UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

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

COURSE OUTLINE

1. **Course:** PHYS 543, Quantum Mechanics II - Fall 2020

   Lecture 01: MWF 10:00 - 10:50 - Online

Instructor	Email	Phone	Office	Hours
Dr Daniel Oblak	doblak@ucalgary.ca	403 220-7660	SB 313	Mondays 10-11 am and by appointment

   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.

   There are three nominal class times per week for this course.

   The Wed and Fri class times will be dedicated to online lectures, which are provided asynchronously via the D2L course website. Lectures will be posted online before or at the nominal time of classes.

   The Mon class times will be dedicated to home-work review, problem-solving, independent term paper study, office hours, and the midterm according to the posted schedule. The synchronous components will be delivered via Zoom (or alternate platform with advance notice).

   Course Site:

   D2L: PHYS 543 L01-(Fall 2020)-Quantum Mechanics II

   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 443 or Chemistry 373.

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	25	Throughout term (see detailed description)
Term paper and presentation	25	Dec 7-9 (see detailed description)
Midterm	15	Nov 16
Final	35	TBD

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 home-work has been returned. Score reductions can be waived if <u>prior</u> arrangements are made and a reasonable reason is provided for a delay.

Term paper and presentations

The term paper and presentation will be based on a detailed review and synopsis of a research paper in a topic related to the course material. Students are encouraged to suggest research papers, which must be approved by the instructor. Students can also ask the instructor for suggestions. Depending on class size the term-paper and presentation will be done either as individuals or groups (two members). The term paper will be handed in and presentations given during the final week of the term. The exact format of the term paper (sections, length, evaluation criteria, etc) and presentation (duration, platform, evaluation criteria, etc) will be finalized after the term-break.

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 %	85 %	75 %	80%	75%	70 %	65 %	60%	55%	50 %	40 %

The final grade percentage will <u>not</u> be rounded up before conversion to a letter grade according to the conversion table.

This course has a registrar scheduled final exam.

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.

   Additional notes may be provided.

7. **Examination Policy:**

   All exams are intended to be completed individually.

   Midterm exam will be delivered during the regular class time on Nov. 16th. Any accommodations, e.g. extended time, will be calculated from the 50 minutes class duration.

   The final exam will be scheduled by the registrar.

   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 Center:** 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 misconduct (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under Section K. Student Misconduct to inform yourself of definitions, processes and penalties. Examples of academic misconduct may include: submitting or presenting work as if it were the student's own work when it is not; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; collaborating in whole or in part without prior agreement of the instructor; borrowing experimental values from others without the instructor's approval; falsification/ fabrication of experimental values in a report. **These are only examples**.

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.

Lecture component - Wed & Fri classes:
(Asynchronous delivery)

Week 1: Lecture 1-2 (Sep 9, 11)
Introduction and review of syllabus
Conservation laws, parity – Chapter 6.1-4

Week 2: Lectures 3-4 (Sep 16, 18)
Symmetries and selection rules – Chapter 6.5-7
Heisenberg picture – Chapter 6.8

Week 3: Lectures 5-6 (Sep 23, 25)
Perturbation theory – Chapter 7.1-2
Fine structure – Chapter 7.3

Week 4: Lectures 7-8 (Sep 30, Oct 2)
Zeeman effect – Chapter 7.4
Hyperfine splitting – Chapter 7.5

Week 5: Lectures 9-10 (Oct 7, 9)
Variational principle – Chapter 8

Week 6: Lecture 11-12 (Oct 14, 16)
WKB approximation – Chapter 9

Week 7: Lecture 13-14 (Oct 21, 23)
Scattering theory – Chapter 10

Week 8: Lecture 15-16 (Oct 28, 30)
Two-level systems – Chapter 11.2
Interaction with E.M. waves – Chapter 11.3-4

Week 9: Lecture 17-18 (Nov 4, 6)
More topics on light-matter interaction

Week 10: Term-break/reading week

Week 11: Lecture 19-20 (Nov 18, 20)
Pure and mixed states – Chapter 12.1
Entanglement and Bell's theorem – Chapter 12.2

Week 12: Lecture 21-22 (Nov 25, 27)
Advanced topics (e.g. second quantization, quantum bits and decoherence, …)

Week 13: Lecture 23-24 (Dec 2, 4)
Advanced topics (e.g. quantum information, laser cooling and trapping, …)

Week 14: Lecture 25 (Dec 9)
Presentations and review

Alternate component - Mon classes:
(Mostly synchronous delivery)

Week 1:
No Monday class.

Week 2: (Sep 14)
Introduction to term paper/presentation
Problem solving

Week 3: (Sep 21)
Review of home-work assignment 1
Problem solving

Week 4: (Sep 28)
Independent work on term paper/presentation
Office hour

Week 5: (Oct 5)
Review of home-work assignment 2
Problem solving

Week 6: Thanksgiving
No class

Week 7: (Oct 19)
Review of home-work assignment 3
Problem solving

Week 8: (Oct 26)
Independent work on term paper/presentation
Office hour

Week 9: (Nov 2)
Review of home-work assignment 4
Problem solving

Week 10: Term-break/reading week

Week 11: (Nov 16)
Midterm exam

Week 12: (Nov 23)
Review of home-work assignment 5
Problem solving

Week 13: (Nov 30)
Independent work on term paper/presentation
Office hour

Week 14: (Dec 7)
Presentations

Course Incomes

Ability to solve differential equations, perform basic matrix/vector operations. Understanding of eigenvectors and eigenvalues. Comfortable working with complex numbers (including complex exponentials). Familiarity with basics of modern physics – atoms, photons and electrons, Coulombs Law, electric potential and other concepts of electromagnetism. Understanding of wavefunctions, the Schrödinger equation, Dirac notation, and Hilbert space.

Course Outcomes:

- Use various perturbation and approximation approaches in quantum mechanics to explain and derive a number of phenomena, e.g. fine and hyperfine structure of atoms and Zeeman splitting.
- Apply scattering theory and understand its consequences under a range of experimental conditions
- Have a broad understanding of the interaction between electromagnetic radiation and atomic quantum systems and be able to address a number of practical applications.
- Address qualitatively and quantitatively how quantum mechanics relates to a number of common technologies and phenomena.

Electronically Approved - Aug 26 2020 08:07

Department Approval