Advanced Computational Methods
Physics 6750
Fall 2017

Lectures and Labs

2 credit hours, 3 in-class hours/week
Mondays and Wednesdays, 10:30 am to 11:55 pm
Room: Physics 377

Final Exam Time

Wednesday, December 13, 10:15 am to 12:15 am

Instructor

Professor Christopher V. Kelly
Office: 283 Physics Building
Email: cvkelly@wayne.edu
Phone: 313-577-8471
Office Hours: Mondays and Wednesdays, Noon to 1:00 pm
or by appointment.

Recommended Texts

A Student's Guide to Python for Physical Modeling (PPM)
by Jesse M. Kinder & Philip Nelson
http://press.princeton.edu/titles/10644.html
We will not be spending much time in this textbook and you will be able to find all the help you need with online resources. However, it can be nice to have the basics combined into a single textbook. If you'd like to have a textbook in your hands, this is a fine one. But we won't be spending much time explicitly working out of this textbook.

Online Resources

Blackboard
blackboard.wayne.edu
Online tutorials
www.learnpython.org/ ; www.datacamp.com ; www.tutorialspoint.com/python/ ; etc.
Software
https://www.anaconda.com/download/ with Python version 3.6

Pre-requisites PHY 3750 and PHY 3700, or consent of the instructor.

Software

We will be primarily working with Python this semester and also gaining a little exposure to MATLAB (The MathWorks, Inc.). All software is available to you in the Physics Computer Lab (377 Physics) from 8:30am to 5pm on work days via a key from the Physics Department office. Python is free. A basic, student version of MATLAB costs $50, but is not required for this course.

Add/Drop Dates

Please refer to WSU's Academic and Registration Calendar (http://reg.wayne.edu/students) for the University's add and drop dates. Note: failing to drop a class by a deadline may hurt your GPA, financial aid status, and/or your tuition bill.

How to be successful in this course

The key to being successful in this course is to engage at all levels. Read the relevant sections of the text before lectures/labs, be attentive during lectures, be a leader during labs, ask questions, learn from your mistakes on homework, quizzes, and exams, and follow up during office hours. Students who display a strong desire to thrive will display their efforts via detailed questions from the readings or assignments that reflect their individual effort to understand the subject matter. Utilize the numerous resources available to you and recognize that success in this course will not be achieved solely through passive observation of the lectures and labs.

Course Content

This course will apply the principles of computer programming. We will build upon the basic concepts learned in prior classes to numerically solve interesting problems in physics.

Much of this course content has been assembled by Professor Peter Hoffmann and modified by your instructor. Thanks to Prop. Hoffmann, for all of his hard work!

Learning Objectives

1) Demonstrate a conceptual understanding of computer programming.
2) Demonstrate competence in Python programming.
3) Demonstrate the capability to learn new programming skills through independent use of help menus and online resources.
4) Apply sophisticated programming techniques to complex problems in physics

Final Grades

Final grades will be calculated from 20% Participation, 30% Homework, 20% Midterm Project and Presentation, and 30% Final Project and Presentation. The minimum letter grade to be awarded based on final percentages are shown in this chart:

Final Cumulative Work	Minimum Letter Grade
90%	A-
80%	B-
70%	C-
60%	D-

Exams

There will be no exams in this course. However, large projects and presentations represent the large fraction of the final grade. Presentation of the final projects may occur during the final exam time.

Homework

Homework will be assigned and submitted every week. Usually, homework will require the writing and submission of working Python code. Code should be submitted as an easy-to-read HTML or PDF file that shows all your computations completed successfully.

Students are encouraged to work together on the homework via small study groups. However, each student is required to write their own code and answers without copying or plagiarizing others. Your homework is expected to be a reflection of your effort and your understanding. Any copying or plagiarizing will be considered cheating, result in no credit, and possibly university-level disciplinary actions (http://www.otl.wayne.edu/wsu_integrity.php). Your homework and project submissions may be checked for plagiarism with SafeAssign.

Participation

Your participation in all activities of the course will help you and other students learn the material. Participation points will be given for pre-class surveys, in-class activities, and out-of-class study-group participation. Frequently in this course, students will be offered the chance to explain how they achieved a programming feat. Participation points may count for up to 20% of your final grade. Repeated absences will decrease your in-class participation grade. Should your participation in class prove to be distracting or disruptive, you may be asked to leave for the day and come to the lecturer's office hours to discuss the situation.

Projects and Presentations

Midterm and final presentations will be required by each student on an individual topic. Topics may come from your out-of-class research projects and/or your personal interest. Each project will require a sophisticated use of Python to achieve something that would be near-impossible to do without computer programming.

Class time has been set aside to allow for each student to present their project to the rest of the class. Each presentation should describe the big picture and purpose of the project, the psuedo-code outline followed, a few of the particularly advanced concepts used in your code, and the working code.

Missed Deadlines

It is important to turn in all assignments in a timely manner and your grade will suffer if you fail to do so. However, I want to support your learning while recognizing that life can be complex. For this reason, homework and project grades will be decreased depending on how late the assignments are turned in, as shown in this table. Exceptions can be made on a case-by-case basis, but only with pre-approval from the instructor.

Days Late	Reduction in Homework Grade	Reduction in Project Grade
1	**15%**	**30%**
≤7	**30%**	**At least 50%**
>7	**At least 50%**	**At least 50%**

Incompletes

The mark of I for Incomplete is given to either an undergraduate or a graduate student when he/she has not completed all of the course work as planned for the term and when there is, in the judgment of the instructor, a reasonable probability that the student can complete the course successfully without again attending regular class sessions. The student should be passing at the time the grade of 'I' is given. A written contract specifying the work to be completed should be signed by the student and instructor. Responsibility for completing all course work rests with the student (*2011-2013 WSU Undergraduate Bulletin,* 41).

Undergraduate vs. Graduate Students

University regulations require that the course work and grading be independent for the undergraduate and graduate students. Graduate students will be assigned longer homework assignments, expected to execute more complex projects, and be expected to be more involved in participating in the course. For example, graduate students are expected to be extra outgoing in helping others error check their code.

Students with Disabilities

If you have a documented disability that requires accommodations, you will need to register with Student Disability Services for coordination of your academic accommodations. The Student Disability Services (SDS) office is located in the Adamany Undergraduate Library. SDS telephone number is 313-577-1851 or 313-577-3365 (TTD only). Once you have your accommodations in place, I will be glad to meet with you privately during my office hours or at another agreed upon time to discuss your needs. Student Disability Services' mission is to assist the university in creating an accessible community where students with disabilities have an equal opportunity to fully participate in their educational experience at Wayne State University. Also see: http://studentdisability.wayne.edu.

Syllabus Modifications

I will be trying a number of teaching techniques throughout this semester, some of which are described in this syllabus. As I learn what is working and what is not, I will be modifying the policies of this course. And so, this syllabus is a dynamic document that may be updated as the semester progresses.

Academic Misconduct

Academic misbehavior means any activity that tends to compromise the academic integrity of the institution or subvert the education process. All forms of academic misbehavior are prohibited at Wayne State University, as outlined in the Student Code of Conduct (http://doso.wayne.edu/codeofconduct.pdf). Students who commit or assist in committing dishonest acts are subject to downgrading (to a failing grade for the test, paper, or other course-related activity in question, or for the entire course) and/or additional sanctions as described in the Student Code of Conduct. Cheating: Intentionally using or attempting to use, or intentionally providing or attempting to provide, unauthorized materials, information or assistance in any academic exercise. Examples include: (a) copying from another student's test paper; (b) allowing another student to copy from a test paper; (c) using unauthorized material such as a "cheat sheet" during an exam. (d) unauthorized access to a test from a previous semester also constitutes cheating. Fabrication: Intentional and unauthorized falsification of any information or citation. Examples include: (a) citation of information not taken from the source indicated; (b) listing sources in a bibliography not used in a research paper. Plagiarism: To take and use another's words or ideas as one's own. Examples include: (a) failure to use appropriate referencing when using the words or ideas of other persons. (b) altering the language, paraphrasing, omitting, rearranging, or forming new combinations of words in an attempt to make the thoughts of another appear as your own. Other forms of academic misbehavior include, but are not limited to: (a) unauthorized use of resources, or any attempt to limit another student's access to educational resources, or any attempt to alter equipment so as to lead to an incorrect answer for subsequent users; (b) enlisting the assistance of a substitute in the taking of examinations; (c) violating course rules as defined in the course syllabus or other written information provided to the student; (d) selling, buying or stealing all or part of an un-administered test or answers to the test; (e) changing or altering a grade on a test or other academic grade records.

WSU Resources for Students

- Student Disability Services (SDS) http://studentdisability.wayne.edu/
- Academic Success Center http://www.success.wayne.edu/
- Counseling and Psychological Services (CAPS) http://www.caps.wayne.edu

- Dean of Students' Office http://www.doso.wayne.edu
- College of Liberal Arts & Sciences: http://clasweb.clas.wayne.edu/CurrentStudents
- Departmental Website: http://physics.clas.wayne.edu//

Schedule and Learning Outcomes

Week 1

- Use the Python environment, including Spyder and Jupyter
- Save Python notebooks in Jupyter as html
- Perform calculations in Python
- Define, manipulate and use data sequence structures, such as lists, arrays and strings
- Load and use Python modules, such as numpy and matplotlib

Week 2

- Define and manipulate lists and arrays
- Define and manipulate strings
- Define and manipulate dictionaries
- Write simple programs in Python
- Define functions in python
- Create 2D data plots

Week 3

- Use programming structures such as loops and conditionals
- Plan a programming task and subdivide into modules, subroutines or functions
- Write multipart programs with submodules
- Calculate with complex numbers
- Use multiple decision trees
- Create mathematically defined drawings
- Define fractals and calculate the fractal dimension of an object

Week 4

- Read and write data in Python
- Calculate roots of nonlinear functions by a variety of methods
- Explain advantages and disadvantages of different root finding methods
- Define functions recursively

Week 5

- Interpolate data
- Calculate the 1^{st} and 2^{nd} derivative of data
- Estimate errors and use strategies to minimize errors in calculations
- Use Euler's method to solve simple 1^{st} order differential equations

Week 6

- Perform matrix calculations
- Perform linear curve fitting
- Convert nonlinear equations into linear ones (if possible) to perform curve fitting
- Solve systems of linear equations
- Perform nonlinear curve fitting

Week 7

- Perform 1D numerical integration
- Estimate integration errors and employ methods to reduce errors
- Calculate multidimensional integration and articulate possible limits in terms of computing time

Week 8

- Define and manipulate statistical distributions, including uniform, normal, binomial and Poisson distributions.
- Calculate random numbers taken from different statistical distributions
- Perform Monte Carlo integration
- Write a program to simulate a random walk
- Write a simple Monte Carlo simulation

Week 9

- Solve 1st and 2nd order ordinary differential equations
- Estimate integration errors and employ different integration methods to reduce error
- Discuss the need to use the correct integration method when calculating physical systems to maintain energy conservation

Week 10

- Solve nonlinear differential equation and calculate phase space trajectories
- Perform Fourier analysis of time data

Week 11

- Perform image analysis and manipulation, including image filtering, rotation and Fourier analysis

Week 12/13

- TBD

Week 14/15

- Work on final projects

Week 16/Final exam time

- Project presentation