Physics 3926F: Computer Simulations in Physics

Department of Physics & Astronomy, Western University, Fall 2020

Course Information

Schedule (see details below): Online Monday & Wednesday 3:30-5:30 PM, beginning Sept 9.

Pre-requisites: Physics 2101A/B, Physics 2102A/B, Physics 2110A/B, Physics 2910F/G (or the former Physics 2900E), and Calculus 2303A/B or 2503A/B. Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Instructor Prof. Pauline Barmby (she/her), @PBarmby on GitHub

Contact: 519-661-2111 ext 81557 (forwarded), email pbarmby@uwo.ca
Office hours: Tuesdays 430-530pm via Zoom (see OWL for link) or by appointment; available on Zoom during lab hours noted above.

TA: Mr. Arpan Das, adas45@uwo.ca, @dasarpan007 on GitHub

Course Delivery Mode, Syllabus, Schedule

Online course: lecture material delivered asynchronously with lab periods scheduled for synchronous collaborative work; *no labs will take place in person*. A short Zoom meeting at 3:30 each Monday will introduce each week's lab. Please keep Monday and Wednesday 3:30-5:30 PM (Eastern time) free in your schedule: after the lab introduction, these 4 hours are available to work on labs with your groups.
Please attend the introductory course meeting on Zoom at 3:30pm, Wednesday September 9 - see OWL for connection information.

Physics 3926 is a project-oriented, computationally-based course that applies numerical methods to problems in physics and astrophysics. Python is used exclusively. Techniques for programming, data analysis, data visualization, and simulation will be developed over the term.

Learning Outcomes: At the end of the course, students will be able to:

1. Create Python programs that use the core language and NumPy and SciPy modules, following best practices for scientific computing
2. Use collaborative editing tools and version control software to develop software in groups
3. Explain when and how computer simulations are used in physics research
4. Apply knowledge of Python to creating programs that analyze and/or simulate physical systems
5. Visualize the results of data analysis and numerical simulations through the creation of appropriate graphics

6. Compare, contrast, and apply numerical methods of solution for the ordinary and partial differential equations that commonly arise in physics and astronomy
7. Synthesize the solution of computational physics problems by documenting their physical basis, numerical solution, and graphical visualization

This course is about using computers to do (astro)physics. Some previous experience with Python is helpful but not mandatory. After reviewing the basics of Python we will learn how to use it to analyze and present data and to solve complex (astro)physical problems. We will apply computer simulations to examples from several branches of physics and astronomy. Along the way, we will learn how to develop realistic numerical models of physical systems and some of the practical aspects of how to solve and interpret these models.

Topic Outline

Learning Python (with application to ODEs; Chapters 1, 2, and 10): weeks 1-4, 7

- Arrays and data structures
- Plots
- Control structures, advanced data structures
- Functions versus scripts, good programming practice
- Writing/maintaining good documentation
- Introduction to version control GitHub

Data analysis (Chapters 4 and 5): week 8, 9

- Interpolation and curve fitting
- Linear Algebra
- Statistical descriptions of data
- Fourier methods

Applications (Chapters 3, 6, 7): weeks 5, 9-13

- Ordinary differential equations (orbital motion)
- Partial differential equations (diffusion, advection, waves)

Course Materials

Required Textbook: *Numerical Methods for Physics*, Second Edition, Revised (Python) by Alejandro L. Garcia (2017, CreateSpace Independent Publishing), ISBN 978-1548865498. We will follow this text closely and use many of its examples and programming projects. You must have access to this textbook. Note that the text uses Python version 2.7 but the course will use Python 3.7; there are several important differences between versions that you need to be aware of.

Video tutorials, a weekly checklist of activities, and links to other resources will be posted to the OWL site (https://owl.uwo.ca) associated with this course. Students are responsible for checking OWL on a regular basis for news and updates. This is the primary method by which information will be disseminated to all students in the class.

Technical requirements:

- Internet access via a computer is required. Most work will be asynchronous: webcam and microphone are not required.
- (free) GitHub account: the course will use GitHub Classroom for introducing version control and for submission of labs and projects.
- Python development environment: many options are available and if you already have a favorite (e.g. Spyder, PyCharm, etc), feel free to keep using it. If you are new to Python IDEs, for this course we recommend Microsoft VS Code or the "code-in-the-browser" system repl.it. Instructions on how to set up VS Code and repl.it and link them to GitHub are on OWL.
- To facilitate team communication, the course will use MS Teams, Slack or some other method chosen by class members; details to be provided.

Methods of Evaluation[1]

Your course grade will be computed as follows:

Component	**Weight**
Lab assignments (12), due 6pm every Wednesday *(Lab #0 due Sunday Sep 13 at 6pm)*	35%
Midterm (see details below, week of Oct 14)	20%
Project 1: due Friday, October 2*	7%
Project 2: due Friday, October 30*	10%
Project 3: due Friday, November 27	10%
Project 4: due Monday, December 21	18%

*Projects 1 and 2 can be done in either order: one must be submitted on October 2 and the other one on October 30. The order of submission doesn't change the weight.

The midterm exam is designed to assess your general programming skills. The exam will be time-limited, to be started at any time within a 24-hour period (to be scheduled) and submitted 2 hours later. The exam will be open-book: consulting references or websites is permitted. Requesting assistance from another person (e.g. by posting questions on websites or social media or through personal discussion) is not permitted and will be considered cheating.

There is no December final exam in this course. The final project (Project 4) is due after the end of classes.

[1] The exact details and weighting of the course evaluations could change due to external circumstances relating to the COVID-19 pandemic situation. Please consult the course OWL site to be sure you have the latest information. The Department of Physics and Astronomy may, in exceptional cases, adjust the final course marks in order to conform to Departmental policy.

Twelve (12) laboratory assignments are scheduled weekly. Regular labs start the week of Monday, September 14. *There is a "bonus" lab assigned at the beginning of the term and due Sunday Sept 13.* Assignments will be posted on GitHub Classroom early on Monday afternoons and must be submitted (via GitHub Classroom) by 6PM Eastern time on Wednesdays. Each laboratory assignment is worth 3% of your final grade; therefore, you can miss two weekly labs without penalty. If you complete all twelve lab assignments, your lowest two grades will be dropped. Missed lab assignments cannot be made up at a later date for any reason.

Learning to work on software in groups is part of the course; group work on lab assignments is optional for some assignments and mandatory for others. Some labs will have randomly assigned groups. All members of a group will receive the same grade on a given assignment (but see below). At least 5 of the labs, beginning with lab 4, must be completed in groups, and 5 out of the 35 total marks will be based on your individual contribution in labs with group work. See the course materials on OWL for a short document (to be posted before lab 4) outlining the performance expected for a student to receive the full 5 marks.

All four projects are to be carried out individually and are report-based, since this course has an "essay" designation. For each project, a written report must be submitted, along with Python code as necessary. The projects will be fully described in separate documents available on the GitHub Classroom site.

Accommodated evaluations

Missed Laboratory exercises: cannot be made up later; however, two labs can be missed for any reason without academic penalty.

Missed midterm: must be made up at a later date and cannot be handled through re-weighting other course components. Midterm make-ups tentatively scheduled for the week of November 9.

Late Projects: Late projects will be penalized 10% per day for up to five days; projects more than five days late will not be accepted. Weekends count: a project due on Friday but submitted on Monday is three days late.

Accommodation and Accessibility

Accommodation Policies

Students with disabilities work with Accessible Education (formerly SSD) which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The Academic Accommodation for Students with Disabilities policy can be found at:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf

Academic Consideration for Student Absence

Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the semester, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student's final grade. Students are expected to contact their instructors within 24 hours of the end of the period of the self-reported absence, unless noted on the syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student's final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are *not* met, students will need to provide a Student Medical Certificate if the absence is medical, or provide appropriate documentation if there are compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. **All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty.**

For policy on Academic Consideration for Student Absences - Undergraduate Students in First Entry Programs, see:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Consideration_for_absences.pdf

and for the Student Medical Certificate (SMC), see:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf

Religious Accommodation

Students should consult the University's list of recognized religious holidays, and should give reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor if their course requirements will be affected by a religious observance. Additional information is given in the Western Multicultural Calendar: https://multiculturalcalendar.com/ecal/index.php?s=c-univwo

You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (see http://www.registrar.uwo.ca/examinations/exam_schedule.html).

Academic Policies

The website for Registrarial Services is http://www.registrar.uwo.ca.

In accordance with policy, http://www.uwo.ca/its/identity/activatenonstudent.html, the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at his/her official university address is attended to in a timely manner.

All of the remote learning sessions for this course will be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals participating in the course for their private or group study purposes. You are not required to use your camera or microphone; please contact the instructor if you have any concerns related to session recordings.

Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

Support Services

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on add/drop courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: https://www.uwo.ca/sci/counselling/

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Student Accessibility Services (SAS) at (519) 661-2147 if you have any questions regarding accommodations.

Western University is committed to a thriving campus as we deliver our courses in the mixed model of both virtual and face-to-face formats. We encourage you to check out the Digital Student Experience website to manage your academics and well-being: https://www.uwo.ca/se/digital/.

Students who are in emotional/mental distress should refer to Mental Health@Western (http://www.health.uwo.ca/mental_health) for a complete list of options about how to obtain help.

Additional student-run support services are offered by the USC, http://westernusc.ca/services.

Version 4: 2020 Sept 14. Modified to include TA contact info, instructor office hours, revised midterm make-up date.
Version 3: 2020 Aug 30
Modified from earlier versions by Prof. A. Sigut