

Univ. of Winnipeg Dept. of Physics
Winter 2020

PHYS-4602 Advanced Quantum Mechanics

Lecture Times: TTh 2:30-3:45PM

Room: 3M58

Instructor: Dr. Andrew Frey

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Office: 2L26

Office Phone: 786-9215

WWW: <http://ion.uwinnipeg.ca/~afrey/FW1920/aqm/>

Office Hours: M 11:30AM-12:30PM, T 1:00-2:00PM, or by appointment

Course Description

This is an advanced course that describes the underlying structure of quantum mechanics and its applications.

Textbooks

There is one required text, but several others may be helpful. These texts are on reserve at the library.

- **Required:** *Introduction to Quantum Mechanics* by Griffiths and Schroeter, 3rd ed (2nd edition is permissible but please tell the instructor)
- **Supplementary:** *Principles of Quantum Mechanics* by Ohanian
- **Supplementary:** *Principles of Quantum Mechanics* by Shankar, 2nd ed
- **Supplementary:** *Quantum Mechanics* by Merzbacher, 3rd ed

In addition, some extra reading (from other texts, journal articles, etc) may be assigned.

Topics

We will discuss

- Foundations of Quantum Mechanics: — States, Superposition & Qbits — Information & Entanglement — Measurement, Probability, & Interpretations — Time Evolution — Quantum Computing — Linear Algebra & Dirac Notation
- Perturbative Approximations: — Formalism — Applications to Hydrogen — Time-Dependent Perturbation Theory
- Nonperturbative Approximations: — Variational Principle & Atomic/Molecular Physics — Semi-classical Approximation & Tunneling — Adiabatic Approximation
- Scattering & the Born Approximation
- Possible Advanced Topics: — Path Integrals — Dirac Equation — Quantum Electrodynamics — Symmetries — Student-requested Topics

Not all topics above will be covered equally. Also, some topics may be skipped due to time constraints or taught in different orders. If time allows, we may discuss other advanced topics.

Teaching Outcomes: By the end of the course, you should have a conceptual and quantitative understanding of the above topics. You should also be able to carry out multi-step calculations and apply quantum mechanics to real-world problems. You will also gain experience with some use of computational resources (particularly Maple software) in physics and in making presentations to an audience of your peers.

Assignment Policies

Reading: Reading assignments will be posted on the course web page each week (usually 1-3 sections per week). You are responsible for keeping up with the reading; material covered in the reading will not necessarily be discussed in the class lectures but may be included in tests.

Homework: Assignments will be posted on the course web page (see above) in PDF format each Thursday. They will **NOT** be handed out in class, so you must tell me if you cannot access the assignments! One student will be assigned to discuss each problem the following Tuesday for a few minutes. The assignment will then be due at 10:59PM on the listed due date in the labeled dropbox outside room 2L26; make sure to mark your paper with your name and “AQM.” Alternately, homework can be emailed to the instructor as black-and-white scanned (*not photographed*) PDF or a PDF prepared with L^AT_EX software. Homework solutions will be posted on the course web page as soon as possible after assignments have been collected. Collaboration on the problems is allowed, but each student must write up the solutions independently. Late assignments will **not** be accepted without prior permission from the instructor. Some assignments will require the use of Maple software, which is available on the computers in room 2L14.

Class Project: Students will give a short class lesson on a subject related to but not necessarily included in the course topics listed above and write a homework assignment (with solution set) on their subject. Detailed instructions will be provided in the course meeting following the in-class test.

Exams: No electronic equipment is allowed during either the in-class test or the final exam, except at the discretion of the instructor. Students should be prepared to present identification at tests and exams.

Religious Holidays: You may choose not to attend class or write tests/examinations on holy days of your religion, but you must notify me at least two weeks in advance. If so, I will provide the opportunity to make up work without penalty.

Organization: Your homework and exam solutions should be written (or typed) neatly with steps explained *as if you were writing a research paper or lab report*. Not all algebra need be shown if the steps are explained in words; however, showing your work may improve your credit if you make a mistake. Homework that is not neatly organized and written will not be graded and will be given **zero credit** (one warning will be allowed). In addition, multiple pages must be stapled together.

Regrading: If you feel that there is a mistake in grading, I will regrade each problem in question completely. It is possible that newly discovered mistakes will reduce your credit. Please also see the section on appeals.

Evaluation

Grades: Course grades will be comprised of the following components:

- Homework Assignments: 35%
- Class Project: 15%
- Class Participation (see below): 5%
- Final Exam: 30%
- In-Class Test: 15%

Guidelines for the assignment of numerical percentage grades to letter grades are as follows:

- A+ = 95-100%
- B+ = 74-79%
- C = 53-60%
- A = 87-94%
- B = 67-73%
- D = 50-52%
- A- = 80-86%
- C+ = 61-66%
- F = 0-49%

Note that these are guidelines. Final grades shall be approved by the Department Review Committee and may be subject to change.

Participation: The participation grade will be based solely on presentations of homework problems during the Tuesday class meeting following the assignment of homework. If a student is prepared to discuss the assigned problem (that is, demonstrates that they have thought about the problem), then the student will receive full credit for that presentation. Otherwise, the student will receive no credit for that presentation. Presenting students are encouraged to take advantage of office hours for advice on the problems.

Exam & Other Important Dates: Dates to note include

- First Lecture: Jan 7, 2020
- Winter Reading Week: Feb 16-22, 2020
- In-Class Test: mid-Feb, 2020
- Voluntary Withdrawal Date: March 13, 2020 (without academic penalty)
- Last Regular Lecture: April 2, 2020
- Project Presentation: Mar 30 - Apr 3, 2020
- Project Homework Assignment: April 9, 2020
- Final Exam: April 18, 2020, 1:30-4:30PM, 3C27 (subject to university scheduling)

Appeals and Misconduct: See the **Regulations and Policies** section of the **Academic Calendar** (<https://uwinnipeg.ca/academics/calendar/docs/regulationsandpolicies.pdf>) regarding appeals and academic misconduct. Pay attention to subsections 8, 9, and 10 and Discipline with respect to plagiarism and other cheating. Note that use of solutions from other courses, previous years, or from the textbook publisher will be considered cheating, and uploading assignments to filesharing sites will be considered aiding and abetting plagiarism. More information can be found at <https://www.uwinnipeg.ca/institutional-analysis/docs/policies/academic-misconduct-policy.pdf>, <https://www.uwinnipeg.ca/institutional-analysis/docs/policies/academic-misconduct-procedures.pdf>, <https://www.uwinnipeg.ca/institutional-analysis/docs/student-non-academic-misconduct-policy.pdf>, and <https://www.uwinnipeg.ca/institutional-analysis/docs/student-non-academic-misconduct-procedures.pdf>. See also <https://www.youtube.com/watch?v=UvFdxRU9a8g>.

Miscellaneous

Emails: I may at times need to communicate with the class as a whole via email, which may be through your official university email address. Please check that account as well as your preferred account.

Avoiding Copyright Violation: Course materials are owned by the instructor who developed them. Examples of such materials are course outlines, assignment descriptions, lecture notes, test questions, and presentation slides. Students who upload these materials to filesharing sites, or in any other way share these materials with others outside the class without prior permission of the instructor/presenter, are in violation of copyright law and University policy. Students must also seek prior permission of the instructor /presenter before photographing or recording slides, presentations, lectures, and notes on the board.

Accessibility Services: Students with documented disabilities, temporary or chronic medical conditions, requiring academic accommodations for tests/exams (e.g., private space) or during lectures/laboratories (e.g., note-takers) are encouraged to contact Accessibility Services (AS) at 204-786-9771 or accessibilityservices@uwinnipeg.ca to discuss appropriate options. All information about a student's disability or medical condition remains confidential. <http://www.uwinnipeg.ca/accessibility>.

Data Collection: Students who plan to conduct research interviews, focus groups, surveys, or any other method of collecting data from any person, even a family member, must obtain the approval of the appropriate ethics committee before commencing data collection. Exceptions are research activities in class as a learning exercise. See <http://www.uwinnipeg.ca/research/human-ethics.html> for submission requirements and deadlines.

Respectful Working and Learning Environment Policy: All students, faculty, and staff have the right to participate, learn and work in an environment that is free of harassment and discrimination. The UW Respectful Working and Learning Environment Policy may be found online at <http://www.uwinnipeg.ca/respect>.