University of Victoria
Department of Physics and Astronomy

Physics 323 - Quantum Mechanics I

Fall 2024 Syllabus

We acknowledge and respect the Lekwungen (Songhees and Esquimalt) Peoples on whose traditional territory the university stands, and the Lekwungen and WSÁNEĆ Peoples whose historical relationships with the land continue to this day.

Course Information

Sections: A01, B01, B02, B03, B04, B05, T01
Units: 1.5
Contact Hours: 3h/week lecture, 18h/semester lab, 1h/week tutorial
Lecture Schedule: ECS 104, Mon/Thurs, 10:00-11:20am, Sept 4 to Dec 4
Tutorial Schedule: COR B111, Tuesdays, 8:30-9:20am, Sept 12 to Nov 28
Lab Schedule:
˙ Section B01 - 2:30-5:20, Mondays, Sept 16 to Dec 2
˙ Section B02 - 4:30-7:20, Tuesdays, Sept 17 to Nov 19
˙ Section B03 - 2:30-5:20, Wednesdays, Sept 18 to Nov 20
˙ Section B04 - 2:30-5:20, Thursdays, Sept 19 to Nov 21
˙ Section B05 - 2:30-5:20, Fridays, Sept 20 to Nov 22
The full lab schedule can be found at `http://www.uvic.ca/science/physics/current/undergraduate/timetables/index.php`.
Prerequisites:
PHYS215 and MATH204. The course is structured assuming you are taking MATH342 at the same time as PHYS323, thus MATH342 is either a prerequisite or co-requisite course. It is STRONGLY recommended that you have completed PHYS248 before taking this class.

Instructor Information

Course Instructor: Travis Martin (Pronouns: He/Him, Preferred Address: Travis)
Office Hours: Zoom, Wednesdays 1:00-2:00pm
Contact Information: `travismartin@uvic.ca`
Contact Availability: Will respond within 2 business days
In-term Feedback: End-of-semester course evaluation surveys

Lab Instructor: Doug McKenzie (Pronouns: He/Him, Preferred Address: Doug)
Office Hours: None
Contact Information: `dmckenzi@uvic.ca`
Contact Availability: Will respond within 2 business days
In-term Feedback: End-of-semester course evaluation surveys

Tutorial Instructor: Afif Omar (Pronouns: He/Him, Preferred Address: Afif)

Office Hours: None
Contact Information: afif@uvic.ca
Contact Availability: Will respond within 2 business days
In-term Feedback: End-of-semester course evaluation surveys

Teaching and Assessment Modality

Lectures will be taught in-person.
Labs will be taught in-person.
Tutorials will be taught in-person.

Equipment requirements: Students are expected to have a computer with access to the internet, and the ability to program/code in either Python or Matlab.

Learning and Teaching Technologies

Course Webpage: Brightspace https://bright.uvic.ca/d2l/le/content/359922 (UVic approved) **Other Technologies:**

Python and/or Matlab will be required for assignments.
Additionally, Mathematica will be used to present simulations, animations and other demonstrations of the mathematics of Quantum Mechanics.

Permissible Digital Tools: Students may use Large Language Models (LLM) (e.g.: ChatGPT) to assist in the development of solutions to computational problems. Students are responsible for ensuring that their solutions are correct. Students must provide screenshots of all relevant interactions with the LLM as part of demonstrating their worked solution.

Course Structure and Description

This course will be taught using a traditional lecture style, with strong encouragement of in-class questions and discussion.

Class will not be recorded. Students are encouraged to follow the course notes and textbook to make up for missed material in the case of absence.

Class Materials:

Textbook

A textbook is strongly recommended for this course. The textbook for this course is for reference material; no homework questions will be assigned from the textbook. *Quantum Mechanics* by McIntyre ($75) is the superior of the offerings for this level of quantum mechanics. *Introduction to Quantum Mechanics* by Griffiths ($87) is an acceptable textbook, but misses out on a lot of the formality. We will be using linear algebra more than Griffiths does. *Modern Quantum Mechanics* by Sakurai ($90) is an excellent textbook, but will likely be too formal in its approach - it is a good text for preparation for grad school.

Copies of all three textbooks are available through the UVic Library.

Course Overview

The end goal of this course is to provide all of the necessary tools and methods for understanding the full quantum mechanical hydrogen wavefunction. Below is a rough outline of the major topics in the order in which they will be discussed.

1. Introduction
   - (a) Single Particle Diffraction (not in textbook)
   - (b) Interpretations (not in textbook)
2. Math Review
   - (a) Statistics (not in textbook)
   - (b) Complex Numbers (not in textbook)
   - (c) Linear Algebra (not in textbook)
3. Simple Systems in Quantum Mechanics
   - (a) Eigenstates & Eigenvectors (multiple chapters)
   - (b) Hilbert Space (multiple chapters)
   - (c) Schrödinger's Equation (Chapter 5)
   - (d) Stern-Gerlach & Quantum States (Chapter 1)
   - (e) Postulates of Quantum Mechanics (Chapter 2)
4. Quantum Mechanics with Operators I
   - (a) Operators and Measurements (Chapter 2)
   - (b) Uncertainty Principle (Chapter 2)
   - (c) Quantum Numbers (multiple chapters)
   - (d) Time Evolution (Chapter 3)
5. Potential Wells
   - (a) Infinite Square Well (Chapter 5)
   - (b) Time Dependent Properties (Chapter 5)
   - (c) Finite Wells (Chapter 5)
   - (d) Visualizing Wavefunctions (Chapter 5)
   - (e) Free Particles & Momentum Basis (Chapter 6)
6. Quantum Mechanics with Operators II
   - (a) Harmonic Oscillator (Chapter 9)
   - (b) Angular Momentum (Chapter 7)
   - (c) Addition of Angular Momentum (not in textbook)

7. Hydrogen
    (a) Relative and Centre of Mass Coordinates (Chapter 7)
    (b) Using Frobenius's Method for Angular Components (Chapter 7)
    (c) Radial Wave Function & Energy Eigenstates (Chapter 8)
    (d) Quantization of Hydrogen (Chapter 8)
8. Additional Topics
    (a) Separable Quantum Mechanics in 3D (not in textbook)
    (b) Identical Particles (Chapter 13)

Course-level Learning Outcomes

By the end of the course, students should...

- be able to translate between standard English language descriptions and the standard notations of quantum mechanics (calculus, matrix, bra-ket).
- be able to represent quantum systems in terms of an appropriate Hilbert space, and exploit the properties of the Hilbert space to simplify calculations.
- develop solutions for finite dimensional systems, such as spin and orbital angular momentum, and switch between bases that span the space of the systems for producing predictions for outcomes of thought experiments.
- be able to solve systems with higher degrees of freedom, characterized by multiple quantum numbers, for both commuting and non-commuting properties.
- be able to develop solutions and visualizations for systems using computing approaches, including computational linear algebra and numerical integration.

Essential Course Components:
Students must complete all labs and receive an overall passing grade in the lab component.
Students must complete and achieve a minimum acceptable grade on the final exam. The minimum acceptable grade will not be set above 40%.

Grading

If the application of this scheme would result in grades that are judged by the instructor to be inconsistent with the University's grading descriptions (`https://web.uvic.ca/calendar2014/FACS/UnIn/UARe/Grad.html`), then the instructor will assign percentages consistent with them.

Assignments: 20%

There will be 8-10 assignments throughout the semester, some of which may have computational questions incorporated. Assignments will be submitted through Brightspace. Your final assignment grade will incorporate only the best N-1 of the assignments. Each assignment carries the same weight otherwise. Assignments are expected to take about 2-4 hours of time for students who attentive to the material.

Computational Project: 10%

There is a computational project in this course, which will be the focus of the tutorials time. Tutorials will guide students through solving eigenfunctions and eigenvalues for a variety of potentials. The project is broken down into seven separate submission tasks. Each task is designed to be completable within the tutorial time, but may be completed outside of the tutorial. Due dates for each task are provided on Brightspace.

Laboratory Activities: 10% (REQUIRED)

The labs with this class are assigned due to logistical reasons, rather than pedagogical reasons. It is a Faculty of Science policy that you must pass the labs in order to pass this course.

Midterm Exams: 30% (synchronous timed, in-class)

There will be two midterms (Oct 10 and Nov 7) in this course that will cover course material that is discussed in class up to the end of the week prior to the exam. For students who perform better on the final exam than either midterm, half of the weight of the midterm will be transferred to the final exam.

Final Exam: 30% (REQUIRED, synchronous timed)

The final exam will be comprehensive, in that it will require knowledge of all of the material of the course.

University Regulations on Academic Integrity

These regulations are reproduced from `http://web.uvic.ca/calendar2011/FACS/UnIn/UARe/PoAcI.html`. For full information, including procedures for dealing with academic integrity infringement, see the webpage linked above.

Academic integrity requires commitment to the values of honesty, trust, fairness, respect, and responsibility. Any action that contravenes this standard, including misrepresentation, falsification or deception, undermines the intention and worth of scholarly work and violates the fundamental academic rights of members of our community.

Several types of academic integrity violations are covered in brief below.

Plagiarism

A student commits plagiarism when he or she:

- submits the work of another person as original work
- gives inadequate attribution to an author or creator whose work is incorporated into the student's work, including failing to indicate clearly the inclusion of another individual's work
- paraphrases material from a source without sufficient acknowledgement as described above

Students who are in doubt as to what constitutes plagiarism in a particular instance should consult their course instructor.

Falsifying Material Subject to Academic Evaluation

Falsifying materials subject to academic evaluation includes, but is not limited to:

- fraudulently manipulating laboratory processes, electronic data or research data in order to achieve desired results
- using work prepared by someone else (e.g., commercially prepared essays) and submitting it as one's own
- citing a source from which material was not obtained
- using a quoted reference from a non-original source while implying reference to the original source
- submitting false records, information or data, in writing or orally

Cheating on Assignments, Tests/Quizzes and Examinations

Cheating includes, but is not limited to:

- copying the answers or other work of another person
- sharing information or answers when doing take-home assignments, tests and examinations except where the instructor has authorized collaborative work
- having in an examination or test any materials or equipment other than those authorized by the examiners impersonating a candidate on an examination or test, or being assigned the results of such impersonation
- *assisting others to engage in conduct that is considered cheating*

Illness policy

Widespread infection rates and variant transmissions mean that COVID-19 should still be taken very seriously. Students and faculty may express a wide range of differing opinions and emotions towards how to best navigate the risks and challenges of the pandemic. As a class, we need to manage these opinions in a productive way.

To help facilitate this, I have the following expectations for how students will behave in my class:

1. Students are required to follow all relevant provincial, university and faculty instructions regarding distancing, handwashing, masks and other similar issues.
2. Students are not permitted to attend any in-person course component (lecture/lab) if ill; students exhibiting any cold or flu-like symptoms will be asked and required to leave and go home. Accommodations for missed material due to illness can be discussed via email.
3. While masks are not mandatory, it can significantly reduce the spread of illness by asymptomatic individuals. I strongly encourage the continued use of masks.
4. Students are requested to get vaccinated in a timely manner if not already vaccinated.

Please also take note of the following:

- Students will not be permitted to enter my personal space before, during or after the lecture. If you have questions, you may ask respectfully from a distance.
- Office hours will be held on Zoom rather than in-person. Students will not be permitted to attend my office without prior permission.
- Students who miss more than 40% of any component of the course (illness lasting longer than 1 month) will be encouraged to complete a Request For Academic Concession to drop the course. Concessions can only cover short term ailments. It is in your best interest to withdraw from a course if you miss that much material.
- If I am sick for any reason, I will inform the class and I will not be attending the lectures for the duration of my illness. In such cases, students will be expected to watch the video recorded lectures. Class will not stop simply because the instructor is sick.

Accommodation and Concession:

Academic concessions can be made for missed exams/assignments due to illness or other severe affliction, as well as conflicts with classes and religious observances. Accommodations will be respected for issues documented through the CAL.

If you miss an exam or assignment, I expect you to contact me as soon as possible. If you anticipate missing a course requirement, you must contact me a reasonable time in advance. If an emergency occurs during a test, please talk to me.

Resources for Students

UVic's Learn Anywhere is the primary learning resource for students that offers many learning workshops and resources to help students with academics and learning strategies.
https://onlineacademiccommunity.uvic.ca/LearnAnywhere/

Indigenous Student Services
https://www.uvic.ca/calendar/undergrad/index.php#/content/62daf5e98b7d47001d0fc388

Centre for Academic Communication
https://www.uvic.ca/learningandteaching/cac/

Learning Strategies Program
https://onlineacademiccommunity.uvic.ca/LearnAnywhere/program/

Community Engaged Learning
https://onlineacademiccommunity.uvic.ca/LearnAnywhere/cel/

UVic Academic Concession and Accommodation Policy
https://www.uvic.ca/calendar/undergrad/index.php#/policy/HJjAxiGO4

University Statements and Policies

Information for all Students
https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/content/62daf5e98b7d47001

Creating a Respective and Productive Learning Environment
https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/policy/HkQ0pzdAN

Policy on Accommodation of Religious Observance
https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/policy/r1q0gofdN

Student Conduct Policy
https://www.uvic.ca/services/studentlife/student-conduct/index.php

Policy on Non-academic Misconduct
https://www.uvic.ca/services/studentlife/student-conduct/non-academic-misconduct/index.php

Academic Accommodations through Centre for Accessible Learning
https://www.uvic.ca/accessible-learning/index.php

Equity, Diversity and Inclusion Statements/Policy
https://www.uvic.ca/vpacademic/about-contacts/equity-diversity-inclusion/index.php
https://www.uvic.ca/calendar/undergrad/index.php#/policy/HkQ0pzdAN

Sexualized Violence Prevention and Response
https://www.uvic.ca/sexualizedviolence/

Policy on Discrimination and Harassment
https://www.uvic.ca/sexualizedviolence/

Student Groups and Resources

Student Wellness
https://www.uvic.ca/student-wellness/

Ombudsperson
https://uvicombudsperson.ca/

Other student groups
https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/content/62daf5e98b7d47001