

Carleton University Physics Department
PHYS 3701 – Elements of Quantum Mechanics (Fall 2021)
Course Outline

Instructor:

Prof. Heather Logan (she/her) (logan@physics.carleton.ca). Please call me “Dr. Logan” or “Professor”. :)

Required Textbook:

Griffiths, David J. and Schroeter, Darrell F., “Introduction to Quantum Mechanics,” Third Edition (Cambridge University Press, 2018). Available directly from Cambridge University Press (\$86.95, shipping to Ottawa is about \$10 and takes about a week). It’s also available on Amazon (\$79.70 as of August 28) and at the Carleton Bookstore (\$86.95, \$74.50 + \$5.31 delivery fee for digital).

Lecture times:

Tuesdays and Thursdays, 10:05–11:25 a.m., on Zoom.

Lecture format:

This is an “online–synchronous” course. All lectures will be delivered live using Zoom. The Zoom link will be posted in Brightspace. To log in to Brightspace, go to <https://brightspace.carleton.ca/>. You may be redirected to log in using your MyCarletonOne name and password. I strongly encourage you to attend the live lectures so that you can ask questions during the lectures. To ask a question, please type “question” into the Zoom chat and I will call on you to unmute and ask your question. If you prefer not to speak, you can type your question into the chat and I will read it out loud before answering.

The Zoom sessions will be recorded and the recordings uploaded to Brightspace (generally later the same day) so that you can review them if you need to. Please note that these recordings are protected by copyright – you are not permitted to distribute them to third party sites, such as social media sites and course materials sites. If you have concerns about being recorded, please email me.

Student hours (also known as office hours):

You are invited to talk to me one-on-one if you have questions about the course material or need help on the assignments. Please email me to arrange a time and I will meet you in the same Zoom channel that we use for lectures.

Technology requirements:

(1) Ability to join and participate in Zoom sessions. I plan to screen-share from my iPad and use it as if it were a chalkboard, so you need to be able to see that and hear me lecturing. You also need to be able to ask questions verbally and/or by typing in the Zoom chat.

(2) Ability to take notes during the lectures. I recommend having a spiral-bound notebook for each of your courses and taking notes during each lecture. When I lecture I endeavour to write on the chalkboard (or tablet) anything that’s important to capture in your notes, rather than just saying it verbally.

(3) Ability to work your homework problems and exams on paper (working your problems by writing on a tablet is also ok if you prefer that). You need to be able to draw diagrams, freely write equations, and do math “by hand”.

(4) Ability to scan your written homework and exam solutions to a single pdf file in order to upload them for submission.

(5) Ability to undergo e-proctoring for the midterm and final exam (see below).

Assignments and Grade Distribution

Homework assignments (45%):

Homework will be assigned every week. Assignments will be posted as a downloadable pdf in Brightspace, and your solutions must be scanned to a **single pdf file** and uploaded into Brightspace by the assignment's due date. **Late assignments will not be accepted** except for legitimate reasons such as illness. It is your responsibility to notify me if you will be unable to upload the assignment by the deadline. In computing your final grade, I will drop your lowest assignment mark.

Working through problems is an essential part of developing a deep understanding of quantum mechanics and is the best way to prepare for the exams. This material is quite mathematical, and is partially meant to provide a foundation for the mathematical aspects of physics that will come in future classes. **Students are encouraged to work together to understand the problems; however, the work handed in must be your own original work.** Solutions showing significant overlap may have the mark divided by the number of people who provide that solution. The assigned homework problems are protected by copyright and posting them to third-party sites is forbidden and considered an academic offence. Likewise, finding solutions to equivalent problems online is forbidden and considered an academic offence.

Students who are having significant difficulties with the material are encouraged to come to my student hours for individualized help.

Midterm exam (20%):

There will be one 80-minute midterm exam during the class time (10:05–11:25 a.m.) on **Tuesday November 2**. It will be e-proctored (see <https://carleton.ca/ses/e-proctoring/>). The midterm will be closed-book and closed-notes and a formula sheet will be provided (to be posted on Brightspace in advance). In the event of a midterm exam deferral for legitimate reasons, please inform me within 24 hours of the regularly scheduled midterm to arrange a time to write the deferred exam.

Final exam (35%):

The final exam will be held during the final exam period in December (Exam Services has said they will publish the final exam schedule on October 8). It will be 3 hours long and will be e-proctored (see <https://carleton.ca/ses/e-proctoring/>). The final exam will be closed-book and closed-notes and a formula sheet will be provided (to be posted on Brightspace in advance).

In the event that a deferred exam is necessary for a student, that exam will replace only the final exam component of the course mark and will be granted only if adequate term work has been completed. Inadequate term work constitutes earning less than 15 of the 65 possible term marks.

In order to pass the course:

- 1) your overall course mark must be at least 50%, and
- 2) your average on the exam component of the course must be at least 50%.

$$\text{Exam average} \equiv (0.20 \times \text{Midterm} + 0.35 \times \text{Final}) / (0.20 + 0.35)$$

Course Description

The goal of this course is to introduce the sometimes surprising concepts of quantum mechanics and to develop the Schrödinger equation formalism for solving some simple quantum systems, such as the “particle in a box,” tunneling, and the hydrogen atom. The course begins with a brief review of the original experimental observations that stimulated the development of quantum physics. You are responsible for all material presented in the lectures or assigned for reading and problem sets. The course is based on the material in Chapters 1 through 6 of the textbook, though I will cover it in a somewhat different order and supplement it with additional introductory material building on what you will have seen in PHYS 2604.

1. The beginnings of quantum theory. Blackbody radiation, photoelectric effect, Compton effect. The quantum picture of the atom and the Bohr model, atomic processes.
2. The development of wave mechanics. Wilson-Sommerfeld quantization rules, de Broglie’s particle waves, double slit experiment, probability distributions. Heisenberg’s uncertainty principle, waves and wave packets, the Schrödinger equation, probability interpretation, stationary states. Wavefunction sketching.
3. Solutions of some one-dimensional systems. Particle in a one-dimensional box, harmonic oscillator and molecular vibrations.
4. Further development of the quantum framework. Observables, eigenfunctions and eigenvalues, operators and expectation values. Dirac’s bra-ket notation.
5. Solutions of more one-dimensional systems. Finite square well and continuum states. Finite potential step, transmission and reflection coefficients, tunneling.
6. The wave equation in three dimensions. The three dimensional box, Schrödinger equation in spherical coordinates, rotational motion. Spherical harmonics, angular momentum operators, commutation relations, parity. Radial wavefunction for hydrogenic atoms, electric dipole transition amplitude and selection rules.
7. Spin and the addition of angular momentum. Atoms in magnetic fields, Zeeman effect, Stern-Gerlach experiment and electron spin, magnetic resonance, spin-orbit coupling, fine structure and the anomalous Zeeman effect. Pauli’s exclusion principle.

Special information regarding COVID-19

All members of the Carleton community are required to follow COVID-19 prevention measures and all mandatory public health requirements (e.g., wearing a well-fitting mask that covers your nose, mouth, and chin at all times while in academic spaces; physical distancing of 2 metres; frequent hand-washing and/or -sanitizing; and self-isolating and getting tested for COVID-19 if you develop any of the symptoms associated with the disease) and mandatory self-screening (see <https://carleton.ca/covid19/cuscreen/>) prior to coming to campus daily. Furthermore, vaccination against COVID-19 is mandatory for anyone participating in in-person university activities. Please follow the instructions at the cuScreen webpage to set up a quick link to cuScreen on your smartphone and familiarize yourself with the application before the start of classes.

If you feel ill or exhibit COVID-19 symptoms while on campus or in class, please leave campus immediately, self-isolate, and complete the mandatory symptom reporting tool (<https://carleton.ca/covid19/cuscreen/symptom-reporting/>). For purposes of contact tracing, students who attend classes or labs on campus must check in to the class location by scanning the posted QR codes using the cuScreen system on your smartphone. Students who do not have a smartphone will be required to record their attendance on paper as indicated on the COVID-19 website (<https://carleton.ca/covid19/>). If the QR system is not working, your instructor will take attendance.

All members of the Carleton community are required to follow guidelines regarding safe movement and seating on campus (e.g., directional arrows, designated entrances and exits, designated seats that maintain physical distancing). To avoid congestion, allow all previous occupants to fully vacate a classroom before entering. No food or drinks are permitted in any classrooms or labs.

For the most recent information about Carleton's COVID-19 response and required measures, please see the University's COVID-19 webpage (<https://carleton.ca/covid19/>) and review the Frequently Asked Questions (FAQs, <https://carleton.ca/covid19/faq/>). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the Student Rights and Responsibilities Policy (<https://carleton.ca/studentaffairs/student-rights-and-responsibilities/>). Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.

Note about COVID-19 and mental health

The global pandemic has led to extra stress and uncertainty for everyone, but this affects each person in a unique way. If you need extra help with course material or have missed something, don't panic—email me and we will set a time to meet. If you're freaking out about stuff in general, I'm here to listen and will try to help to the extent that I'm able. Carleton also offers an array of mental health and well-being resources, which can be found at <https://carleton.ca/wellness/>.

Children and video sessions

You are welcome to have children with you during video sessions as I fully understand that childcare situations may be complicated for many of us at this time. Do your best to participate and engage, but also please get in touch with me if you have any questions or concerns.

University policies

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

ABS = Student absent from final exam

DEF = Deferred

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

Academic accommodations, regulations, plagiarism, etc.

Carleton University is committed to providing access to the educational experience in order to promote 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. More information can be found at:

<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, here:

<https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/>

Academic accommodations for students with disabilities/Disabled students

If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. 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 and I will do what I can to address it.

Addressing human rights concerns

The University and all members of the University 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 (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities (<https://carleton.ca/equity>) at equity@carleton.ca. If you're comfortable doing so, you can also contact me to address any concerns related to the course or classroom environment.

Religious obligations

Please contact me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. 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)).

Survivors of sexual violence

As a community, Carleton University 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 as per 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/>

Accommodations for missed work (in place of doctor's notes)

Carleton recognizes that the COVID-19 pandemic has placed unprecedented strain on the health-care system and that health-care resources should not be diverted to produce doctor's notes for missed academic work. For this reason, Carleton is currently using a self-declaration form for students to self-declare illness, self-isolation, or other emergencies that cause them to miss coursework or exams. The form can be found at: <https://carleton.ca/registrar/wp-content/uploads/self-declaration.pdf>

For pregnancy

Please contact me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. 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)).

Accommodation for student activities

Carleton University recognizes the substantial benefits, both to the individual student and for 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. Please contact me with any requests for academic accommodation during the first two weeks of class, 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)).

Academic integrity (this is important)

Academic misconduct undermines the values of honesty, trust, respect, fairness, and responsibility that we expect in this class. Carleton University provides supports such as academic integrity workshops to ensure, as far as possible, that all students understand the norms and standards of academic integrity that we expect you to uphold. Your teaching team has a responsibility to ensure that our application of the Academic Integrity Policy upholds the university's collective commitments to fairness, equity, and integrity. [Adapted from Carleton University's Academic Integrity Policy, 2021]

Examples of actions that do not adhere to Carleton's Academic Integrity Policy include:

- Plagiarism (e.g., passing off another person's words, equations, problem-solving strategies, or thoughts as your own, without citing the source)
- Accessing unauthorized sites for assignments or tests (e.g., posting the assigned questions on Chegg or searching the internet for solutions to similar problems)

- Unauthorized collaboration on assignments or exams (e.g., communicating with another student during an exam)

For details of what constitutes plagiarism, refer the Faculty of Science Academic Integrity website (<https://science.carleton.ca/academic-integrity/>). To further understand Academic Integrity, consider attending the Learning and Support Academic Integrity Workshop (<https://carleton.ca/csas/learning-support-2/learning-support-workshops/>).

Sanctions for not abiding by Carleton’s Academic Integrity Policy

A student who has not adhered to Carleton’s Academic Integrity Policy may be subject to one of several sanctions:

1. If you take full responsibility for your actions, and it is the first time you have violated the policy, you will receive zero on the assessment. If you are found to have violated the policy but do not take responsibility, an additional grade deduction will be applied (e.g. an A– will become a B+).
2. Subsequent violations of the policy may result in more severe sanctions such as failing the course, suspension from all studies and/or expulsion.

Process of an Academic Misconduct Investigation

Step 1: The instructor believes misconduct has occurred and submits documentation to the Dean of the Faculty of Science.

Step 2: The Dean reviews documentation and can proceed with or dismiss the allegation.

Step 3: If sufficient evidence, the student receives an allegation statement by email. Ombuds services is copied on the email.

Step 4: The student provides a written response to the evidence provided.

Step 5: Either party may request a meeting between student, Dean, and the ombudsperson.

Step 6: Dean informs the student of the decision.

Appeal: Student has the right to appeal the decision.

Additional details about this process can be found on 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.

Resources for academic help and skill-development

Academic and Career Development Services: <http://carleton.ca/sacds/>

Writing Services: <http://www.carleton.ca/csas/writing-services/>

Peer Assisted Study Sessions (PASS): <https://carleton.ca/csas/group-support/pass/>

Math Tutorial Centre: <https://carleton.ca/math/math-tutorial-centre/>

Science Student Success Centre: <https://sssc.carleton.ca/>