Carleton University Physics Department
PHYS 3701 – Elements of Quantum Mechanics (Fall 2012)
Course Outline

Instructor: Prof. Heather Logan (`logan@physics.carleton.ca`, 613-520-2600 x4319, 2450 HP)
Lecture times: Wednesdays and Fridays, 1:05–2:25 p.m., in Tory Building 206.
Prerequisites: PHYS 2604 (Modern Physics I); MATH 2000 (Calculus and Intro. Analysis; may be taken concurrently) or MATH 2004 (Multivariable Calculus for Engineering Students) or MATH 2008 (Intermediate Calculus); and MATH 3705 (Mathematical Methods I; may be taken concurrently). If you do not have all the prerequisites, you must contact me to get permission to enrol in this course. Generally prerequisites can be waived only if you have covered comparable course material elsewhere.
Course web page: Announcements and homework assignments will be posted in CULearn. Please check it on a regular basis. To log in, go to `http://www.carleton.ca/culearn`.
Required Textbook: Scherrer, R., "Quantum Mechanics: An Accessible Introduction" (Pearson Addison Wesley, 2005) ISBN: 0805387161. Available at the Carleton Bookstore ($145.00 new, $108.75 used) and at Haven Books (at Sunnyside Ave and Seneca St, $123.85 new).
Office hours: in 2450 HP, days and times to be announced, or by appointment (email me).
Midterm exam date: to be announced (probably last week of October).

Assignments and Grade Distribution

Homework assignments (40%):
Homework will be assigned every week. Assignments will be posted on CULearn and distributed in class. Solutions will be made available after the homework due date. **You are encouraged to work together on the homework assignments; however, the work you hand in must be your own.** Please make every effort to complete the homework. Working problems is essential to acquiring a deep understanding of the material and is the best way to prepare for the exams. **Late homework will not be accepted** without an acceptable reason such as illness.

Midterm exam (20%):
There will be one 80-minute midterm exam, given during the lecture period. The midterm exam will be **closed book and closed notes**. A formula sheet will be provided.

Final exam (40%):
The final exam will be 3 hours long, given during the final examination period in December. The final exam will be **closed book and closed notes**. A formula sheet will be provided.

In the event that a deferred exam is necessary for a student, that exam will replace only the final exam component of the course mark and will be granted only if adequate term work has been completed. Inadequate term work constitutes earning less than 15 of the 65 possible term marks.

In order to pass the course:
1) your overall course mark must be at least 50%, and
2) your average on the exam component of the course must be at least 50%.

$$\text{Exam average} \equiv (0.20 \times \text{Midterm} + 0.40 \times \text{Final})/(0.20 + 0.40)$$

Course Description

The goal of this course is to introduce the sometimes surprising concepts of quantum mechanics and to develop the Schrödinger equation formalism for solving some simple quantum systems, such as the "particle in a box," tunneling, and the hydrogen atom. The course begins with a brief review of the original experimental observations that stimulated the development of quantum physics. You are responsible for all material presented in the lectures or assigned for reading and problem sets. The course is based on the material in Chapters 1 through 9 of the textbook.

1. The beginnings of quantum theory. Blackbody radiation, photoelectric effect, Compton effect. The quantum picture of the atom and the Bohr model, atomic processes.

2. The development of wave mechanics. Wilson-Sommerfeld quantization rules, de Broglie's particle waves, double slit experiment, probability distributions. Heisenberg's uncertainty principle, waves and wave packets, the Schrödinger equation, probability interpretation, stationary states. Wavefunction sketching.

3. Solutions of some one-dimensional systems. Particle in a one-dimensional box, harmonic oscillator and molecular vibrations.

4. Further development of the quantum framework. Observables, eigenfunctions and eigenvalues, operators and expectation values. Dirac's bra-ket notation.

5. Solutions of more one-dimensional systems. Finite square well and continuum states. Finite potential step, transmission and reflection coefficients, tunneling.

6. The wave equation in three dimensions. The three dimensional box, Schrödinger equation in spherical coordinates, rotational motion. Spherical harmonics, angular momentum operators, commutation relations, parity. Radial wavefunction for hydrogenic atoms, electric dipole transition amplitude and selection rules.

7. Spin and the addition of angular momentum. Atoms in magnetic fields, Zeeman effect, Stern-Gerlach experiment and electron spin, magnetic resonance, spin-orbit coupling, fine structure and the anomalous Zeeman effect. Pauli's exclusion principle.

Important University Regulations

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities, psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders, chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or `pmc@carleton.ca` for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation for disability, pregnancy or religious obligations at `http://carleton.ca/equity/accommodation`.