UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

Department of Physics & Astronomy
Science B 605
403 220-5385
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REVISED COURSE OUTLINE FOR REMOTE LEARNING

To account for the necessary transition to remote learning from March 13 onward, adjustments have been made to assessment deadlines and requirements so that all coursework tasks are in line with the necessary and evolving health precautions for all involved (students and staff). If you are unable to meet the deadlines or requirements specified, please connect with your course instructor to work out alternative dates/assessments.

1. **Course:** PHYS 443, Quantum Mechanics I - Winter 2020

   Lecture 01: TR 12:30 - 13:45 - Remote Learning (check with your instructor or coordinator for details)

Instructor	Email	Phone	Office	Hours
Dr Daniel Oblak	doblak@ucalgary.ca	403 220-7660	SB 313	Fri. 3:30-4:30 pm (may be adjusted to better fit student schedules)

   Course Site:

   D2L: PHYS 443 L01-(Winter 2020)-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 229 or 325; and 343; and Mathematics 311; and Mathematics 433 or Physics 435; and Mathematics 375 or 376; and Mathematics 367 or 377.

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	15	Throughout term (see detailed description)
Midterm	20	February 27 (during normal class time)
Final Exam	35	April 29 (take-home exam)

   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 %	40 %

   Homework assignments

   Homework is to be handed in in-class (at the start of the class) or deposited in the online repository according to the schedule, which will be announced in class and with at least one week notice for any changes to the schedule. There are no homework-assignments during the first week of classes, reading-week, midterm week, and final exam week. Unless otherwise specified, homework assignments handed in late will receive a score reduction of 25% if handed in before 5 pm on the due date, a score reduction of 50% if handed in before 5 pm the following day and a reduction of 75% if handed in later than that and before the solutions are posted. After the solutions are posted, no score will be given for the homework assignment. Late submissions must be handed in in my mailbox in Science B 312 or in the online repository, unless otherwise specified.

The lowest graded homework assignment score will not be counted towards your final grade.

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. Slots for the presentations will be randomly drawn during Lecture 0 and absent students will be assigned to the remaining slots.

Each presentation must strictly last no longer than 5 minutes and feature a single slide to be projected onto a screen for illustration for the class. Presentations will be held at beginning of class once a week, starting in week 3 (Jan 28th). There will be one or two presentations depending on the number of students and multiple catch-up presentations during the last week of classes. *Presentations scheduled from Mar 15 and on-wards will all be postponed for the final two lectures. These presentations will be given as a video-conference via a suitable online platform. Slides will be sent to the course instructor who will share the slide on his screen to all participants in the video-call. Presenter will also be available to answer questions from the class.*

Final exam

The final exam will be a take-home exam and thus open book. The exam questions will be distributed via D2L and are to be handed-in electronically via a D2L drop-box. The exam will be made available from 12:00 pm to 11:59 pm on April 29th, which is the registrar assigned date for the exam.

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

   The University has suspended requirements for students to provide evidence for reasons for absences so please do not attend medical clinics for medical notes or Commissioners for Oaths for statutory declarations. Please let your instructor know immediately if you are ill and cannot meet the deadlines specified.

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.

7. **Examination Policy:**

   Calculator and one-page (double sided) formula sheet (letter format) allowed during mid-term.

   Final exam will be an open book take-home 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 Center:** The Students Union Wellness Centre provides health and wellness support for students including information and counselling on physical health, mental health and nutrition. For more information, see www.ucalgary.ca/wellnesscentre or call 403-210-9355.

c. **Sexual Violence:** The University of Calgary is committed to fostering a safe, productive learning environment. The Sexual Violence Policy (https://www.ucalgary.ca/policies/files/policies/sexual-violence-policy.pdf) is a fundamental element in creating and sustaining a safer campus environment for all community members. We understand that sexual violence can undermine students' academic success and we encourage students who have experienced some form of sexual misconduct to talk to someone about their experience, so they can get the support they need. 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 .

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. **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on assembly points.

f. **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.

g. **Safewalk:** Campus Security will escort individuals day or night (See the Campus Safewalk website). Call 403-220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.

h. **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.

i. **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.

j. **Internet and Electronic Device Information:** Unless instructed otherwise, cell phones should be turned off during class. All communication with other individuals via laptop, tablet, smart phone or other device is prohibited during class unless specifically permitted by the instructor. Students that violate this policy may be asked to leave the classroom. Repeated violations may result in a charge of misconduct.

k. **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.

l. **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 14/17)
Introduction and review of syllabus
Origin of quantum mechanics - notes
Intro to the Schrodinger equation - Notes + Chapter 1.1

Week 2: Lectures 2 – 3, (January 21/23)
Wavefunctions and probability - Chapter 1.2 – 1.4
Solutions to the Schrodinger equation (Infinite square well potential) - Chapter 2.1 – 2.2

Week 3: Lectures 4 – 5, (January 28/30)
Solutions to the Schrodinger equation (harmonic oscillator potential and free particle) - Chapter 2.3 – 2.4

Week 4: Lectures 6 – 7, (February 4/6)
Solutions to the Schrodinger equation (delta function and finite square well potentials) - Chapter 2.5

Week 5: Lectures 8 – 9, (February 11/13)
Hilbert space, matrix notation, observables, eigenfunctions - Chapter 3.1 – 3.3
Revisiting the Stern Gerlach experiment, bra/key (Dirac) notation
Density matrix and Schrodinger's equation

Week 6: No lectures, (Reading week)

Week 7: Lecture 10 & midterm, (February 25/27)
Review of material
Midterm on February 27

Week 8: Lectures 11 – 12 (March 3/5)
The uncertainty principle and operators - Chapter 3.4 – 3.6

Week 9: Lectures 13 – 14 (March 10/12)
Schrodinger equation in 3D (and 2D if time permits) - Chapter 4
Hydrogen atom and angular momentum, generators - Chapter 4.2 – 4.4

Week 10: Lectures 15 – 16 (March 17/19)
Identical particles - Chapter 5.1 - 5.3

Bosons and fermions, atoms and solids

Week 11: Lectures 17 – 18 (March 24/27)
Conservation laws - Chapter 6.1 – 6.3
Symmetries and selection rules - Chapter 6.4 – 6.7

Week 12: Lectures 19 – 20 (March 31/April 2)
Heisenberg picture - Chapter 6.8
Perturbation theory - Chapter 7.1 – 7.2

Week 13: Lectures 21 – 22 (April 7/9)
Perturbation theory - Chapter 7.3 – 7.5

Week 14: Lecture 23 (April 14)
TBD

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 - Mar 18 2020 18:42

Department Approval

Electronically Approved - Mar 18 2020 18:49

Associate Dean's Approval for alternate final examination arrangements or remote learning