

Univ. of Winnipeg Dept. of Physics
Winter 2021

PHYS-4602 Advanced Quantum Mechanics

Lecture Times: MWF 9:30-10:20AM

Room: zoom

Instructor: Dr. Andrew Frey

Office: working remotely

WWW: <http://ion.uwinnipeg.ca/~afrey/FW2021/aqm/>

Office Hours: by appointment on zoom

E-mail: a.frey@uwinnipeg.ca

Office Phone: use email

Course Description

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

Textbooks

There is one required text, which you should have from PHYS-3301.

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

In addition, I may assign some extra reading (from other texts, journal articles, etc) provided online.

Topics

We will discuss

- Foundations of Quantum Mechanics: — Basic Postulates — Information, Superposition, & Entanglement — Quantum Computing — Interpretations of Quantum Mechanics — Dirac Notation & Wavefunctions
- 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, exams, and/or homework assignments.

Homework: Assignments will be posted on the course web page (see above) in PDF format each Monday (I will announce any schedule change in class); please let me know if you require alternate delivery. The

assignment will then be due at 10:59PM on the listed due date; make sure to mark your solution with your name. See below for submission instructions. 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 or Mathematica software, available online.

Homework Submission Instructions: All assignments should be uploaded as PDF or Word document files to this link: <https://uwcloud.uwinnipeg.ca/s/ptx3smosp2xFtmE> (also listed on the course homepage). Note that you will not be able to see or edit your submission, so you must resubmit the whole file if you need to make changes. You should submit your assignments as scans to PDF (*not photographs*) of a written hardcopy, PDF prepared with L^AT_EX software, or PDF exported from a word processor (such as MS Word). If you do not have access to a scanner, there are free apps available for Apple and Android mobile devices. If you type your assignment with a word processor, you *must* use an equation editor for mathematics. Please label your files with your first initial, last name, and assignment number (for example, AFrey_hw1.pdf); if you need to break your assignment into multiple parts, label them in order with lower case letters (AFrey_hw1a.pdf, AFrey_hw1b.pdf, etc). You will each receive via email a personalized link to a shared folder where the marker or I will return your marked assignments.

Class Project: Students will prepare 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; depending on feasibility over zoom, the class lesson may be given as a presentation during class or as a set of lecture notes. Detailed instructions will be provided in the course meeting following the in-class test.

Term Test and Exam: The term test and final exam will be take-home format with scheduled times. You will receive detailed instructions about allowed resources in advance of the scheduled dates. You should prepare your test/exam solution following the Homework Submission Instructions above using “test” or “exam” instead of assignment number and upload it to the same link <https://uwcloud.uwinnipeg.ca/s/ptx3smosp2xFtmE> by the scheduled deadline. Please follow the detailed instructions on the test and exam for each.

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).

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: 40%
- In-Class Test: 15%
- Class Project: 15%
- Final Exam: 30%

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

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

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

Exam & Other Important Dates: Dates to note include

- First Lecture: Jan 6, 2021
- Winter Reading Week: Feb 14-20, 2021
- In-Class Test: Late Feb/Early March, 2021
- Voluntary Withdrawal Date: March 16, 2021
(without academic penalty)
- University Holiday: April 2, 2021
- Last Lecture: April 7, 2021
- Course Project Due: TBA
- Final Exam: TBA
(subject to university scheduling)

Exceptional Circumstances: A permitted or necessary change in mode of delivery may require adjustments to important aspects of this course outline, like class schedule and the number, nature, and weighting of assignments and/or exams. When it is necessary to cancel a class due to exceptional circumstances, every effort will be made to inform students via UWinnipeg email.

Regulations, Policies, and Academic Integrity: Students are encouraged to familiarize themselves with the Regulations and Policies found in the University Academic Calendar at: <https://uwinnipeg.ca/academics/calendar/docs/regulationsandpolicies.pdf>. Particular attention should be given to sub-sections 8 (Student Discipline), 9 (Senate Appeals), and 10 (Grade Appeals).

Please note the importance of maintaining academic integrity, and the potential consequences of engaging in plagiarism, cheating, and other forms of academic misconduct.

Even unintentional plagiarism, as described in the UW Library video tutorial Avoiding Plagiarism (<https://www.youtube.com/watch?v=UvFdxRU9a8g>) is a form of academic misconduct.

Similarly, uploading essays and other assignments to essay vendor or trader sites (filesharing sites that are known providers of essays for use by others who submit them to instructors as their own work) is a form of misconduct, as it involves aiding and abetting plagiarism. More detailed information can be found here:

Academic Misconduct Policy and Procedures: <https://www.uwinnipeg.ca/institutional-analysis/docs/policies/academic-misconduct-policy.pdf> and <https://www.uwinnipeg.ca/institutional-analysis/docs/policies/academic-misconduct-procedures.pdf>.

Miscellaneous

Emails: The primary method of email communication for this course will be through your official university email address. Please check that account regularly. However, if you contact me from a different email account, I may respond to that account. I will notify you through your university email and/or by announcement in class if I also need to communicate through your listed “preferred” email accounts.

Comments: I welcome feedback and comments on the course. If you are more comfortable commenting anonymously, please upload a plain text file to the homework upload link (PDF and word documents are ok but may contain information that identifies you).

Copyright and Intellectual Property: 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. Students found to be in violation of an instructors

intellectual property rights could face serious consequences pursuant to the *Academic Misconduct or Non-Academic Misconduct Policy*; such consequences could possibly involve legal sanction under the Copyright Policy (https://copyright.uwinnipeg.ca/docs/copyright_policy_2017.pdf).

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-services>.

Research Ethics: 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 Learning Environment: Students are expected to conduct themselves in a respectful manner on campus and in the learning environment irrespective of platform being used. Behaviour, communication, or acts that are inconsistent with a number of UW policies (e.g. *Respectful Working and Learning Environment Policy* <https://www.uwinnipeg.ca/respect/respect-policy.html>, *Acceptable Use of Information Technology Policy* <https://www.uwinnipeg.ca/institutional-analysis/docs/policies/acceptable-use-of-information-technology-policy.pdf>) could be considered non-academic misconduct. More detailed information can be found here: *Non-Academic Misconduct Policy and Procedures*: <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>.

Zoom Etiquette and Privacy: This course will be conducted using Zoom software. As basic etiquette, please leave your microphone muted unless you are speaking. Since it can be difficult for me to see the participant list and chat window while I am screen sharing, please unmute and speak to ask any immediate questions. To help create a sense of community in our class, please consider turning on your video, but you should feel comfortable that anything visible in the background respects your privacy. Please be aware of University privacy policies relation to the collecting of personal data by the University (<https://www.uwinnipeg.ca/privacy/admissions-privacy-notice.html>) and privacy relating to the use of Zoom (<https://www.uwinnipeg.ca/privacy/zoom-privacy-notice.html>). We may use zoom proctoring for part of the term test or exam, so please also note the University Zoom proctoring policy (<https://www.uwinnipeg.ca/privacy/zoom-test-and-exam-proctoring.html>). You can find answers to frequently asked questions (FAQ) related to zoom and remote learning at <https://www.uwinnipeg.ca/covid-19/remote-learning-faq.html>.