

QUANTUM PHYSICS 3 FALL 2022

PHYS 434

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CLASS SCHEDULE

Section	Location	Time	Instructor(s)
PHYS 434 001 [LEC]	B1 271	Mondays & Wednesdays 11:30 a.m. - 12:50 p.m.	Christine Muschik christine.muschik@uwaterloo.ca
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INSTRUCTOR / TA INFORMATION

Instructor: Christine Muschik

Office Hours: Fridays, 4PM – 5PM

Teaching Assistants:

Estevao DeOliveira: evbdeoli@uwaterloo.ca

Leonardo Almeida Lessa: l4almeid@uwaterloo.ca

COURSE DESCRIPTION

Calendar Description for PHYS 434

Symmetries and conservation laws. Review of time-independent perturbation theory (degenerate and non-degenerate, Rayleigh-Schrodinger, Brillouin-Wigner and canonical perturbation theory; effective Hamiltonian derivation). Time-dependent perturbation theory (1st and 2nd order, adiabatic perturbation, Aharonov-Bohm effect). Fermi's golden rule. Two-level systems. Emission and absorption of radiation (applications). Second quantization of electromagnetic field in free space; photons. Spontaneous emission and natural lifetime; Lamb shift. Elements of scattering theory. Introduction to the Dirac equation. [Offered: F]

Prereq: PHYS 334 or AMATH 373; PHYS 364 or (AMATH 351 and 353)

This course will start with a review of the most important concepts from the two previous quantum mechanics courses. We will then cover continuous quantum variables (i.e. wave functions in position x and momentum p). We will study quantum time evolutions in different pictures (the Schrödinger picture, the Heisenberg picture, and the interaction picture), and apply these formalisms to different examples. In the next part, we will have an in-depth look at rotations and quantum spin systems. We will also cover symmetries in quantum mechanics. In this context, we will for example see how the momentum operator p acts as generator for translations in space, and how angular momentum

operators act as generators for rotations. These are examples of continuous symmetries. We will also study discrete symmetries such as the parity symmetry, which leads us to the concept of identical particles, the distinction between Fermions and Bosons, and the puzzling consequences of quantum statistics. If time allows, we will cover modern topics in our last week (quantum teleportation, quantum computing).

LEARNING OUTCOMES

By the end of this course students should be able to:

Understanding of the principles of quantum mechanics. Ability to apply quantum mechanical concepts in a variety of different settings.
Ability to do calculations with wave functions in x and p with ease.
Ability to do calculations involving time evolutions. Ability to use and change between different formalisms (Schrödinger, Heisenberg, Interaction picture).
Understanding of quantum spin systems and application of the concepts involved (e.g. addition of angular momentum).
Ability to do calculations for spin $1/2$ systems and spin 1 systems with ease.
Understanding of continuous & discrete symmetries in quantum mechanics and understanding of the connection between symmetries and conserved quantities.
Understanding of symmetries wave functions and application in different settings.

TENTATIVE COURSE SCHEDULE

To be announced.

TEXTS / MATERIALS

Title / Name	Notes / Comments	Required
J. J. Sakurai and J. Napolitano, Modern Quantum Mechanics	Course Textbook	Yes

STUDENT ASSESSMENT

Component	Value
Homework	50%
Final Exam	50%

Homework grades will be given based on the student's solutions to weekly assignments (or on a subset of thereof).

ASSIGNMENT SCREENING

No assignment screening will be used in this course.

ADMINISTRATIVE POLICY

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.](<https://uwaterloo.ca/academic-integrity/>)

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance. (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-70>)

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for their actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties. (<https://uwaterloo.ca/academic-integrity/>) (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71>) (<https://uwaterloo.ca/secretariat/guidelines/guidelines-assessment-penalties>)

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-70>) (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71>) maybe appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72, Student Appeals. (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-72>)

Note for students with disabilities: [AccessAbility Services](https://uwaterloo.ca/accessability-services/) (<https://uwaterloo.ca/accessability-services/>), located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term. <https://uwaterloo.ca/accessability-services/>

Turnitin.com: Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.

UNIVERSITY POLICY

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