PHYS 2801, Fall 2026

Computational Methods in Physics

We, the people of the Faculty of Science at Carleton University, acknowledge that our campus is located on the traditional, unceded territories of the Algonquin Anishinabeg people. Miigwetch for your hospitality and stewardship of this territory and the teachings that come from it. We are grateful for this land, the air that we breathe, and the water that sustains us all as well as for the animals, plants and other living beings: these enable us to research, teach, mentor, support, study, and learn. We recognize our responsibility to our natural environment and to reconciliation with Indigenous peoples.

Course overview

This course provides a practical introduction to computational methods and tools used in modern physics. Students will develop skills to formulate and solve physics problems computationally, analyse and interpret data, and work with scientific software and computing environments. Topics include Python programming, command-line tools and shell scripting, version control and code repositories, numerical methods, probability and statistical data analysis, and an introduction to machine learning and artificial intelligence in physics.

The course emphasizes hands-on problem solving and critical evaluation of computational results. Students will learn not only how to apply computational and data-analysis methods, but also how to assess their validity, recognize common pitfalls and questionable analysis practices, and use physical and statistical reasoning to determine whether results can be trusted.

Course instructor: Dag [Dawg] Gillberg

Email: dag@physics.carleton.ca

Note: If you have questions or would like to talk, you can send an email, visit me during student hours (see below), or approach me after lecture.

Best ways to be in touch:
via email, or during student hours

Student hours:
Thursdays 1 pm - 2 pm in my office

Course Brightspace page

Dag's office: Room 2404, Herzberg

Class location: Please check Carleton Central for the room location.

Class times: Tuesday + Thursday 16:00-17:30

Prerequisites:
(PHYS 1001 or PHYS 1003 or PHYS 1007) **and** COMP 1005 **or** permission from deparment

Department: Physics

Course TA: Cyrus Robertson Orkish
CYRUSROBERTSONORKISH@cmail.carleton.ca

Weblinks

Course page: https://brightspace.carleton.ca/d2l/home/451755

Physics department Jupyter server: https://jupyterhub-phys2801.physics.carleton.ca

Course schedule

Lecture slides will be posted on the course Brightspace page before each lecture. The course is structured in three blocks, with a term test ('midterm') after the first two blocks, and the final exam at the end. The term tests are written during the Thursday lecture slot.

Block I: Scientific computing and numerical physics

Block II: Probability and data analysis

Block III: Machine learning and modern computational physics

Week	**Date**	**Topics**
1	Sept 10	**Introduction** & course overview; analytical vs numerical approaches; Python/Jupyter setup; first examples
2	Sept 15+17	Python/NumPy + numerical derivatives and integrals. **Tutorial 1.**
3	Sept 22+24	Computing tools: terminals, files, bash, scripting and LaTeX. **Tutorial 2.**
4	Sept 29+Oct 1	Numerical methods: *numerical accuracy, convergence, root-finding*
5	Oct 6+8	**Review / numerical problem solving**: choosing methods, debugging, convergence. **Term test 1** (Oct 8).
6	Oct 13+15	**ODEs**: Euler, midpoint/RK methods; first- vs second-order. **Tutorial 3**
7	Oct 19-23	**READING WEEK**
8	Oct 27-29	**Probability and random variables:** Common PDFs. **Tutorial 4**.
9	Nov 3+5	**Statistical analysis and fitting:** linear regression. **Tutorial 5.**
10	Nov 10+12	**Review:** ODEs, probability, linear regression. **Term test 2** (Nov 12).
11	Nov 17+19	**Git and reproducible computing** — repositories, commits, branches, collaboration; advanced shell. **Tutorial 6.**
12	Nov 24+26	**Scientific data analysis** — scientific method, bias, p-hacking, validation, good/bad practices. Intro to machine learning and neural networks.
13	Dec 1+3	**Neural networks in practice:** supervised learning, regression/classification, loss functions, gradient descent. **Tutorial 7.**
14	Dec 8+10	**Modern neural-networks:** AI/LLMs + course review

Important dates and deadlines can be found here: https://calendar.carleton.ca/academicyear/, including class suspension for fall, winter breaks, and statutory holidays.

Course-level learning outcomes

By the end of this course, students should be able to:

1. **Use standard computational tools and workflows used in physics**, including Python, Jupyter notebooks, command-line tools and shell scripts, LaTeX, and version-control systems.
2. **Represent, manipulate and visualize scientific data** using appropriate data structures, numerical libraries, file formats and plotting techniques.
3. **Formulate physics problems computationally and apply appropriate numerical methods** to solve them, including numerical differentiation and integration, root finding, ordinary differential equations, and parameter estimation.
4. **Apply probability and statistical methods to physics data**, including common probability distributions, estimation of statistical quantities and uncertainties, regression and goodness-of-fit testing.
5. **Critically assess computational and data-analysis results**, and recognize common pitfalls such as bias, confounding, p-hacking and inappropriate interpretation of statistical results.
6. **Explain and apply introductory machine-learning methods in physics**, including supervised learning and neural networks, and evaluate issues such as training, validation and overfitting.
7. **Use AI tools effectively and critically in computational work**, including evaluating AI-generated code and recognizing the need to independently validate its output.

Assessments

Grade breakdown

Component	Grade value	Comment
In-class quizzes	5%	Wooclap quizzes during lectures.
Assignments	25%	Typically related to tutorials. Submit via Brightspace a few days after tutorial.
Term test 1	15 %	During the Thursday lecture slot
Term test 2	15 %	During the Thursday lecture slot
Final Exam	40 %	3 hour exam scheduled by the university

Late and missed work policies

Late work

Extensions to an assignment can be given if there is a valid reason. However these need to be granted by the course instructor **before** the deadline of the assignment. The standard late penalty is a deduction of 10% per day. For example, if you submit an assignment 2 days late (e.g. 30 hours after the deadline) and score 80/100, your mark will be 64 / 100 (20% less than 80).

Very late assignments will typically get accepted as long as they are submitted during the semester with the maximal penalty of 50%.

Missed work

Quizzes

In case you miss a class and hence miss participating in the Wooclap quiz question, it might be possible to answer these questions during the student hour.

Term tests

In case you are going to miss a term test; you **need to inform** the instructor **in advance**! There will most likely not be any deferred term tests, but instead an **oral exam** on the content shortly after the term test.

Final exam

This is scheduled and handled by the university. If you have a valid reason, you can write a deferred exam.

Learning materials

Students are not required to purchase textbooks or other learning materials for this course.

All required learning materials will be made available through the course Brightspace page at no additional cost. These materials include lecture slides and notes, tutorial instructions and worksheets, assignments, and other course-related resources.

Academic accommodations and regulations

Carleton is committed to providing academic accessibility for all individuals. You may need special arrangements to meet your academic obligations during the term. The accommodation request processes, including information about the Academic Consideration Policy for Students in Medical and Other Extenuating Circumstances, are outlined on the Academic Accommodations website (https://students.carleton.ca/course-outline/).

Use of artificial intelligence (AI)

The appropriate use of AI tools is an important topic in this course, and we will discuss both their potential and their limitations in computational physics. Some course activities or assignment questions may specifically ask students to use and critically evaluate AI tools.

For assignments, limited use of AI tools is permitted unless otherwise stated. If AI is used, students must clearly indicate where and to what extent it was used. Students remain responsible for the work they submit and are expected to critically assess AI-generated code, explanations, or other output rather than accepting it without verification.

During tutorials, students should not use AI tools to solve the exercises. The tutorials are intended to provide hands-on practice developing computational and problem-solving skills. Students are encouraged to work through problems themselves, discuss approaches with neighbouring students, and ask the instructor or teaching assistant for guidance when needed.

The use of AI tools is not permitted during term tests or the final examination.

Statement on academic integrity

Students are expected to uphold the values of academic integrity, which include fairness, honesty, trust, and responsibility. Examples of actions that that compromise these values include but are not limited to plagiarism, accessing unauthorized sites for assignments or tests, unauthorized collaboration on assignments or exams, and using Generative Artificial Intelligence (GenAI) tools when course assessment instructions indicate such use is not permitted.

Misconduct in scholarly activity will not be tolerated and will result in consequences as outlined in Carleton University's Academic Integrity Policy. A list of standard sanctions in the Faculty of Science can be found here.

Additional details about this process can be found on the Faculty of Science Academic Integrity website.

Students are expected to familiarize themselves with and abide by Carleton University's Academic Integrity Policy.

Student rights & responsibilities

Students are expected to act responsibly and engage respectfully with other students and members of the Carleton and the broader community. See the 7 Rights and Responsibilities Policy for details regarding the expectations of non-academic behaviour of students. Those who participate with another student in the commission of an infraction of this Policy will also be held liable for their actions.

Student concerns

If a concern arises regarding this course, your first point of contact is me:

Email or drop in during student hours and I will do my best to address your concern. If I am unable to address your concern, the next points of contact are (in this order):

The Undergraduate Chair is **Thomas Gregoire**, ThomasGregoire@cunet.carleton.ca

The Physics Department Chair is **Kevin Graham**

Note: You can also bring your concerns to Ombuds services.