UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

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

1. **Course:** PHYS 303, Quantum Mysteries and Paradoxes - Spring 2020

   Lecture 01: TR 09:00 - 11:45 - Online

Instructor	Email	Phone	Office	Hours
Dr Philip Langill	pplangil@ucalgary.ca	403 220-5402	SA 101B	TR 1:30-3:00 pm

Remote Learning Supplemental Information:

This course is being offered online in real-time via scheduled meeting times, you are required to be online at the same time. Please refer to the details below for more complete information.

Remote Learning Details:

Online lectures will be delivered in real time via Zoom. A link to the Zoom meeting will be distributed to students via D2L before each lecture.

In-class activities and questions will be administered through Tophat. The Midterm and Final exams will also employ Tophat.

Our Tophat course is named Phys303Spring20, and the joincode is816440. Particulars about enrolling into Tophat will be provided.

Many of the associated tools in Zoom, Tophat, and D2L will be employed in this online offering of Phys303. All of these tools will be explained in lecture

Course Site:

D2L: PHYS303-S20-Quantum Mysteries and Paradoxes

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.

Although not math intensive, this course does make use of high-school algebra and functions.

This course is not intended for Physics or Astrophysics majors and will not count as a pre-requisite in these fields.

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
Tophat in-class questions	8	
Tophat after-class quizzes	12	
In-class activities	20	
Zoom break-out participation - peer evaluated	10	
Midterm exam	20	May 28
Final exam	30	Registrar to schedule

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 %

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 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):

   Cox, Brian and Forshaw, Jeff, *The Quantum Universe (And Why Anything That Can Happen, Does)*: Da Capo Press, Incorporated.

   Recommended Textbook(s):

   Butterworth, Jon; Randall, Lisa, *The Most Wanted Particle*: Workman.

   There are many quality online materials available which could be used by students to enhance the learning and undersanding of concepts central to Phys303 (YouTube videos, unique websites, etc.). We will share and explore these resources throughout this course.

   Other supplemental material will be provided and posted on D2L.

7. **Examination Policy:**

   No aids are allowed on tests or examinations.

   For additional info regarding examinations, see the Addendum section below.

   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.

Syllabus

Part00

- Overview of the course

- Online and interactive tools employed in Tophat, D2L and Zoom

- "Netiquette" in online interaction

Part01

- Cosmic zoom and scales of the universe, math review and units

- Classical physics, light, photons, classical particle behavior, radioactivity, subatomic particles, atoms and nuclei, light-matter interactions

- Mass-energy equivalence, antimatter, spin

- Probability, randomness, and entropy

Part02

- Electromagnetic waves, wave description and superposition

- Young's double slit experiment

- Single particle double slit experiments

- Single photon interference experiments

- Wave particle duality, DeBroglie wavelength of particles

- 'clock concept' for defining and adding waves

Part03

- The role of observation, Pauli Exclusion Principle, indistinguishability

- interaction-free measurement, quantum measurement problem, Heisenberg Uncertainty Principle

- entanglement, generation of photon pairs

- Local hidden variables and the EPR argument, realism and determinism

Part04

- Quantum wave function, quantum prediction, unitarity

- Quantum information and the black hole paradox

- Qbits and quantum computing, cryptography

Examinations

Details regarding the administering of exams will be carefully explained in lecture. The multiple choice component will be administered via the Tophat quiz tool. The written response component will involve the D2L dropbox tool.

A final exam will be scheduled by the Registrar's Office. The regular duration will be 2 hours, but extended to 3 hours to allow for interruptions and technical issues. Additional time will be granted to SAS students, and other accommodation will be done on a case-by-case basis in case of issues.

Peer Teamwork Evaluation

Some amount of time each lecture will be devoted to break-out sessions where students will share and discuss ideas with classmates. A post-breakout evaluation will be required by each student, to assess the involvement of their classmates and themselves. Details will be given in lecture.

What you will Learn in this Course
- Explain what a scientific theory is, and is not.
- Improve one's ability to explain and describe scientific principles and concepts to non-science experts.
- Describe historical and modern experiments that have been performed which illustrate the quantum behavior of nature.
- Demonstrate basic knowledge about the historical development of quantum physics.
- Describe wave and particle aspects of nature at both the macroscopic and quantum scales.
- Describe the characteristics of fundamental particles, and distinguish Fermions from Bosons.
- Explain the interactions between photons and atoms and describe modern advances in light production.
- Describe the virtual particle interactions between nuclear constituents and fundamental particles.
- Explain how Feynman Diagrams and the rules of conserved quantities are used to describe fundamental interactions.
- Explain the principle of superposition and apply this to macroscopic and quantum phenomena.
- Describe how quantum interference leads to Heisenberg’s Uncertainty Principle and wave particle duality.
- Explain single particle interference and the principle of indistinguishability.
- Describe the properties and behaviors of entangled particles.
- Apply the rules of quantum behavior to explain Hawking Radiation and Tunneling

Course Outcomes:

- At the end of the course, students will have a clear mental picture of some of the ways in which quantum mechanical systems behave counterintuitively as compared to everyday experience, at a more advanced level than is presented in most popular books.
- Students will also be aware of some of the far-reaching consequences of this counterintuitive behaviour, and some of their applications.

Electronically Approved - May 06 2020 16:51

Department Approval

Electronically Approved - May 11 2020 17:12

Associate Dean's Approval for arrangements for remote learning