



UNIVERSITY OF CALGARY  
FACULTY OF SCIENCE  
DEPARTMENT OF PHYSICS AND ASTRONOMY  
COURSE OUTLINE

1. **Course:** Physics 303, Quantum Mysteries and Paradoxes Spring 2017

**Instructor:** Dr. Adam D'Souza | 403-220-3041 | SB 130 | [adsouza@ucalgary.ca](mailto:adsouza@ucalgary.ca) | Office Hours: T 1:00-3:00 PM or by appointment

**Lecture Sections:** L01 | TR 9:00-11:45 AM | EDC 388

**Course Website:** [d2l.ucalgary.ca](http://d2l.ucalgary.ca)

**Departmental Office:** SB 605, 403-220-5385, [phasugrd@ucalgary.ca](mailto:phasugrd@ucalgary.ca)

2. **Prerequisites:** None.

3. **Grading:** The University policy on grading and related matters is described in sections [F.1](#) and [F.2](#) of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Assignments (approximately bi-weekly)	25%
Midterm tests (2, in class)	20% (May 30 and Jun 15, 10% each)
Final Examination	25% (To be scheduled by the Registrar)
In-class exercises	15%
TopHat pre-test questions (100% participation)	2.5%
TopHat post-test questions (25% participation, 75% correctness)	2.5%
Poster (group project)	10%

Percentage to letter grade conversion scale:

> = 93 %	A +	> = 75 %	B +	> = 60 %	C +	> = 45 %	D +
> = 86 %	A	> = 70 %	B	> = 55 %	C	> = 40 %	D
> = 80 %	A -	> = 65 %	B -	> = 50 %	C -	< 40 %	F

Assignments are due on time as announced. Late assignments will be considered only in well-documented emergencies (e.g. a doctor's note should be provided in case of illness).

4. **Missed Components of Term Work:** The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in [Section 3.6](#). It is the student's responsibility to familiarize himself/herself with these regulations. See also [Section E.6](#) of the University Calendar
5. **Scheduled out-of-class activities:** There are no scheduled activities outside of class time.
6. **Course Materials:** "*Quantum Physics: A First Encounter*", by Scarani, Oxford University Press

7. **Examination Policy:** Exams will be closed book. No aids allowed. Students should also read the Calendar, [Section G](#), on Examinations.
8. **Course fees:** none
9. **Writing across the curriculum:** In this course, the quality of the student's writing in laboratory reports will be a factor in the evaluation of those reports. See also [Section E.2](#) of the University Calendar.
10. **Human studies statement:** Students in this course are not expected to participate as subjects or researchers. See also [Section E.5](#) of the University Calendar.

**11. OTHER IMPORTANT INFORMATION FOR STUDENTS:**

- (a) **Academic 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.
- (b) **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on [assembly points](#).
- (c) **Student Accommodations:** 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 [http://www.ucalgary.ca/policies/files/policies/procedure-for-accommodations-for-students-with-disabilities\\_0.pdf](http://www.ucalgary.ca/policies/files/policies/procedure-for-accommodations-for-students-with-disabilities_0.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 and Astronomy, Dr. David Feder, by email ([dfeder@ucalgary.ca](mailto:dfeder@ucalgary.ca)) or by phone (403.220.3638).
- (d) **Safewalk:** Campus Security will escort individuals day or night (<http://www.ucalgary.ca/security/safewalk/>). Call 220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.
- (e) **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). As one consequence, 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 also <http://www.ucalgary.ca/secretariat/privacy>.
- (f) **Student Union Information:** [VP Academic](#) Phone: 220-3911 Email: [suypaca@ucalgary.ca](mailto:suypaca@ucalgary.ca).  
SU Faculty Rep: Phone: 220-3913 Email: [science1@su.ucalgary.ca](mailto:science1@su.ucalgary.ca), [science2@su.ucalgary.ca](mailto:science2@su.ucalgary.ca) and [science3@su.ucalgary.ca](mailto:science3@su.ucalgary.ca)  
Student Ombuds Office: 403 220-6420  
Email: [ombuds@ucalgary.ca](mailto:ombuds@ucalgary.ca); <http://ucalgary.ca/provost/students/ombuds>
- (g) **Internet and Electronic Device Information:** You can assume that in all classes that you attend, your cell phone should be turned off unless instructed otherwise. Also, communication with other individuals, via laptop computers, Blackberries or other devices connectable to the Internet is not allowed in class time unless specifically permitted by the instructor. If you violate this policy you may be asked to leave the classroom. Repeated abuse may result in a charge of misconduct.
- (h) **U.S.R.I.:** At the University of Calgary, feedback provided by students through the Universal Student Ratings of Instruction (USRI) survey provides valuable information to help with evaluating instruction, enhancing learning

and teaching, and selecting courses ([www.ucalgary.ca/usri](http://www.ucalgary.ca/usri)). Your responses make a difference - please participate in USRI Surveys.

## 12. OTHER COURSE RELATED INFORMATION:

### (a) Course Description

Aims to explain basic quantum phenomena for students outside the physical sciences. Topics covered may include wave-particle duality, quantum interference, as well as the paradoxes of entanglement and quantum nonlocality. Applications such as quantum cryptography and quantum teleportation are discussed, as are the philosophical interpretations of the quantum picture of the world.

### (b) Course Learning Outcomes

At the end of the course, students should 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. They will also be aware of some of the far-reaching consequences of this counterintuitive behaviour, and some of their applications.

### (c) Course Learning Incomes

This course will require a high-school level understanding of arithmetic, a very minimal amount of basic algebra, and an open mind.

### (d) Syllabus & Lab Schedule

The scientific method: progress through model building and falsification.  
Introduction to physics: fundamental interactions and particles.

Principles of quantum physics: single-particle interference.  
The indistinguishability principle.  
Interaction-free measurement.  
Waves and particles: early history of quantum physics.  
Neutron interferometry, spin.  
Interference with large molecules, decoherence.  
Which-path information, Heisenberg mechanism.  
Quantum cryptography: quantum key distribution.

Two-particle interference: quantum correlations.  
Quantum eraser.  
Impossibility of superluminal communication based on quantum correlations.  
Einstein-Podolski-Rosen argument.  
Bohm's theory.  
Bell's theorem: quantum non-locality.  
Polarization of photons.  
Experimental tests of Bell's inequalities.  
Interpretations of quantum physics: decoherence, many worlds.

Quantum information: qubits.  
No-cloning theorem.  
Photon bunching.  
Quantum teleportation.  
Entanglement swapping.  
Quantum computing.