

# Course Outline

PHYS 3701: Elements of Quantum Mechanics (Winter 2021)  
Department of Physics, Carleton University

## General information:

**Professor:** Yue Zhang, 3324 HP, [yue.zhang13@carleton.ca](mailto:yue.zhang13@carleton.ca)

**Teaching assistant:** Carel Rethmeier, [carelrethmeier@cmail.carleton.ca](mailto:carelrethmeier@cmail.carleton.ca)

**Course date/time:** 2:35 – 3:55 PM, Mondays and Wednesdays.

**First/Last Day of Class:** January 11 – April 12, 2021.

**Course location:** Course will be delivered via Zoom. Link and passcode will be shared.

**Office Hour:** Every Tuesday 1:30 – 2:30 PM. Same Zoom link as for lectures.

**Course Description:** Analysis of interference experiments with waves and particles; fundamental concepts of quantum mechanics, Schrödinger equation; angular momentum, atomic beams; hydrogen atom; atomic and molecular spectroscopy; Pauli principle; simple applications in the physics of elementary particles.

**Course Web Page:** Lecture notes and homework assignment will be posted at the cuLearn course page (log in at <http://www.carleton.ca/culearn>). Please check for updates on a regular basis. Additional email communications will take place as needed.

**Prerequisites:** PHYS 2604, MATH 2000 [1.0] (may be taken concurrently), or MATH 2004 or MATH 2008, and MATH 3705 (may be taken concurrently), or permission of the Department.

**Textbook (recommended but not required):** *Introduction to Quantum Mechanics*, third edition, by David J. Griffiths and Darrell F. Schroeter, Cambridge University Press 2018.

## Course Content:

- ▷ Motivations: experimental evidence, Planck's law, particle-wave duality for photon and electron, de Broglie matter wave, the classical limit.
- ▷ The Schrödinger equation and wavefunction, statistical interpretation, average of operators, Ehrenfest's theorem, stationary state.
- ▷ Solving a bunch of Schrödinger equation problems in one space dimension, application of the Heisenberg uncertainty principle.
- ▷ Formalism. Linear operators, Dirac's bra and ket, Hermitian operators and observables, the matrix representation, common eigenstates, conservation laws.
- ▷ Schrödinger equation in three space dimensions, orbital angular momentum, spherical harmonics, hydrogen atom, radial wavefunctions, energy levels, atomic transition selection rules,

Paschen–Back effect.

▷ Spin angular momentum, Stern–Gerlach experiment, Pauli exclusion principle, spin-orbit coupling, total angular momentum, Clebsch–Gordan coefficients, Zeeman effect.

## Grading Scheme:

### Homework Assignments (40%):

There will be five assignments during the term. Assignments will be posted at cuLearn, and submission of homework also takes place at cuLearn. You are encouraged to study together, and write separately. **The work you hand in must be your own.** Late assignments will not be accepted, unless permission is received from the professor for documented reasons.

### Mid-term Exam (20%):

The midterm exam will be held during class hour at a date to be determined. It will be 1.5 hours long, closed book exam. A formula sheet will be provided.

### Final Exam (40%):

The final exam will be held during the final exam period. It will be 3 hours long, closed book exam. A formula sheet will be provided.

**For the exams it is forbidden to: use unauthorized aids, look up any information online, consult with any other person, or share exam content with anyone.**

If you missed an exam, you must notify the professor within three working days after the date of the exam. Deferred exams will be permitted for documented reasons (illness, injury or other extraordinary circumstances beyond the student's control). For more information, please see Section 4 of the Academic Regulations of the University: <http://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/>

## Important dates:

January 11, 2021: First Day of Class.

February 12, 2021: April examination schedule available online.

February 15, 2021: Statutory holiday. University closed.

February 15-19, 2021: Winter Break. Classes are suspended.

April 2, 2021: Statutory holiday. University closed.

April 14, 2021: Winter term ends. Classes follow a Friday schedule.

April 16-27, 2021: Final examinations in winter term and fall/winter courses may be held. Examinations are normally held all seven days of the week.

## University policies

### Grade Definition:

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	C+ = 67-69	D+ = 57-59
A = 85-89	B = 73-76	C = 63-66	D = 53-56
A- = 80-84	B- = 70-72	C- = 60-62	D- = 50-52
F = <50			

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

Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.

### Academic Regulations, Accommodations, Plagiarism, Etc.:

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:

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

### Academic Integrity

The University Senate defines plagiarism as “presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one’s own.” This can include:

- reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source;
- submitting a take-home examination, essay, laboratory report or other assignment written, in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, or paraphrased material, concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another’s data or research findings;
- failing to acknowledge sources through the use of proper citations when using another’s works and/or failing to use quotation marks;
- handing in “substantially the same piece of work for academic credit more than once without prior written permission of the course instructor in which the submission occurs.”

Plagiarism is a serious offence that cannot be resolved directly by the course’s instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of “F” for the course.

### **Course Copyright**

Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copyright protected and remain the intellectual property of their respective author(s). All course materials, including PowerPoint presentations, outlines, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s).

Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).

### **Academic Accommodations**

Text from <https://students.carleton.ca/course-outline/>

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.

#### ***Pregnancy Obligation:***

Please contact your instructor 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, visit the Equity Services website

<https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>

#### ***Religious Obligation:***

Please contact your instructor 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, visit the Equity Services website

<https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>

#### ***Academic Accommodations for Students with Disabilities:***

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](mailto: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>

- The deadlines for contacting the Paul Menton Centre regarding accommodation for final exams for the Fall exam period is **November 13, 2020** and for the Winter exam period is **March 12, 2021**.

***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>

***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 your instructor 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 policy at <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

**Assistance for Students:**

Career Services: <https://carleton.ca/career/>

Academic Advising: <https://carleton.ca/academicadvising/>

Co-operative Education: <https://carleton.ca/co-op/>

Centre for Student Academic Support: <https://carleton.ca/csas/>

Writing Services: <https://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/>

**Freedom of Information and Protection of Privacy:**

Carleton University is committed to protecting the privacy of those who study or work here (currently and formerly). To that end, Carleton's Privacy Office seeks to encourage the implementation of the privacy provisions of Ontario's *Freedom of Information and Protection of Privacy Act* (FIPPA) within the university.

In accordance with FIPPA, please ensure all email communication with staff/faculty is via your Carleton email account. To get your Carleton email you will need to activate your MyCarletonOne account through Carleton Central. Once you have activated your MyCarletonOne account, log into the MyCarleton Portal.

**Important Dates:**

<https://calendar.carleton.ca/academicyear/>

<https://carleton.ca/registrar/registration/dates-and-deadlines/>