

UNIVERSITY OF CALGARY
DEPARTMENT OF PHYSICS and ASTRONOMY
COURSE OUTLINE

1. Physics 615, Advanced Quantum Mechanics I

Lecture Sections: L01: MWF, 11:00 – 11:50, SS117 Fall 2012

Instructor: Dr. B. Sanders Office: SB303 Tel: 403-210-8462 E-mail address:
sandersb@ucalgary.ca

Office Hours: By Appointment

2. PREREQUISITES: None

- 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	80%
Project	20%

One problem will be set in each class. Each problem is of equal value and graded out of ten. The cumulative total of assignment grades will contribute to 80% of the final grade. The project will be graded out of twenty. The assignment and project numerical grades will be added to determine the final percentage grade, which will be converted to a final course letter grade based on a conversion table.

- 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: <http://www.ucalgary.ca/pubs/calendar/current/sc-3-6.html>. It is the student's responsibility to familiarize himself/herself with these regulations. See also <http://www.ucalgary.ca/pubs/calendar/current/e-3.html>.

- 5. REGULARLY SCHEDULED CLASSES HAVE PRECEDENCE OVER ANY OUT-OF-CLASS-TIME-ACTIVITY.** If you have a clash with this out-of-class-time-activity, please inform your instructor as soon as possible so that alternative arrangements may be made for you.

- 6. TEXTBOOK:** "No textbook required for this course".

Department _____ Approval _____
Date _____

Associate Dean's Approval for
out of regular class-time activity: _____
Date: _____

11. OTHER IMPORTANT INFORMATION FOR STUDENTS:

- (a) **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 K. Student Misconduct (<http://www.ucalgary.ca/pubs/calendar/current/k.html>) 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 at <http://www.ucalgary.ca/emergencyplan/assemblypoints>.**
- (c) **ACADEMIC ACCOMMODATION POLICY.** Students with documentable disabilities are referred to the following links:
Calendar entry on students with disabilities:
<http://www.ucalgary.ca/pubs/calendar/current/b-1.html>
Disability Resource Centre: <http://www.ucalgary.ca/drc/>
- (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 will be 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.
SU Faculty Rep. **Phone:** 220-3913 **Email:** sciencerep@su.ucalgary.ca Website <http://www.su.ucalgary.ca/home/contact.html>.
Student Ombudsman: <http://www.su.ucalgary.ca/services/student-services/student-rights.html>
- (i) **INTERNET and ELECTRONIC COMMUNICATION DEVICE Information.** You can assume that in all classes that you attend, **your cell phone should be turned off.** 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.

Course: Phys 615 - Advanced Quantum Mechanics I

Instructor: Barry Sanders <http://www.igjs.org/people/home/bsanders/>

Office: SB303 (Meet by appointment; contact Lucia Wang at wangl@ucalgary.ca)

Calendar description: Review of special relativity, electrodynamics, and nonrelativistic quantum mechanics. Klein-Gordon and Dirac equations with minimal coupling. Antimatter and the PCT Theorem. Foldy-Wouthuysen transformation and relativistic corrections to Hydrogen spectroscopy. Introduction to quantum field theory. (Formerly: Basic formalism of the theory and its interpretation, symmetry generators. Scattering theory. Bound states. Charged particles in electric and magnetic fields. Approximation methods.)

Quantum mechanics without relativity would allow us to conceive of a great many possible physical systems. Open any textbook on nonrelativistic quantum mechanics and you will find a rich variety of made-up examples –particles in rigid boxes, particles on springs, and so on – which do not exist in the real world but are perfectly consistent with the principles of quantum mechanics. However, when you put quantum mechanics together with relativity, you find that is nearly impossible to conceive of any possible physical systems at all. Nature somehow manages to be both relativistic and quantum mechanical; but those two requirements restrict it so much that it has only a limited choice of how to be – hopefully a very limited choice. Steven Weinberg, “Where we are now”, Science **180**, 276-278 (1973).

ASSESSMENT

Assignments	Project
80%	20%

Assignments: One problem will be set in each class and is due by 16:00 seven days later. Each problem is of equal value, and the cumulative total of assignment grades will contribute to 80% of the final grade.

Project: The project is a ten-page typed technical, properly-referenced scholarly essay or, alternatively, a twenty-minute presentation (including question time) on any relevant topic mutually agreed between the student and the instructor. Examples of topics: superstrings; loop quantum gravity; magnetic monopoles; time-varying speed of light or fine-structure constant; preons and rishons; supersymmetry; cosmic strings; tachyons; dark matter; anyons. NB: The relative final-grade weighting of the project and assignments may be varied for any student if requested by the penultimate week of classes.

Course Syllabus

OUTLINE

I. Review	IV. Interpretation of spinors
1. Special relativity	1. Spin and negative energy
2. Electromagnetism	2. Holes and antimatter
3. Quantum mechanics	3. Charge conjugation and time reversal
II. Relativistic quantum mechanics	4. PCT Theorem
1. Klein-Gordon equation	V. Foldy-Wouthuysen Transformation
2. Dirac equation	1. Relativistic formulation
3. Minimal coupling	2. Free-particle transformation
4. Plane-wave solution	3. General transformation
III. Relativistic covariance of the Dirac equation	4. Relativistic correction to Hydrogen spectroscopy
1. Nonrelativistic limit for minimal coupling	VI. Relativistic quantum field theory
2. Dirac matrices	1. Free field theory: coupled harmonic oscillators
3. Lorentz transformations	2. Many-particle systems and second quantization
4. The adjoint spinor	3. Fermions, anti-commutation, and Pauli's exclusion principle
5. Improper Lorentz transformations	4. Divergence and renormalization

PARTICIPATION AND PUNCTUALITY

Classroom attendance is not required, but arriving at class punctually is required.

DEADLINES AND PENALTIES

Assignments and the written project are due at 16:00. Late assignments are acceptable but will be penalized according to the following formula: a grade g will be revised: $g \rightarrow 0.95^n g$ for n the number of University working days beyond the due date. A fraction of a day counts as one full day, and each day is deemed to end officially at 16:00. An assignment will be graded $g=0$ if it is submitted subsequent to the release of the solutions.

Plagiarism will not be tolerated: for a task worth g , the assigned grade will be $-g/3$ in the 1st instance and $-2g/3$ in the 2nd instance. A course grade of F will be assigned in the 3rd instance of plagiarism.

Assignment solutions, the project, and answers to the final examination must be legible. You are expected to use typical textbook style for presenting solutions to examples in answering problems; e.g. solutions that are presented as a string of equations connected by banalities such as conjunctions or conjunctive adverbs are not acceptable. Don't just solve the problem: explain how you solve it!

In relativity, movement is continuous, causally determinate and well defined, while in quantum mechanics it is discontinuous, not causally determinate and not well defined. –David Bohm, *Wholeness and the Implicate Order* (Routledge, London, 1980), p. xv.