

Course outline

PHYS 5701: Intermediate Quantum Mechanics with Applications - Fall 2023

Instructor: Thomas Grégoire (HP 3310, 613-520-2600 x4371, gregoire@physics.carleton.ca)

Office Hours: TBA

Lectures: Tuesday-Thursday, 8:35 - 9:55 pm. First lecture on Thursday Sept. 7 and last lecture on Thursday Dec. 7 2023.

Prerequisites: PHYS 4707 (Introduction to Quantum Mechanics I) and PHYS 4708 (Introduction to Quantum Mechanics II). Some of these prerequisite can be waived with consent of the instructor.

Suggested textbook: "Modern Quantum Mechanics", J.J. Sakurai and Jim Napolitano, Third edition, Cambridge University Press

Other references: :

- "Quantum Mechanics, An experimentalist approach", Eugene D. Commins, Cambridge University Press
- R, Shankar, "Principle of Quantum Mechanics", second edition, Springer
- Schumacher and Westmoreland, "Quantum Processes, Systems, & Information", Cambridge

Course Modality: This course will be an in-person course only and is not suitable for remote learning. The lectures will be delivered mainly on the blackboard and will not be recorded. If a student cannot attend class for a limited period of time due to health issues, reference material will be provided.

Website: I will use Brightspace (<https://brightspace.carleton.ca/>) as the course website. I will post problem sets and reading.

Note: U. of O. students can obtain a MyCarletonOne account to access Brightspace

Content of the course and learning objectives: The goal of this course is to present important aspects of Quantum Mechanics in more depth, mathematical sophistication than what is typically covered in an undergraduate course and to introduce a few more advanced topics. Material covered in undergraduate courses vary by institution and so you might be familiar with some of the topics covered in the course. I invite you to fill out the survey on the Brightspace page to give me a more accurate picture of your preparation in quantum mechanics. The course will be roughly structured as follows:

- Review of the Fundamental of Quantum Mechanics (chapter 1)
- Time evolution (chapters 2.1, 2.2)
- WKB approximation (chapter 2.5)
- Path Integrals (2.6)
- Density Matrix (3.4)

- Bell inequalities (3.10)
- Rotation and the Theory of angular momentum (3.1,3.2,3.3,3.5)
- Addition of Angular, Clebsch-Gordan coefficients and the Wigner-Eckart Theorem (3.8,3.11)
- Review of time independent perturbation theory (5.1,5.2)
- Time dependent perturbation theory (5.5,5.7,5.8)
- Scattering theory (6.1,6.3,6.4)

The learning objectives are:

- Understand the fundamental postulates of Quantum Mechanics and how they relate to the concepts of Hilbert space, operators and abstract vectors.
- Be able to manipulate kets, bra and operators to compute various quantities of interest in quantum mechanics such as probabilities, expectation values and matrix elements.
- Understand how the momentum operator, the hamiltonian operator and the angular momentum operators relate to symmetry transformations.
- Be able to add angular momentum using Clebsch-Gordan coefficients and understand how the Wigner-Eckart theorem give rise to selection rules in matrix elements.
- Understand the basic principle of scattering in quantum mechanics and be able to apply Fermi's golden rules, use the Born approximation and the partial wave expansion.

Assessment

Carleton and U. of O use slightly different translation between letter grades and percentage grades. I will establish your final grade using the table appropriate to your University. At Carleton the correspondence is:

$A+ = 90 - 100$	$B+ = 77 - 79$	$C+ = 67 - 69$	$D+ = 57 - 59$
$A = 85 - 89$	$B = 73 - 76$	$C = 63 - 66$	$D = 53 - 56$
$A- = 80 - 84$	$B- = 70 - 72$	$C- = 60 - 62$	$D- = 50 - 52$
$F = \text{below } 50$			

At the University of Ottawa the correspondence is:

$A+ = 90 - 100$	$B+ = 75 - 79$	$C+ = 65 - 69$	$D+ = 55 - 59$
$A = 85 - 89$	$B = 70 - 74$	$C = 60 - 64$	$D = 50 - 54$
$A- = 80 - 84$			$E = 40 - 49$
$F = \text{below } 40$			

The passing grade for a graduate course at Carleton is B- and at the University of Ottawa is B .

Homework assignments (60 %): There will be approximately 5 problem sets during the term. You are encouraged to work on your assignments together, but the work that is handed in **must be your own**. In general you should not look for solutions to the problems on the internet, in particular it is strictly forbidden to use 'homework help' websites or AI tools to solve the problems. Late assignment will not be accepted without an acceptable reason. Problem sets can be handed in in class or electronically on the Brightspace page.

Final (40 %): The final exam will be a take home exam that will be distributed during the final exam period. You have to work on the final exam alone.

Academic policy: Please read: Please read:

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

Academic integrity: Plagiarism and cheating at the graduate level are viewed as being particularly serious and the sanctions imposed are accordingly severe. Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy (See <http://www2.carleton.ca/graduate-studies/policies-and-guidelines>). The Policy is strictly enforced and is binding on all students. Plagiarism and cheating is presenting another's ideas, arguments, words or images as your own, using unauthorized material, misrepresentation, fabricating or misrepresenting research data, unauthorized co-operation or collaboration or completing work for another student weaken the quality of the graduate degree. Academic dishonesty in any form will not be tolerated. Students who infringe the Policy may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; a refusal of permission to continue or to register in a specific degree program; academic probation; or a grade of Failure in the course.

Academic policy: 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/>

Plagiarism : Plagiarism is the passing off of someone else's work as your own and is a serious academic offence. For the details of what constitutes plagiarism, the potential penalties and the procedures refer to the policies on academic integrity <https://carleton.ca/secretariat/wp-content/uploads/Academic-Integrity-Policy.pdf>

What are the penalties for Plagiarism?

A student found to have plagiarized an assignment may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; and/or a reprimand; a refusal of permission to continue or to register in a specific degree program; academic probation; award of an FNS, Fail, or an ABS.

What are the Procedures?

All allegations of plagiarism are reported to the Dean' office. Documentation is prepared by instructors and/or departmental chairs. The Dean writes to the student and the University Ombudsperson about the alleged plagiarism. The Dean reviews the allegation. If it is not resolved at this level then it is referred to a tribunal appointed by the Senate.

Academic accommodation: 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/>

Students with disabilities requiring academic accommodations

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). *The deadlines for contacting the Paul Menton Centre regarding accommodation for final exams for the the Winter exam period is March 15, 2023.

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 at equity@carleton.ca.

Religious Obligations Please contact me with 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 (PDF, 2.1 MB) **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/>

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 (PDF, 2.1 MB).

Accommodations for Missed Work Carleton recognizes that students may be experiencing greater stress and other life factors that are not in their control. As a result, Carleton has put into place a protocol for students to apply for accommodations using a self-declaration form in the event of missed work. The form can be found at: <https://carleton.ca/registrar/wp-content/uploads/self-declaration.pdf> Note that these forms should be used for short-term concerns related to missed work; if you are experiencing chronic, ongoing challenges which necessitate a broader solution, I recommend reaching out

to the Paul Menton Centre and/or the Care Support team. In case of miss work, the following policies will apply to the various component of the course:

- Homework: In case of a missed homework, the corresponding mark will be dropped from the homework average. Regular homework are an important part of the course and are needed to meet the learning objective of the course, and as such, accommodation (for legitimate reasons) can be granted for a maximum of 2 homework.
- For the final exam, accommodation must be arranged through the registrar's office.

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 is the Office of the Dean of graduate and postdoctoral studies.

Assistance for students: The following resources might be useful :

- Important dates and Deadlines: <https://calendar.carleton.ca/academicyear/>
- Academic and Career Development Services: <https://students.carleton.ca/departments/career-services/>
- Writing Services: <http://www.carleton.ca/csas/writing-services/>
- Peer Assisted Study Sessions (PASS): <https://carleton.ca/csas/group-support/pass/>
- Science Student Success Centre: <https://sssc.carleton.ca/>
- Math Tutorial Centre: <https://carleton.ca/math/math-tutorial-centre/>

Important Information: • Student or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).

- Students must always retain a hard copy of all work that is submitted.
- 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.
- 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 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.