



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

1. **Course:** Physics 673, Quantum and Nonlinear Optics, Winter 2016

**Instructor:** Dr. Paul Barclay | SB 135 | (403) 220.8517 | pbarclay@ucalgary.ca | Office Hours: Mon 14:00-15:30, Tues 13:00 – 14:30, cookie time: Friday 14:00-15:30

**Lecture Sections:** LEC 1 | MWF 09:00-09:50 | ST 131

**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:** PHYS 615 or equivalent.

Note: The Faculty of Science policy on pre- and co-requisite checking is outlined in the 2015-2016 Calendar. A student may not register in a course unless a grade at least “C-“ has been obtained in each pre-requisite course; it is the responsibility of students to ensure that their registrations are in order. See <http://www.ucalgary.ca/pubs/calendar/current/sc-3-5.html> for details.

3. **Grading:** The University policy on grading and related matters is described 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: 40%  
Midterm Exam (1): 20% (take home)  
Final Examination: 40% (take home)

The University policy on grading and related matters is also found in the UofC Calendar. Details can be found at; <http://www.ucalgary.ca/pubs/calendar/current/f.html>

Percentage to letter grade conversion scale:

> = 92 %	A +	> = 76 %	B +	> = 64 %	C +	> = 52 %	D +
> = 85 %	A	> = 72 %	B	> = 60 %	C	> = 50 %	D
> = 80 %	A -	> = 68 %	B -	> = 55 %	C -	< 50 %	F

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:** None.

6. **Course Materials:** Required: *Optical Resonance and Two Level Atoms (Allen and Eberly)*. A list of recommended texts will be distributed in class.

Online Course Components: none

7. **Examination Policy:** Exams will be closed book, closed notes, but a calculator will be allowed. Students should also read the Calendar, [Section G](#), on Examinations.
8. **Approved Mandatory and Optional Course Supplemental Fees:** None.
9. **Writing across the curriculum statement:** 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:** This course is being evaluated for education research, you will be given separate paperwork indicating whether students in the course are willing to part of that study. 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 fulfil 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. Michael Wieser, by email ([mwieser@ucalgary.ca](mailto:mwieser@ucalgary.ca)) or by phone (403.220.3641).
- (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: [suvpaca@ucalgary.ca](mailto:suvpaca@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.

## Schedule of Topics

### **1. Quantum mechanics primer**

Schrodinger, Heisenberg, and density matrix pictures of quantum mechanics; the interaction picture and rotating reference frames in quantum mechanics

### **2. 2-level Rabi Problem**

Bloch vector picture; semi-classical dressed-state analysis; density operator (matrix) formalism; Optical Bloch Equations (OBE)

### **3. Quantization of the light field and quantum states of light**

Canonical quantization of the electromagnetic field; quasi-mode picture and quantization of the modes of a dielectric cavity; thermal, coherent, and squeezed states of light

### **4. Theory of spontaneous emission**

Semi-classical derivation; quantum derivation; cavity-enhanced Purcell factor

### **5. Cavity QED**

Perturbative analysis in the weak-coupling limit, strong and weak coupling in the non-perturbative regime

### **6. Introduction to quantum stochastic methods in quantum optics**

Quantum Brownian motion, harmonic oscillator coupled to a heat bath, examples with the "Quantum Optics" toolbox

### **7. Special topics (time permitting)**

Quantum optomechanics, solid state quantum optics

## **Recommended Texts:**

*Currently being updated / revised (December 2015).*

"Single-photon Devices and Applications," by C. Santori, D. Fattal, Y. Yamamoto

"Optical Coherence and Quantum Optics," by L. Mandel E. Wolf

"Optical Resonance and Two-Level Atoms," by L. Allen and J.H. Eberly

"Quantum Noise," by C. W. Gardiner and P. Zoller

"A Computation Toolbox for Quantum and Atomic Optics," by Sze M. Tan.

"Quantum Electronics," by Amnon Yariv

**Recommended for supplemental reading:**

"Quantum Optics," by Marlon O. Scully and M. Suhail Zubairy

"Methods in Theoretical Quantum Optics," by Stephen M. Barnett and Paul M. Radmore

"Lectures on Quantum Optics," by Werner Vogel and Dirk-Gunnar Welsch

"Statistical Methods in Quantum Optics 1: Master Equations and Fokker-Planck Equations," by Howard J. Carmichael

"Cavity Quantum Electrodynamics," edited by Paul R. Berman

"Atom-Photon Interactions: Basic Processes and Applications," by Claude Cohen-Tannoudji, Jacques Dupont-Roc, and Gilbert Grynberg

"Semiconductor-Laser Physics," by Chow, Koch, and Sargent

"Laser Physics," by Murray Sargent III, Marlan O. Scully, and Willis E. Lamb, Jr.

"Quantum Well Lasers," by Peter S. Zory, Jr.

"Lasers," by Anthony Seigman

"Classical Electrodynamics," by John D. Jackson

"Waves and Fields in Optoelectronics," by Hermann A. Haus

"Optical Waveguide Theory," by Allan W. Snyder and John D. Love

Department Approval \_\_\_\_\_ Date \_\_\_\_\_