

Carleton University Physics Department
PHYS 5702W – Relativistic Quantum Mechanics
(Winter 2026)

Course Delivery Information

Instructor:

Prof. Heather Logan (she/her) (you are welcome to call me “Heather”, “Dr. Logan”, or “Professor”)
Email: logan@physics.carleton.ca
Office: Herzberg 2470

Teaching Assistant (TA):

Fazlul Yasin (he/him)
Email: FazlulYasin@cmail.carleton.ca

Required Textbook:

Peskin, Michael E. and Schroeder, Daniel V., *An Introduction to Quantum Field Theory*. Available from the Carleton Bookstore (CAD\$133.50) or directly from Routledge/CRC Press (as of Dec 15, 2025, on sale for USD\$71.99 paperback/eBook or USD\$119.00 hardback with free shipping, 7-14 business days).

Course web page:

Hosted in Brightspace, at <https://brightspace.carleton.ca/>. I will use this site to distribute readings and homework assignments and to host information about the exams. You will use it to upload your completed homework assignments and to view your grades and marked assignments. I will send out any time-sensitive announcements by email.

Lecture times:

Mondays and Wednesdays, 4:05–5:25pm, in Richcraft Hall 1201. The first lecture is on Monday January 5 and the last one is on Monday April 6. There are no lectures on February 16 or 18 because that week is Winter Break.

Office hours (dedicated times for you to ask questions about homework or course material):

By appointment with the course TA (Fazlul) or with me. To arrange an appointment, please email Fazlul or me at the addresses given above.

Lecture, assignment, and exam format:

Lectures will be held in-person. Lecture attendance is strongly encouraged, but if you’re sick or have an emergency, it’s ok to stay home. To increase accessibility I will post scans of my lecture notes to Brightspace after each lecture. I’ll be following the textbook pretty closely, so read the assigned textbook sections first before resorting to my notes.

Homework assignments are to be done outside of class time. The question papers will be made available on the Brightspace page. Your solutions for each assignment should be submitted by scanning them to a single pdf file which you will upload to the Brightspace page. More details are on page 3.

Two midterms and a final exam will be held in-person. The two midterm exams will be held in our usual classroom during two of the normal lecture periods. The final exam will be held during the April final exam period at a time and location to be assigned by the university. More details are on page 3.

Course Description

PHYS 5702 [0.5 credit]

Relativistic Quantum Mechanics

Relativistic wave equations. Expansion of S matrix in Feynman perturbation series. Feynman rules. An introduction to quantum electro-dynamics with some second quantization. Gauge theories. May include introduction to Standard Model.

Prerequisite(s): PHYS 5701 and permission of the Department.

This course covers the foundations of quantum field theory, starting with the quantization of the Klein-Gordon (for scalars) and Dirac (for fermions) relativistic wave equations, proceeding through the translation of the scattering matrix into Feynman diagrams, and culminating with the techniques for calculation of differential cross sections for tree-level processes involving scalars, fermions, and/or photons. This material is the basis of our theoretical understanding of particle physics. The course covers the following chapters of Peskin & Schroeder:

1. Quantization of the Klein-Gordon field [Chapter 2] (weeks 1 and 2);
2. Perturbation theory and Feynman diagrams [Chapter 4] (weeks 3–5);
3. Quantization of the Dirac field [Chapter 3] (weeks 6–8);
4. Feynman rules for fermions and QED [Chapter 4] (week 9); and
5. Simple processes in Quantum Electrodynamics [Chapter 5] (weeks 10–12).

(Calculation of loop diagrams, renormalization, non-Abelian gauge theories, and the “functional methods” approach to QFT are covered in a PhD-level course, PHYS 6701.)

Learning Outcomes

After successfully completing this course, you will be able to:

- Perform calculations using four-vectors, and express the components of four-vectors in terms of measurable quantities in a variety of reference frames;
- Use the expansion of quantum fields in terms of momentum-space creation and annihilation operators to evaluate operators acting on various quantum states;
- Perform calculations using spinors and Dirac matrices, and use the anticommutation of fermion-field operators to determine the relative signs of Feynman diagrams;
- Explain the relationship between individual “rules” in the Feynman-rules prescription and their underlying field-theoretic origins; and
- Use Feynman rules to compute scattering amplitudes and differential cross sections for tree-level processes involving scalars, fermions, and/or photons.

Assignments, exams, and grade distribution

Homework assignments (25%; lowest 2 assignment marks will be dropped):

Homework will be assigned every week, with due dates on Wednesdays at 10pm. (The complete schedule will be provided in Brightspace.) The questions for each assignment will be posted in Brightspace, and your solutions must be scanned to a single pdf file and submitted by uploading into Brightspace.

Working the assigned problems is the most important thing you can do to develop a deep understanding of the material, and is the best way to prepare for the exams. This material builds on your prior physics/math education, particularly in quantum mechanics, special relativity, and complex analysis. You are encouraged to discuss the problems with other students, the TA, and me; however, **the work you hand in must be your own original work.** Use of online homework-help sites, generative AI / Large Language Models / chat-bots (including Google’s “AI Overview”), or searching for or viewing solutions to equivalent problems online, is strictly forbidden and will not prepare you well for the exams. If you are having difficulties with the material, please email the TA and/or me to arrange for individualized help.

Late/missed assignment policy: Assignments will be accepted through Brightspace upload up to 48 hours (two days) after the due date, no questions asked. This automatic extension is meant to accommodate short-term illness or injury, caregiving emergencies, unanticipated workload overload, technology failures, etc. To cover longer-term or more serious situations, I will also be dropping the lowest two assignments. If you find yourself in this situation, please contact me by email to discuss strategies for getting back on track with the coursework.

Two midterm exams (20% each):

There will be two in-person 80-minute midterm exams in the regular classroom during the regular lecture time (4:05–5:25pm) on **Monday February 9** and **Monday March 16**. The midterms will be open-book but no electronic devices will be allowed. (If you have purchased an electronic copy of the textbook, please talk to me at least a week before the first midterm so that we can arrange a way for you to access a paper copy during the exam.) I plan to have the first midterm exam marked and returned to you well before the last day to withdraw from a course, which is March 15.

Missed midterm exam policy: If you have to miss either of the midterm exams due to illness or some other emergency, please let me know by email as soon as possible so that I can arrange a time for you to write a deferred midterm. Deferred midterms will be scheduled outside of the regular lecture time, and may be held on Friday evening or the weekend. Neither of the midterms will be dropped.

Final exam (35%):

The final exam will be 3 hours long and will be held in-person **during the final exam period, April 11–23** (Exam Services has said that they will publish the final exam schedule on February 13, though they are sometimes a few days late). The final exam will be open-book but no electronic devices will be allowed. Deferrals of final exams, due to illness or other emergency, are handled centrally by Exam Services; for more information and a link to the deferral application web-form, see <https://carleton.ca/registrar/deferral/>. A self-declaration is allowed instead of a doctor’s note, but see the link for more information about required documentation and submission deadlines.

Inclusive teaching statement

Physics is for everyone. I am committed to fostering an inclusive learning environment for everyone in this course regardless of gender identity/expression, sex, sexual orientation, race, ethnicity, dis/ability, age, socioeconomic class, religion, appearance, national origin, etc. All participants in this course should be treated with respect during all interactions. I welcome your feedback (by email or in person) on ways to improve any aspects of the course environment.

Statement on Generative AI usage: DON'T.

Use of Generative AI, Large Language Models, or chat-bots such as ChatGPT, Gemini, Claude, Grok, DeepSeek, etc. for any purpose related to this course is strictly prohibited.

Academic accommodations and human rights

Carleton University is committed to promoting academic accessibility for all individuals.

Academic accommodation refers to educational practices, systems, and support mechanisms designed to accommodate diversity and difference. The purpose of accommodation is to enable students to perform the essential requirements of their academic programs. At no time does academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University. For more information: <https://students.carleton.ca/course-outline/> .

University rules regarding registration, withdrawal, appealing marks, and most anything else you might need to know can be found on the University's website: <https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/> .

Human rights and non-discrimination:

Carleton University and all members of the Carleton community share responsibility for ensuring that the University's educational, work, and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex, pregnancy, or sexual orientation, please contact the Department of Equity and Inclusive Communities (<https://carleton.ca/equity>) at equity@carleton.ca.

If you feel comfortable doing so, you can also contact me to address any concerns related to the course or classroom environment. I am a member of the Carleton Physics Department's Equity, Diversity, and Inclusion committee.

Academic accommodations for students with disabilities/Disabled students:

If you have a documented disability requiring academic accommodations in this course, please access the Paul Menton Centre for Students with Disabilities (PMC)'s centralized accommodation-handling web portal called Ventus at <https://ventus.carleton.ca/student/> . PMC can also be reached at 613-520-6608 or pmc@carleton.ca. **You have to log in to Ventus each semester to select which courses you want your accommodations to apply to.** This has to be done no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). For more details, visit the Paul Menton Centre website (<https://carleton.ca/pmc>).

Regardless of documentation, if your learning experience could be improved by me adjusting the way I do things in this course, please don't hesitate to let me know (by email or in person) and I will do what I can to address it. I have "lived experience" and will take your requests seriously.

Religious obligations:

Please email me during the first two weeks of class with any requests for religious accommodations, or as soon as possible after you find out that you will need such an accommodation. For more details, please review the Student Guide to Academic Accommodation (<https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf> (2.1 MB pdf)).

For survivors of sexual violence:

Carleton is committed to maintaining a positive learning, working, and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations in accordance with Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/sexual-violence-support/>

For pregnancy:

Please email me during the first two weeks of class with any requests for academic accommodation, or as soon as possible after you find out that you will need such an accommodation. For more details, please review the Student Guide to Academic Accommodation (<https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf> (2.1 MB pdf)).

For extracurricular student activities:

Carleton recognizes the substantial benefits, both to the individual student and to the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level (this also includes things like student conferences and research). Please contact me during the first two weeks of class with any requests for academic accommodation, or as soon as possible after the need for accommodation is known to exist. For more details, see the Senate Policy on Accommodation for Student Activities (<https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf> (25 kB pdf)).

Some resources for peer support, academic help, and skill development

Graduate Association for Students in Physics (GASP): <https://gasp.physics.carleton.ca/>
Graduate Students' Association at Carleton: <https://gsacarleton.ca/>
Science Student Success Centre: <https://sssc.carleton.ca/>
Math Tutorial Centre: <https://carleton.ca/math/math-tutorial-centre/>
Academic Support Services: <https://students.carleton.ca/academics/>
Writing Services: <http://www.carleton.ca/csas/writing-services/>

Carleton's letter grade scheme

In accordance with the Carleton University Undergraduate Calendar Regulations, the letter grades assigned in this course will have the following percentage equivalents:

A+ = 90–100 B+ = 77–79.99 C+ = 67–69.99 D+ = 57–59.99 F = below 50

A = 85–89.99 B = 73–76.99 C = 63–66.99 D = 53–56.99

A– = 80–84.99 B– = 70–72.99 C– = 60–62.99 D– = 50–52.99

WDN = Withdrawn from the course (**deadline to withdraw from Winter 2026 courses is Mar 15**)

ABS = Student absent from final exam

DEF = Deferred

FND = (Failed, no Deferred) = student could not pass even with 100% on final exam

Academic integrity and how to avoid cheating (important!)

Examples of actions that violate Carleton's Academic Integrity Policy include:

- Plagiarism (e.g., passing off the words, equations, problem-solving strategies, or thoughts of another entity—human or AI¹—as your own, without citing the source) – see also Sec. 5 of Carleton's policy on the Responsible Conduct of Research at <https://carleton.ca/secretariat/policies/> ;
- Accessing unauthorized materials for assignments or tests (e.g., using your phone or unauthorized notes during exams, posting the assigned questions on internet help sites, searching the internet for solutions to similar problems, or using chat-bots in any way);
- Unauthorized collaboration on assignments or exams (e.g., communicating with another student during an exam).

For details of what constitutes plagiarism, please see the Faculty of Science Academic Integrity website (<https://science.carleton.ca/academic-integrity/>). Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy (<https://carleton.ca/registrar/academic-integrity/>). The Policy is strictly enforced and is binding on all students. To further understand Academic Integrity, consider attending the Learning Support Academic Integrity Workshop (<https://carleton.ca/csas/learning-support/learning-support-workshops/>).

Additional details about this process can be found on the Faculty of Science Academic Integrity website (<https://science.carleton.ca/academic-integrity/>).

¹This phrasing is not meant to imply that a Large Language Model or other generative artificial intelligence has thoughts, or is doing anything beyond producing a mindless remix of existing human work without attribution or permission.