PHY407H Computational Physics
Fall 2022 Syllabus

Forewords:

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Lectures, labs, and office hours will be online synchronous. During labs, room MP257 will be open for students wishing to use the workstations, but no instructor or TA will be present. The final exam is the only in-person course component.

The course website is on Quercus, including organizational info, lecture notes, pre-lecture problems, labs, announcements, discussion board, etc. Check it frequently, as it is your main, resource for this course.

Instructor: Prof Miriam Diamond, mdiamond@physics.utoronto.ca
MP 801A, 647-705-9716

TAs:

- Gabe Dublin (lab), gabe.dublin@mail.utoronto.ca
- Mikhail Schee (lab), mikhail.schee@mail.utoronto.ca
- Evelyn Macdonald (lab), evelyn.macdonald@mail.utoronto.ca
- Ahmed Rayyan (lab), a.rayyan@mail.utoronto.ca
- Sahibjeet Singh (final project marker), ssingh@physics.utoronto.ca
- Quark & Qubit the Guinea Piggies (motivational assistants)

Course Description: This is an introduction to scientific computing in physics. Students will be introduced to computational techniques used in a range of physics research areas. By considering select physics topics, students will learn computational methods for function analysis, ODEs, PDEs, eigenvalue problems, non-linear equations and Monte Carlo techniques. "Survival skills" in scientific computing, such as command line programming, debugging, solution visualization, computational efficiency and accuracy will be developed. The course is based on python and will involve working on a set of computational labs throughout the semester as well as a final project.

Grading Scheme:

- Pre-lectures: 10% (10 quizzes, 1% each)
- Labs: 60% (best 10 out of 11 reports, 6% each)
- Final Exam: 30%

Required Textbook: Computational Physics by Mark Newman (2nd edition, 2013). Available at the UofT bookstore. The following website has the first few chapters available for free, plus excellent resources (e.g. python code snippets): http://www-personal.umich.edu/~mejn/cp/ .

Prerequisites and background: PHY224H and 254H are prerequisites. Preparation of other physics courses is strongly recommended. CSC courses can be helpful, though only marginally so, and certainly not required. It is highly recommended you get started by making sure you are familiar with the content of the tutorials at https://computation.physics.utoronto.ca/

Typical weekly schedule (all hours are quoted in Eastern Time)

- Monday: pre-lecture Quercus quiz due before lecture (after week 1), lecture at 12:00 PM (noon)
- Wednesday: lab 9:00 AM - 12:00 PM
- Thursday: office hours 10:00 - 11:30 AM
- Friday at 12:00 PM (noon): last time to ask questions about the lab to the TAs or instructor. No answer will be guaranteed after this time, since all of us typically have busy research schedules on Friday afternoons.
- Friday at 5:00 PM: lab due, next lab and next pre-lecture questions assigned.

Pre-lecture quizzes: Composed of multiple-choice / true-false questions based on the upcoming week's readings from the textbook. Must be completed (on Quercus) before the lecture, with a score of 0 automatically assigned if missed.

Lectures: Mondays 12:00-1:00 PM, synchronously on Zoom (link posted on Quercus). This course, including your participation, will be recorded on video and will be available to students in the course for viewing remotely and after each session on Quercus.

You are encouraged to prepare your questions about the upcoming lab and ask them in the latter part of the lecture. The professor will post her notes on Quercus before the corresponding lecture starts. You are responsible for the material covered in the lectures, even if it is not in the text or the posted lecture notes.

Labs: Wednesdays 9:00-12:00, online on gather.town (https://gather.town/ , links and passwords provided on Quercus) with MP257 open for students who want to use the workstations. Gathertown is a blend between Zoom and a 90's video game: your avatar can move around a 2D map of a room and share your screen, voice and webcam with whomever is in your virtual vicinity. There is a chat feature, you can raise your hand to attract the TA's attention, and you have some control over when your webcam + mic are open. Labs will not be recorded.

Lab activities are computational exercises that you can work on during the lab time, as well as on your own before or afterward. They involve a variety of physics concepts and introduce you to some major scientific computing tools. It is highly recommended to do all your labs with a partner (but you cannot form a group larger than 2.) You can switch who you pair up with from lab to lab. You and your partner can hand in the same lab report, just make sure to sign up for the same "Lab Group" on Quercus when you submit. If you don't

have a lab partner, you will be basically doing twice as much work as required. See the Lab Assignment Policy document for more detail.

Lateness penalty for lab reports: lose 10% for each 24-hour period. If you submit after 5:00 PM the following Monday, your submission will not be marked, as you will get 0.

Office Hours: Office hours will take place online (Zoom link provided on Quercus), every Thursday 10:00-11:30 AM, with a lab TA.

Topics Schedule: (subject to change)

Week	Dates	Textbook Chapters	Lab topic
0	12-17 Sep	2-3, 4.3	Intro to python and programming, pseudocode
1	19-24 Sep	4, 5.1-5.3	Numerical errors, integration techniques: trapezoid rule, Simpsons rule, errors on integrals, choosing #steps
2	26 Sep – 1 Oct	5.5-5.11	Gaussian quadrature, infinite ranges, multiple integrals, derivatives, interpolation
3	3-8 Oct	6	Solving linear & nonlinear systems: Gaussian elimination, pivoting, LU decomp, eigensystems, QR, relaxation, binary search, Newton's method, secant method, golden ratio search
4	10-15 Oct	7	Fourier Transforms: DFT, 2D DFT, FFT (*Thanksgiving Monday: prof will record the lecture*)
5	17-21 Oct	8	ODEs 1
6	24-29 Oct	8	ODEs 2
7	21 Oct - 5 Nov	9	PDEs 1
	7-13 Nov		*Reading week*
8	14-19 Nov	9	PDEs 2
9	21-26 Nov	10	Random Processes
10	28 Nov – 3 Dec	10	Monte Carlo techniques
11	5-10 Dec		Prof's demos of fun stuff

Computer Software: for more info, see the document called "Requirements, guidelines and suggestions regarding software", distributed as an appendix to this syllabus. Some of the most important points:

- Gathertown only works reliably with Firefox and Chrome (though Chromium-based browsers, such as Brave, might work).
- The programming language for this course is python 3.
- GitHub (https://github.com/) is a hosting service for collaborative projects. It is recommended, but not required, that you try using it when working on your labs. The professor will post all lecture notes and lab materials for the course in her public GitHub repository, https://github.com/mdiamon/PHY407-UofT .

Course videos and materials belong to the instructor, the University, and/or other source depending on the specific facts of each situation and are protected by copyright. In this course, you are permitted to download session videos and materials for your own academic use, but you should not copy, share, or use them for any other purpose without the explicit permission of the instructor. For questions about recording and use of videos in which you appear please contact your instructor.

Plagiarism detection ("essays" here refer to lab assignments and final exam)**:** Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq).

Academic integrity is essential to the pursuit of learning and scholarship in a university. The University treats cases of cheating and plagiarism very seriously; the Code of Behaviour on Academic Matters (https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from their instructors or from other institutional resources (for example, the University of Toronto website on Academic Integrity, https://www.academicintegrity.utoronto.ca/).

Accommodations: If you have a learning need requiring an accommodation, the University of Toronto recommends that students immediately register at Accessibility Services at http://www.studentlife.utoronto.ca/as

> Location: 4th floor of 455 Spadina Avenue, Suite 400
> Voice: 416-978-8060 Fax: 416-978-5729
> Email: accessibility.services@utoronto.ca

The University of Toronto supports accommodations of students with special learning needs, which may be associated with learning disabilities, mobility impairments, functional/fine motor disabilities, acquired brain injuries, blindness and low vision, chronic health conditions, addictions, deafness and hearing loss, psychiatric disabilities, communication disorders and/or temporary disabilities, such as fractures and severe sprains, recovery from an operation, serious infections or pregnancy complications.

The University provides reasonable accommodation of the needs of students who observe religious holy days other than those already accommodated by ordinary scheduling and statutory holidays. Students have a responsibility to alert members of the teaching staff in a timely fashion to upcoming religious observances and anticipated absences and

instructors will make every reasonable effort to avoid scheduling tests, examinations or other compulsory activities at these times.

The University of Toronto strives to provide a family-friendly environment. You may wish to inform the professor if you are a student with family responsibilities. If you are a student parent or have family responsibilities, you also may wish to visit the Family Care Office website at familycare.utoronto.ca.

Please reach out to the professor as early as possible to communicate any anticipated absences related to religious observances, learning needs, and family responsibilities, and to discuss any possible related implications for course work. Confidentiality of learning needs is respectfully and strictly maintained.

Equity, Diversity and Excellence: The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.