UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

Department of Physics & Astronomy
Science B 605
403 220-5385
phasoffice@phas.ucalgary.ca

COURSE OUTLINE

1. **Course:** PHYS 443, Quantum Mechanics I - Winter 2021

   Lecture 01: TR 12:30 - 13:45 - Online

Instructor	Email	Phone	Office	Hours
Dr Daniel Oblak	TBA	TBA	TBA	TBA

Online Delivery Details:

Some aspects of this course are being offered in real-time via scheduled meeting times. For those aspects you are required to be online at the same time.

To help ensure Zoom sessions are private, do not share the Zoom link or password with others, or on any social media platforms. Zoom links and passwords are only intended for students registered in the course. Zoom recordings and materials presented in Zoom, including any teaching materials, must not be shared, distributed or published without the instructor's permission.

This course has a registrar scheduled, synchronous final exam. The writing time is 2 hours + 50% buffer time.

There are two nominal class times per week for this course. These will predominantly be dedicated to online lectures, which are delivered synchronously via Zoom. Recordings of the lectures and notes will be posted subsequently on the course D2L page. A number of classes will be set aside for review, problem solving practice, mid-term and presentation catch-up at the end of the term.

Course Site:

D2L: PHYS 443 L01-(Winter 2021)-Quantum Mechanics I

Note: Students must use their U of C account for all course correspondence.

2. **Requisites:**

See section 3.5.C in the Faculty of Science section of the online Calendar.

Prerequisite(s):
Physics 343; and 229 or 325; Mathematics 311 or 313; and Mathematics 375 or 376; and Mathematics 367 or 377; and Physics 435 or Mathematics 433.

3. **Grading:**

The University policy on grading and related matters is described in F.1 and F.2 of the online University Calendar.

In determining the overall grade in the course the following weights will be used:

Component(s)	Weighting %	Date
Homework assignments	30	Throughout term (see detailed description)
Presentations	10	Throughout term (see detailed description)
Term project	15	Before end of term (see detailed description)
Midterm exam	15	February 25 (during normal class time)
Final exam	30	TBD

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Minimum % Required	95 %	90 %	85 %	80%	75%	70 %	65 %	60%	55%	50 %	45 %

Homework

The lowest graded homework assignment score will not be counted towards your final grade.
Homework is to be handed in according to the schedule (approximately every 2nd week), which will be announced on the course website with at least one week notice for any changes to the schedule. Homework must be submitted via the course website (dropbox) on D2L. There are no homework-assignments during the first week of classes, reading-week, midterm week, and final exam week.
Homework assignments handed in late will receive a score reduction of 25% if handed within 24 hours of the due date and a score reduction of 50% if handed in before the marked homework has been returned.

Presentations

Each student must make one presentation, which covers an applications or real-world example of the theoretical topics covered in class. A list of topics will be continuously updated on the course D2L site. Each presentation should last about 5 minutes. Presentations will be held at beginning of each class following the drop-date for the course, i.e., January 26th. There will be one or two presentations each class depending on the number of students. Slots for the presentations will be randomly drawn from the class-list and announced in the second week of classes.
The presentations will be delivered over zoom and recorded for grading purposes. Slides will be sent to the course instructor who will share the slide on his screen to all participants during class. Presenter will also be available to answer questions from the class. Students may contact the instructor in advance if there are reasons why synchronous delivery of the presentation is not possible. The presentations will be evaluated by the instructor and a small number of peers according to a rubric.

Term Project

For the term project students will work in groups of two members. The groups will be formed close to the reading week. The term project will be focused on a critical review of online (popular) educational material on quantum mechanics, e.g., tutorials on video-sharing platforms. Each group will review a 10-15 min video (or section of a video) with the aim to describe what are the important aspects of this concept as compared to what was covered in the content and why? The group will also be asked to assess if any information was misleading or a common misconception, if it contained good examples of how to physically/intuitively think about that concept presented in the video, or if anything was under-emphasized. More details about the format for the assessment will be provided when the groups are formed.

This course will have a final exam that will be scheduled by the Registrar. The Final Examination Schedule will be published by the Registrar's Office approximately one month after the start of the term. The final exam for this course will be designed to be completed within 2 hours.

The final exam will be administered using an on-line platform. Per section G.5 of the online Academic Calendar, timed final exams administered using an on-line platform, such as D2L, will be available on the platform. Due to the scheduling of the final exams, the additional time will be added to **the end** of the registrar scheduled **synchronous** exam to support students. This way, your exam schedule accurately reflects the **start time** of the exam for any **synchronous** exams. E.g. If a **synchronous** exam is designed for 2 hours and the final exam is scheduled from 9-11am in your student centre, the additional time will be added to the **end** time of the **synchronous** exam. This means that if the exam has a 1 hour buffer time, a synchronous exam would start at 9 am and finish at 12pm. – **updated April 6, 2021**

Final grades will not be rounded up or down.

4. **Missed Components Of Term Work:**

The university has suspended the requirement for students to provide evidence for absences. Please do not attend medical clinics for medical notes or Commissioners for Oaths for statutory declarations.

In the event that a student legitimately fails to submit any online assessment on time (e.g. due to illness etc...), please contact the course coordinator, or the course instructor if this course does not have a coordinator to arrange for a re-adjustment of a submission date. Absences not reported within 48 hours will not be accommodated. If an excused absence is approved, then the percentage weight of the legitimately missed assignment could also be pro-rated among the components of the course.

5. **Scheduled Out-of-Class Activities:**

   There are no scheduled out of class activities for this course.

6. **Course Materials:**

   Required Textbook(s):

   David J. Griffiths and Darrell F. Schroeter, *Introduction to Quantum Mechanics (3rd Edition)*: Cambridge University Press.

   Notes on topics not covered by the textbook will be provided electronically after lectures.

   In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

   - A computer with a supported operating system, as well as the latest security, and malware updates;
   - A current and updated web browser;
   - Webcam/Camera (built-in or external);
   - Microphone and speaker (built-in or external), or headset with microphone;
   - Current antivirus and/or firewall software enabled;
   - Stable internet connection.

   For more information please refer to the UofC ELearning online website.

7. **Examination Policy:**

   All exams are intended to be completed individually.

   Midterm exam will be delivered during the regular class time on Feb. 25th. Any accommodations, e.g. extended time, will be calculated from the usual class duration.

   The final exam will be scheduled by the registrar. The exam questions will be distributed via D2L and are to be handed-in electronically via a D2L drop-box.

   Reports on technical problems must be received withing 24 hours from the start of the exam.

   Students should also read the Calendar, Section G, on Examinations.

8. **Approved Mandatory And Optional Course Supplemental Fees:**

   There are no mandatory or optional course supplemental fees for this course.

9. **Writing Across The Curriculum Statement:**

   For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section E.2 of the University Calendar.

10. **Human Studies Statement:**

    Students will not participate as subjects or researchers in human studies.

    See also Section E.5 of the University Calendar.

11. **Reappraisal Of Grades:**

    A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade being reappraised may be raised, lowered or remain the same. See Section I.3 of the University Calendar.

    a. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **ten business days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall submit the Reappraisal of Graded Term work form to the department in which the course is offered within 2 business days of receiving the decision from the instructor. The Department will arrange for a reappraisal of the work within the next ten business days. The reappraisal will only be considered if the student provides a detailed rationale that outlines where and for what reason an error is suspected. See sections I.1 and I.2 of the

University Calendar

b. **Final Exam:** The student shall submit the request to Enrolment Services. See Section I.3 of the University Calendar.

12. **Other Important Information For Students:**

a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, Mental Health Services Website) and the Campus Mental Health Strategy website (Mental Health).

b. **SU Wellness Services:** For more information, see www.ucalgary.ca/wellnesscentre or call 403-210-9355.

c. **Sexual Violence:** The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at 403-220-2208. The complete University of Calgary policy on sexual violence can be viewed at (https://www.ucalgary.ca/policies/files/policies/sexual-violence-policy.pdf)

d. **Misconduct:** Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity. Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional Code of Conduct and promote academic integrity in upholding the University of Calgary's reputation of excellence. Some examples of academic misconduct include but are not limited to: posting course material to online platforms or file sharing without the course instructor's consent; submitting or presenting work as if it were the student's own work; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. Please read the following to inform yourself more on academic integrity:

Student Handbook on Academic Integrity
Student Academic Misconduct Policy and Procedure
Research Integrity Policy

Additional information is available on the Student Success Centre Academic Integrity page

e. **Academic Accommodation Policy:** Students needing an accommodation because of a disability or medical condition should contact Student Accessibility Services in accordance with the procedure for accommodations for students with disabilities available at procedure-for-accommodations-for-students-with-disabilities.pdf.

Students needing an accommodation in relation to their coursework or to fulfill requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to the Associate Head of the Department of Physics & Astronomy, Dr. David Feder by email phas.ahugrd@ucalgary.ca or phone 403-220-8127. Religious accommodation requests relating to class, test or exam scheduling or absences must be submitted no later than **14 days** prior to the date in question. See Section E.4 of the University Calendar.

f. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see Legal Services website.

g. **Student Union Information:** VP Academic, Phone: 403-220-3911 Email: suvpaca@ucalgary.ca. SU Faculty Rep., Phone: 403-220-3913 Email: sciencerep@su.ucalgary.ca. Student Ombudsman, Email: ombuds@ucalgary.ca.

h. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction (USRI) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

i. **Copyright of Course Materials:** All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes, assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or non-academic misconduct, in addition to any other remedies available at law.

Schedule of topics

Schedule is approximate and may be adjusted depending on progress and feedback.

Week 1: Lecture 0 – 1 (January 12/14)
Introduction and review of syllabus
Origin of quantum mechanics, blackbody radiation
Intro to the Schrödinger equation

Week 2: Lectures 2 – 3, (January 19/21)
Wavefunctions and probability - Chapter 1.2 – 1.4
Separation of variables, solutions to the Schrödinger equation (Infinite square well)

Week 3: Lectures 4 – 5, (January 26/28)
Solutions to the Schrödinger equation (harmonic oscillator)

Week 4: Lectures 6 – 7, (February 2/4)
Solutions to the Schrödinger equation (free particle and delta function and finite square well)

Week 5: Lectures 8 – 9, (February 9/11)
Solutions to the Schrödinger equation (finite square well)
Hilbert space, matrix notation, observables, eigenfunctions

Week 6: No lectures, (Reading week)

Week 7: Lecture 10 & midterm, (February 23/25)
Review of material
Midterm on February 25

Week 8: Lectures 11 – 12 (March 2/4)
Generalized statistical interpretation, bra/ket (Dirac) notation
The uncertainty principle and operators

Week 9: Lectures 13 – 14 (March 9/11)
Schrödinger equation in 3D (and 2D if time permits)
Hydrogen atom

Week 10: Lectures 15 – 16 (March 16/18)
Angular momentum, generators
Identical particles, Bosons and Fermions

Week 11: Lectures 17 – 18 (March 23/25)
Addition of spins
Symmetries of wavefunctions, exchange interaction

Week 12: Lectures 19 – 20 (March 30/April 1)
Structure of atoms
Conservation laws

Week 13: Lectures 21 – 22 (April 6/8)
Symmetries and selection rules
Heisenberg picture

Week 14: Lecture 23 – 24 (April 13/15)
Term project delivery and review

Course Incomes:

Ability to solve differential equations, perform basic matrix/vector operations, understanding of eigenvectors and

eigenvalues, and working with complex numbers (including complex exponentials).

Familiarity with basics of modern physics – atoms, photons and electrons, linear and angular momentum, potential and kinetic energy, and other concepts from classical mechanics, Coulombs Law, electric potential and other concepts from electromagnetism.

Course Outcomes:

- Know the background and experiments which led to the development of quantum mechanics.
- Explain, qualitatively and quantitatively, the role of photons, electrons and Bohr's model in explaining these experiments
- Be able to discuss and interpret experiments displaying wavelike behaviour of matter, and how this motivates the need to replace classical mechanics by the Schrödinger equation
- Understand the postulates of quantum mechanics: the Schrödinger equation, the wave function and its physical interpretation, stationary and non-stationary states, time evolution
- Be able to solve the Schrödinger equation for simple one-dimensional systems -- the ones explicitly taught (e.g. square well, harmonic oscillator, potential barrier), as well as similar, new ones
- Gain a basic understanding of the formalism and 'language' of quantum mechanics and how it relates to linear algebra (Dirac's notation).
- Use solutions of the Schrödinger equation to compute probabilities, expectation values, uncertainties and time evolution.
- Understand the background and implications of the uncertainty relation and it's relation to physical phenomena.
- Explain the quantum mechanical derivation of the structure of (mainly Hydrogen-like) atoms and know how to apply selection rules.
- Understand qualitatively and quantitatively how quantum mechanics relates to a number of common technologies and phenomena.

Electronically Approved - Apr 06 2021 16:55

Department Approval