Physics 614

Quantum Mechanics I (3 credits)

Fall 2009

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Class meets Monday, Wednesday, Friday, 11:00-11:50 am (CP 183). There will be no classes on Monday, September 7 (Labor Day), Wedensday, November 25 and Friday, November 27 (Thanksgiving).

Grading: There will be a midterm exam, tentatively scheduled on Monday, October 19 (20 points). The final exam is scheduled on Wednesday, December 16, 10:30 am (30 points).

Your homework will be graded (50 points). Solutions will be placed in the library, and will be discussed during the office hours.

Office hours: Wednesday, 4:00-5:00 pm, or by appointment.

Student Evaluations: Course evaluations are an important (and mandatory!) component of our Department's instructional program. An on-line course evaluation system was developed to allow each student ample time to evaluate each component of the course and instructor, thus providing the Department with meaningful numerical scores and detailed commentary while minimizing the loss of instructional time in the classroom. The evaluation window for Fall 2009 will open on Wednesday, 18 November 2009 and close on Wednesday, 9 December 2009. To access the system during this time, simply go the Department of Physics Web page at http://www.pa.uky.edu/ and click on the link for Course Evaluations; then follow the instructions. You will need to use your student ID# to log into the system, and this will also allow us to monitor who has filled out evaluations. However, when you log-in you will be assigned a random number that will keep all your comments and scores anonymous.

Textbook: Ernest S. Abers, Quantum Mechanics, ISBN 0-13-146100-1, Pearson Education, New Jersey 07458, 2004.

Other useful books. There are many good books on Quantum Mechanics. To recall what you already know about Quantum Mechanics I recommend to you two good undergraduate texts:

- S. Gasiorowicz, Quantum Physics, ISBN 0-471-85737-8, John Wiley & Sons, 1996.
- D. J. Griffiths, Introduction to Quantum Mechanics, ISBN 0-13-124405-1 Prentice-Hall, New Jersey 07458, 1995.

I assume that you know Quantum Mechanics at the level of these courses, and advise you to consult these books if you find our textbook too difficult.

There are many superb books on Quantum Mechanics at the graduate and advanced level. I list below, in no particular order, a few of my favorites:

- L. Landau, E. Lifshitz, Quantum Mechanics (Nonrelativistic Theory), ISBN 0-08-029140-6, Butterworth-Heineman, Oxford OX2 8DP, 1999.

- G. Baym, Lectures on Quantum Mechanics, ISBN 0-805-30667-6, Westview Press, 1990.
- K. Gottfried, T.-M. Yan, Quantum Mechanics, ISBN 0-387-22823-2, Springer-Verlag, New York, 2004.
- E. Merzbacher, Quantum Mechanics, ISBN 0-471-88702-1, John Wiley & Sons, 1998.
- L. I. Schiff, Quantum Mechanics, McGraw-Hill, New York, 1968.

Prerequisites. As I already mentioned I assume that you have had an undergraduate course on Quantum Mechanics. I also expect you to have some knowledge of Classical Mechanics and Classical Electrodynamics. I ask you to recall the Lagrangian and Hamiltonian formalisms of Classical Mechanics, to this end you can consult

- H. Goldstein, Classical Mechanics, 3d ed., ISBN-10-0201657023, Addison Wesley, 2001,

or any other text on Classical Mechanics, where the Lagrangian and Hamiltonian formalisms are discussed.

In our course we will use the CGS system of units for mechanics, and the Gauss system of units when we will discuss electricity and magnetism. These systems of units are more natural from the physical point of view than the International Units that are mainly used in undergraduate education. You may wish to consult

- J. D. Jackson, Classical Electrodynamics, 3d ed., ISBN-10-47130932X, John Wiley & Sons, New York, 1998,

where the Gauss system of units is discussed in detail.

The Syllabus

1. **Basics of Classical Mechanics**

   Action, the action principle, Euler-Lagrange equations. Canonical momenta and the Hamiltonian, canonical equations of motion. Poisson brackets. Groups, the rotation group. Symmetries and conservation Laws. The Noëther theorem.

2. **Mathematics of Quantum Mechanics**

   The superposition principle. Double-Slit and Stern-Gerlach experiments. Linear vector spaces, linear operators. Scalar product, Hilbert spaces. Observables. Discrete and continuous spectra. Dirac notation, Dirac δ-function. Examples of Hilbert spaces.

3. **Basics of Quantum Mechanics**

   Observables, probability amplitudes, and expectation values. Canonical quantization. Heisenberg and Schrödinger pictures. The uncertainty principle. Classical limit and the Ehrenfest Principle. Translation operator in Hilbert space. Derivation of the Schrödinger equation in coordinate space. Wave functions.

4. **The Schrödinger Equation**

Local conservation of probability. Phase and group velocity. Spreading of wave packets. Stationary States. Discrete and continuous spectrum. Properties of wave function. Degeneracy of the Hamiltonian. Complete sets of commuting observables. Parity.

5. **Algebraic Methods in Quantum Mechanics**

Operator approach to harmonic oscillator. Rotations in Hilbert space. unitary representations of rotations.

6. **Orbital Angular Momentum. Systems with Central Potential**

Spherical harmonics. Parity of states with different angular momenta. Reduction of a two-particle problem with a central potential to an equivalent one-particle problem. Algebraic derivation of the Coulomb problem spectrum. Accidental degeneracy. Schrödinger equation in spherical coordinates. Coulomb Problem.

7. **Spin. Addition of Angular Momenta**

Spin one half. Addition of angular momenta.

8. **Charged Particles in External Magnetic Fields**

Classical charged particle in magnetic field. Electric and magnetic fields in quantum mechanics. Gauge invariance. The Aharonov-Bohm effect. Orbital and spin magnetic moments. Larmor precession. Gyromagnetic ratio.