NEW YORK UNIVERSITY
COLLEGE OF ARTS AND SCIENCES – DEPARTMENT OF PHYSICS
Course Outline PHYS-UA-210: Computational Physics
Fall 2021

Lectures: Tuesdays & Thursdays 12:30 – 1:45 PM; 726 Broadway, Room 1045

Recitations: Thursdays 5:00 – 6:15 PM; 726 Broadway, Room 1067

Instructor: Prof. Anthony R. Pullen

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Office: 726 Broadway, Room 938
Office Hours: TBD

TA: Cameron Norton

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Office Hours: by appointment

Course Website:

Located on Brightspace

Course Description

This course will introduce the concepts of computational physics, the application of computers to solve physics problems. We will learn and use the Python programming language in this course. Computation is an indispensable tool in physics; very little in modern theoretical and experimental physics research is done without the aid of computational methods. Upon completion of this course, the student will have the basic computational tools needed to solve physics-related problems, both in industry as well as graduate-level research.

We will cover the following topics:

- Python Programming
- Numerics
- Differentiation/Integration
- Linear Algebra
- Root-finding/Optimization
- Fourier Analysis
- Differential Equations
- Random Processes/Monte Carlo methods

Programming Language

We will use Python in this course. It is free, modular, and has broad adoption in both industrial and academic research settings. The concepts introduced in this course will have equivalent applications in most computational languages including C, Fortran, Java, IDL, and Julia.

Prerequisites

- Classical & Quantum Waves (PHYS-UA-105)
- Mathematical Physics (PHYS-UA-106)

OR

- Foundations of Science 6 (SCIEN-AD 113 & 117)
- Calculus I (MATH-UA 121)

See Prof. Pullen if you have not satisfied either of these sets of prerequisites.

Required Textbook

- M. Newman, *Computational Physics* (1st Edition – Revised & Expanded), 2013

Other References

- W. Press, S. Teukolsky, W. Vetterling, and B. Flannery, *Numerical Recipes* (3rd Edition), 2007 – the bible for scientific computing
- R. Landau, M. Páez, and C. Bordeianu, *Computational Physics* (3rd Edition), 2015
- J. Van Der Plas, *Python Data Science Handbook* – available for free online (google book title)

Classes/Recitations

The class will consist of a combination of chalkboard lectures and demonstrations using Jupyter notebooks. Make sure to read the relevant chapters before attending class. Lecture notes will be available just before each class period.

Recitations will take place Thursday evenings and will include a brief review of the material, opportunities to ask questions, and help with homework assignments.

Problem Sets

Eight problem sets will be assigned up until the beginning of November. The problem sets will be posted on the course website on Tuesday of the week that the relevant material is presented and are due at 11:59 PM of the following Monday. The submitted solution must consist of a Jupyter notebook containing the code and results. The solutions must be submitted to the GitHub classroom repository for this course. I will explain this more on the first day of class. DO NOT submit a printed solution set to the TA or me; they will not be accepted. Solution sets will be posted on the course website on the Wednesday after its due. Grades will be returned within a week after the homework due date.

Students can discuss the assignment with the instructor, other students, or anyone else. However, students are always required to turn in their own independent code and reports.

Late Homework Policy: Late homeworks will be accepted for reduced credit – 75% credit for up to 2 days late, 50% credit for longer.

Final Project

A major part of your grade will be a large project performed in groups of two students each, culminating in a presentation between mid-November and December. Project topics will be provided. You will also hand in a report written in LaTex. The draft report is due November 29, after which presentations will commence. The final report is due December 15.

Exams

There are no exams in this course.

Grading

- Problem Sets – 65%
- Final Project Presentation – 15%
- Final Project Report – 20%

Tentative Schedule

The schedule on the next page is tentative and subject to change. In the "Newman Chapters" column, the cells with "(Landau)" denote chapters from Landau, Páez, and Bordeianu, while the cell with "(NumRec)" denotes *Numerical Recipes*.

Class Dates	Topics	Newman Chapters	Problem Set Due
9/2	Python Programming	2	
9/7, 9/9	Python Programming & Graphing	2, 3	9/13
9/14, 9/16	Number Representations & Arrays	1,2 (Landau)	9/20
9/21, 9/23	Numerics	3 (Landau)	9/27 Teams Declared
9/28, 9/30	Integration	5	10/4
10/5, 10/7	Interpolation & Differentiation	5	10/11
10/14 **No class 10/12**	Random Processes	10	10/18
10/19, 10/21	Linear Algebra	6	10/25
10/26, 10/28	Eigensystems	6	11/1
11/2, 11/4	Root-finding & Optimization	6	11/8 (Last Homework)
11/9, 11/11	Fourier Analysis	7	
11/16, 11/18	Ordinary DEs	8	
11/23 **No class 11/26**	Monte Carlo Integration	10	
11/30, 12/2	Partial DEs	9	Draft Report Due (11/29) Presentations (11/29-12/3)
12/7, 12/9	Partial DEs	9	
12/14	Metropolis Algorithm	10	Final Report Due (12/15)