Campus): 410-455-2472; Monday – Friday 8:30 a.m. – 5 p.m.; For After-Hours Support, Call 988.
- **Center for Counseling and Well-Being** (Shady Grove Campus): 301-738-6273; Monday-Thursday 10:00a.m. – 7:00 p.m. and Friday 10:00 a.m. – 2:00 p.m. (virtual) **Online Appointment Request Form**.
- Pastoral Counseling via **The Gathering Space for Spiritual Well-Being**: 410-455-6795; [i3b@umbc.edu](mailto:i3b@umbc.edu); Monday – Friday 8:00 a.m. – 10:00 p.m.

### **Other Resources:**

- **Women's Center** (open to students of all genders): 410-455-2714; [womenscenter@umbc.edu](mailto:womenscenter@umbc.edu); Monday – Thursday 9:30 a.m. – 5:00 p.m. and Friday 10:00 a.m. – 4 p.m.
- **Shady Grove Student Resources, Maryland Resources, National Resources.**



## Child Abuse and Neglect

*The following content has been created by others and is mandated to be on all syllabi.*

Please note that Maryland law and [UMBC policy](#) require that faculty report all disclosures or suspicions of child abuse or neglect to the Department of Social Services and/or the police even if the person who experienced the abuse or neglect is now over 18.

## Pregnant and Parenting Students

*The following content has been created by others and is mandated to be on all syllabi.*

UMBC's [Policy on Sexual Misconduct, Sexual Harassment and Gender Discrimination](#) expressly prohibits all forms of discrimination and harassment on the basis of sex, including pregnancy. Resources for pregnant, parenting and breastfeeding students are available through the University's [Office of Equity and Civil Rights](#). Pregnant and parenting students are encouraged to contact the Title IX Coordinator to discuss plans and ensure ongoing access to their academic program with respect to a leave of absence – returning following leave, or any other accommodation that may be needed related to pregnancy, childbirth, adoption, breastfeeding, and/or the early months of parenting.

In addition, students who are pregnant and have an impairment related to their pregnancy that qualifies as disability under the ADA may be entitled to accommodations through the [Office of Student Disability Services](#).

## Religious Observances & Accommodations

*The following content has been created by others and is mandated to be on all syllabi.*

UMBC [Policy](#) provides that students should not be penalized because of observances of their religious beliefs, and that students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences or requested modifications for religious observances in advance, and as early as possible. For questions or guidance regarding religious observances and accommodations, please contact the Office of Equity and Civil Rights at [ecr@umbc.edu](mailto:ecr@umbc.edu).

## Hate, Bias, Discrimination and Harassment

*The following content has been created by others and is mandated to be on all syllabi.*

UMBC values safety, cultural and ethnic diversity, social responsibility, lifelong learning, equity, and civic engagement. Consistent with these principles, UMBC [Policy](#) prohibits discrimination and harassment in its educational programs and activities or with respect to employment terms and conditions based on race, creed, color, religion, sex, gender, pregnancy, ancestry, age, gender identity or expression, national origin, veterans status, marital status, sexual orientation, physical or mental disability, or genetic information.

Students (and faculty and staff) who experience discrimination, harassment, hate, or bias based upon a protected status or who have such matters reported to them should use the [online reporting/referral form](#) to report discrimination, hate, or bias incidents. You may report incidents that happen to you anonymously. Please note that, if you report anonymously, the University's ability to respond may be limited.