Physics 220 (3 credits)
Introduction to Quantum Physics; Fall, 2013

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Office Hours: MWF 1:30-2:30, other times by appointment.

Course Description:

The course examines the observations that led to the quantum theory, in particular, the wave nature of matter and the particle nature of light. After reviewing the Bohr semi-classical model of the atom, we study the deBroglie wave-particle duality, and the Heisenberg uncertainty principle, via Fourier analysis. We then introduce the Schrodinger equation and the probabilistic interpretation of quantum mechanics. After solving one-dimensional problems, we introduce orbital and spin angular momentum, culminating in a three-dimensional description of the hydrogen atom. We conclude with the Pauli exclusion principle and multi-electron atoms. The course provides an introduction to physics at the small-scale that is necessary for those intending further study in physics, chemistry, and engineering. Philosophical issues raised by the quantum theory are discussed.

Prerequisite: Physics 101 or the permission of the instructor. Linear algebra is a suggested corequisite.

Course Requirements and Grading:

Weekly problem sets, due the following week. Problem sets will be checked or given a zero. Homework and class participation can change your total test grade by one grade (*i.e.*, from a B to a B+ or a B-).

Two, one hour midterm quizzes (dates to be announced), each accounting for 25% of the total test grade. One, two hour final exam, accounting for 50% of the total test grade.

Attendance: required.

Text: <u>Modern Physics for Scientists and Engineers, 2nd ed.</u> by Taylor, Zafiratos, and Dubson. <u>Introduction to Quantum Physics</u> by French and Taylor will be on reserve in the library. You may find it useful secondary reading.

Physics 220: Tentative Schedule

Week 1: The discovery of the electron, the Thomson model.

Week 2: The discovery of the nucleus: Rutherford scattering. Constant coefficient ordinary differential equations.

Week 3: X-rays and Bragg diffraction, radiation spectra, the Bohr semi-classical atom, quantization of orbits.

Week 4: The photoelectric effect, deBroglie wave-particle duality, matter waves, Born interpretation of the quantum wave function as a probability.

Week 5: The classical wave equation, partial differential equations, separation of variables, boundary conditions, eigenvalues and eigenfunctions.

Week 6: Initial conditions and Fourier series. Derivation of the Heisenberg uncertainty principle.

Week 7: The Schrodinger wave equation, the infinite square well, normalization, expectation values.

Week 8: Qualitative solutions, the quantum harmonic oscillator, diatomic molecules, numerical solutions.

Week 9: Tunelling, spherically symmetric solutions, 3-D Cartesian solutions, degeneracy.

Week 10: 3-D spherical solutions, spherical harmonics, simultaneous eigenvalues.

Week 11: Total and z-component orbital angular momentum, the Stern-Gerlach experiment, spin angular momentum, the Zeeman effect. The hydrogen atom.

Week 12: Symmetry of wave functions, the Pauli exclusion principle, multi-electron atoms.