Physics 323 — Quantum Mechanics I — Fall 2014

Instructor: Pavel Kovtun, Elliott 110

Lectures: Monday and Thursday, 10:00 – 11:20, Elliott 162

Tutorials: Tuesday 12:30 – 13:20, Elliott 061

Office hours: Monday 15:30 – 17:30

This is the first part of a two-semester undergraduate course on Quantum Mechanics. The lectures are twice a week, the tutorials are once a week, plus there are labs. The tutorials are optional but recommended. There will be regular homework assignments, a midterm exam, and a final exam. The midterm exam is on Monday October 20-th.

Description: It is not possible to learn Quantum Mechanics from a short one-semester class like this one. Most of what you are going to learn in this class will *not* come from the lectures or tutorials, but from your own study. It may be helpful to discuss various questions in Quantum Mechanics with your colleagues, friends, the TAs, myself, other faculty members, family members, church members etc.

Plan: To figure out how Quantum Mechanics works, you need to be open-minded. It will pay off if you don't have pre-conceived notions of what Quantum Mechanics is or what it should be. Quantum Mechanics is not about the wave function $\psi(x)$, or the Schrödinger equation, or dead and alive cats. It's much bigger than all those things, and still it's only a small part of the world.

We'll start with a review of the early 20-th century experiments which were at odds with classical physics, and then proceed to elementary quantum theory. A prime example of "Quantum Mechanics in your face" is the Stern-Gerlach experiment which showed that the state of quantum particles makes no sense from the point of view of the classical mechanics. We'll discuss the formulation of Quantum Mechanics in terms of operators and states, expectation values, and the wave function. We'll look at position and momentum in Quantum Mechanics, the uncertainty relation, and the Schrödinger equation. We'll study a number of Quantum-Mechanical examples in one dimension, including bound states, scattering states, tunneling, and the quantum oscillator. We'll look at the spin precession in external magnetic field, and at the time-dependent transitions between different spin states, which are responsible for the Nuclear Magnetic Resonance. We'll study the angular momentum in Quantum Mechanics, and will find that it can only take a discrete set of values, separated by a unit of $\hbar$. And hopefully we will have time to do a proper Quantum-Mechanical calculation of the energy spectrum of the Hydrogen atom.

Prerequisites: I will assume that you have taken Physics 215, *Introduction to Quantum Physics*. In addition, I will assume that you have some knowledge of classical mechanics and electromagnetism. Working with Quantum Mechanics requires mathematical tools such as complex numbers, linear algebra, differential equations, special functions, Fourier transforms and approximation methods. So it's a good idea to get comfortable with some book on basic mathematical methods used in physics such as *"Mathematics for physicists"* by Dennery and Krzywicki, or *"Mathematical methods for physicists"* by Arfken and Weber.

Especially for the first part of the class, make sure you remember your linear algebra. If you don't remember it, start reviewing it right now. You should be comfortable with vectors, matrices, finding eigenvectors and eigenvalues. Make sure you understand how matrices represent linear operators in a vector space, remind yourself what a basis is, and how the change of basis works. If you don't have this elementary linear algebra at your fingertips, you may find this class difficult.

Books: There is no required textbook for this class, and I will not follow any particular book. A recent textbook that is perhaps closest to the spirit of the course is *"Quantum Mechanics: a paradigms approach"* by D. McIntyre, which starts with states and operators. Similar in spirit is M. Beck's *"Quantum Mechanics: Theory and Experiment"*. Another popular textbook is *"Introduction to Quantum Mechanics"* by D. Griffiths, which takes a different approach, starting from position-space wave functions. For basic concepts of Quantum Mechanics, look at the first chapters of *"The Principles of Quantum Mechanics"* by P. Dirac, and *"Modern Quantum Mechanics"* by J. Sakurai. You may wish to look at *"Feynman lectures on Physics"* Vol.III, or more advanced texts such as *"Quantum Mechanics – non-relativistic theory"* by Landau and Lifshitz. I recommend that you take a trip to the library, and browse through the books on Quantum Mechanics in the Physics section. Note that the above books by McIntyre, Beck, Griffiths, and Sakurai should be available in the Reserve section of the library. If they are not, let me know.

Homework assignments: For the homework assignments, feel free to discuss the problems with your colleagues, but the final written solution must be your own. Homework assignments (or parts thereof) submitted by email are not accepted. Late assignments are not accepted. Note that doing the assignments is the best way to prepare for the final exam. If you can't make it to my office hours, feel free to send me an email and we'll set up an appointment.

Labs: This class comes with labs, for logistical rather than pedagogical reasons. The lab grade will count for 15% of the total class grade. Note that it is a departmental policy that you have to pass the labs in order to pass the course.

Evaluation: Homework assignments will count for 20% of the course grade, the midterm exam will count for 15% of the course grade, the labs will count for 15% of the course grade, and the final exam will count for 50% of the course grade. *One has to pass the final exam to get a passing grade.* The university-mandated correspondence between letter grades and percentage points is as follows: A+: 90 or more; A: 85-89; A−: 80-84; B+: 77-79; B: 73-76; B−: 70-72; C+: 65-69; C: 60-64; D: 50-59; F: below 50.