PHYS 220 Introduction to Computational Physics

Dates and Location:
Tuesday & Thursday 8:30AM - 9:45AM Janet & Walter Sondheim 108

INSTRUCTOR: Prof. Pengwang Zhai
Email: pwzhai@umbc.edu

OFFICE HOURS: PHYS313: Tuesday 1:00PM~1:50PM

Recommended TEXTS:
"**A Survey of Computational Physics: *introductory computational science*** " By R. H. Landau et al.
Python Multimodal eTextBook publicaly available from
http://www.compadre.org/psrc/items/detail.cfm?ID=11578

Grading:
Homework (30%), Graded In-class Assignments (GCA) 20%, Midterm Project (20%), Final Project (30%),
A: >=90; B: >=80 and <90; C: >=70 and <80; D: >=60 and <70; F: <60

Important Dates:

First day of class: Tuesday, Jan. 27
Final Project Topic Due: Thursday, March 5
Take-home Midterm: Thursday, March 26 (due Thursday, April 02)
Project Presentation schedule: March 26
Final project report due: April 28
Project Presentations: April 30 –May 12
Last day of class: Thursday, May 12

Learning Goals:

1. 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.
2. Understand fundamental numerical methods for evaluating integrals and derivatives and solving linear and nonlinear equations.
3. Write computer programs to solve physics problems involving ordinary differential-equations (ODE), such as projectile motion with drag and nonlinear oscillation.
4. Write programs to solve physics problems involving partial differential equations (PDE), such as finding electrostatic potential and simulating heat diffusion.

5. Use Monte Carlo method to simulate and understand random walk problem, such as photon transport in isotropic-scattering medium.
6. Have a good mastery of basic data analysis methods, such as linear regression, uncertainty analysis, and Fourier analysis.

Assignments:
I do NOT accept late submissions with exceptions outlined in the next section. Your lowest homework score will be dropped in the calculation of your final grade. For each graded assignment you will need to include the following:

(1) A pdf file which contains: an outline of the algorithm design; figures, and/or tables, and descriptions/discussions, Google Colab address of the source code you developed.

(2) A Google Colab notebook shared with the instructor as Viewer or Commenter. The notebook must run top-to-bottom without errors and reproduce the results submitted. Students must include a statement of sources and tools used, including AI tools if applicable. Collaboration on ideas is allowed; submitted code must be written independently.

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, and 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., doctor note).

Use of AI and Code Assistance
This course emphasizes **individual understanding and implementation** of computational methods used in physics. Students are expected to write, understand, and debug their own code.

Permitted Assistance

Students **may use** the following resources **unless explicitly prohibited** in a specific assignment:

- Course notes, textbooks, and lecture materials
- Official documentation (e.g., Python, NumPy, Matplotlib)
- General programming references and tutorials
- AI tools (e.g., ChatGPT, Copilot) **for**:
    - Explaining concepts or syntax
    - Debugging error messages
    - Clarifying numerical methods or algorithms
    - Understanding library functions

Use of these tools must be **supportive**, not **substitutive**.

Prohibited Use

The following are **not permitted** unless explicitly authorized:

- Submitting AI-generated code or text as your own

- Copying solutions (in whole or in part) from AI tools, websites, or other students
- Using AI to generate complete solutions to homework, GCAs, exams, or projects
- Using AI during exams or in-class assignments unless explicitly allowed
- Modifying AI-generated code superficially without understanding it

If you cannot explain your code or reasoning, it will be treated as unauthorized assistance.

Attribution Requirement

When AI or external code assistance is used in a **permitted manner**, students must include a brief acknowledgment, for example:
"I used ChatGPT to help understand the syntax of NumPy array indexing. The prompts I used were: … "
Failure to acknowledge assistance may be treated as academic misconduct.

Enforcement and Verification

The instructor may:

- Ask students to explain submitted code or results
- Compare submissions for similarity
- Require resubmission or clarification
- Assign reduced or zero credit if misuse is identified

Academic integrity violations will be handled according to university policy.

Guiding Principle

Use AI as a tutor, not as a solution generator.
You are responsible for all submitted work.

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. Students are responsible for checking their UMBC 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. **You will need to bring your laptop to each lecture to be able to work through in-class problems, which counts towards your final grades.**

Graded In-class Assignments (GCAs)

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.

Exams

There will be one take-home midterm. You will have one week to complete the exam. 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

Students will complete a semester-long computational physics project. A list of suggested project topics will be provided. Students may choose one of these topics or propose a closely related alternative, subject to instructor approval. Projects must include physical motivation, numerical method selection, validation, and interpretation of results. You will work in groups of 3, and write a python program demonstrating that you understand the concepts we discussed in class. The final project will consist of a project proposal, an in-class oral presentation (15 minutes, plus 5 minutes for questions), and a written report (including python source code shared via Google colab, program output (major results, plots, etc.), and a citation of any related journal articles). 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.

All group members are required to contribute original code to the project. Division of labor must ensure that each student practices computational implementation. Individual submissions and oral questioning will be used to assess individual contributions. More details about the Final Project can be found in a different document.

COURSE OUTLINE:

- **Computer Setup And Programing Warm-Up**
  - Google colab log-in and learn features
  - Python programming basics
  - Numpy and Matplotlib
- **Numerical Integration**
  - Quadrature methods
  - Monte Carlo method
  - Real-world Problem: Integrate Radiance to Flux
- **Numerical Differentiation and Root Searching**
  - Bisect method
  - Newton-Raphson method
  - Real-world Problem: Cloud property remote sensing
- **Monte Carlo method**
  - 2-D random walk
  - 3-D random walk
  - Real-world Problem: Photon scattering in cloud
- **Midterm Projects**
- **Linear algebra and matrix computing**
  - Matrix inversion and Eigenvalue
  - Singular value decomposition
  - Real-world problem: Greenhouse effect and atmospheric temperature profile
- **Data fitting**
  - Quadrature fitting
  - Lest-square fitting
  - Real-world problem: Satellite data analysis
- **Differential Equations: ODE and PDE**
  - Trajectory

- Wave equation
- Real-world problems

The following topics will be offered if time permits:

- Introduction to High Performance Computing
- Applications of Machine Learning to Physics Problems

- **Final Projects**

Accessibility and Disability Accommodations, Guidance and Resources (required)

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) 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 for registration information and office procedures.

SDS email: 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 (required)

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 ecr@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 Mandated Reporters with Mandatory Reporting Obligations

All faculty members and teaching assistants are considered Mandated Reporters, per UMBC's Interim Policy on Sex Discrimination, Sex-Based Harassment, and Sexual Misconduct. 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; Monday – Friday 8:00 a.m. – 10:00 p.m.

Women, Gender, and Equity Center (open to students of all genders): 410-455-2714; womenscenter@umbc.edu; Monday – Thursday 9:30 a.m. – 5:00 p.m. and Friday 10:00 a.m. – 4 p.m.

Other Resources

Shady Grove Student Resources, Maryland Resources, National Resources.

Child Abuse and Neglect

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 (*NOW REQUIRED*)*

UMBC's Interim Policy on Sex Discrimination, Sex-Based Harassment, and Sexual Misconduct 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

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.

Hate, Bias, Discrimination and Harassment

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.