PHYS 3701 B - Winter 2025

Elements of Quantum Mechanics

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 Instructor: Wafia Bensalem

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Best Ways to be in Touch: in class, via email, or during student hours

Student Hours: Fridays, 14:30-15:30, HP3313

Office Location: Room 3313, Herzberg Laboratories

Class Times: Wed & Fri, 13:05 – 14:25

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

Department: Physics

Teaching Assistant: Fazlul Yasin
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Topics Covered and Learning Outcomes

Topics to be Covered

Week	Subject	Textbook chapter sections
1	- Course Details - Introduction: The Beginnings of Quantum Physics	
	- Wave Function / Schrodinger Equation - Statistical Interpretation / Probability / Normalization - Momentum / Uncertainty principle	1.1 - 1.6
2	- Stationary States - Infinite Square well	2.1, 2.2
3	- Harmonic oscillator	2.3
4	- Free Particle - The Delta-Function Potential	2.4, 2.5
5	- The Delta-Function Potential - Finite Square Well	2.5, 2.6
6	**Midterm Exam on February 12**	
	- Hilbert Space - Observables / Operators	3.1, 3.2
7	- Eigenfunctions - Generalized Statistical Interpretation - Uncertainty Principle	3.3 - 3.5
8	Vectors / Operators / Dirac Notation	3.6
9	- 3D Schrodinger Equation - Hydrogen Atom	4.1, 4.2
10	- Angular Momentum - Spin	4.3, 4.4
11	- Electron in a Magnetic Field - Addition of Angular Momenta	4.4
12	- Electromagnetic Interactions	4.5
13	Review	

Important dates and deadlines can be found here:
https://carleton.ca/registrar/registration/dates/academic-dates/
Including class suspension for fall, winter breaks, and statutory holidays.

Course level learning outcomes:

This course focuses on introducing you to the fundamental concepts of Quantum Mechanics which completely changed our view of the world around us. The quantum realm is very strange and unpredictable in the classical sense and refutes the idea of an abstract universe perceived by the senses. Objects can occupy two spaces at the same time and can live double lives as waves and particles; and information seems to travel faster than the speed of light! The strangeness of the quantum world is legendary! The intuitions we have developed through our lived experiences cease to function on very small scales. So, you will have to **re-train the way you think** to understand this exciting and strange world. When our ability to form an analogy to a common experience breaks down, we must rely on **mathematics** to be the common language between the macroscopic and microscopic worlds.
You will be introduced to the main concepts of non-relativistic quantum mechanics, and you will develop an understanding of the underlying foundations and build both **conceptual** and **quantitative/mathematical** skills necessary to understand quantum mechanics.

This course will introduce you to the Schrödinger equation and its basic properties and interpretations. Elementary solutions of the Schrödinger equation in 1-dimension will be derived and analyzed. The uncertainty principle will be discussed. The Schrödinger equation in three dimensions will be introduced and applied to the hydrogen atom. The angular momentum of quantum particles including spin will be analyzed.

Assessments

- There will be 8 **assignments** which will be posted as pdf files on Brightspace. Your **solutions must be posted as pdf files** to Brightspace; they can be scanned versions of hand-written solutions. The lowest assignment grade will not be included in the overall assignment grade calculation.
- The **midterm exam** will occur on **February 12th** during the class time. It will be closed-book and closed-notes and a formula sheet will be provided (to be posted on Brightspace in advance). The midterm exam is not optional and must be attempted to successfully pass the course.
- The **final exam** will occur during the final exam period as scheduled by the university. It will be closed-book and closed-notes. A formula sheet will be provided (to be posted on Brightspace in advance). The final exam is not optional and must be attempted to successfully pass the course.

Grade Breakdown

Component	Grade Value
Assignments	**40%**
Midterm exam	**20%**
Final exam	**40%**

Late and Missed Work Policies

Late Work

Assignments must be handed in by the indicated due date or they will not be graded and receive a mark of zero.

Missed Work

If you encounter extenuating circumstances preventing you from doing a coursework, you can provide an academic considerations form. You can also provide a *longer-term accommodation* *in case of long-term (> 5 days)* extenuating circumstances. Only one form is allowed for each student.

- If you miss the midterm for an approved reason, your final exam will count for 60% of your final grade.

Learning Material(s)

Learning Material	Options for Purchasing	Approximate Cost
D. Griffiths and D. Schroeter, Introduction to Quantum Mechanics, Third Edition, Cambridge University Press	- Bookstore - Used (Kijiji, FB-marketplace, ...) - financial aid	$87

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 are outlined on the Academic Accommodations website (https://students.carleton.ca/course-outline/).

Statement on Chat GPT/Generative AI usage

As our understanding of the uses of AI and its relationship to student work and academic integrity continue to evolve, students are required to discuss their use of AI in any circumstance not described here with the course instructor to ensure it supports the learning goals for the course.

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 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 artificial intelligence tools such as ChatGPT when your assessment instructions say it 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):

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