Syllabus for PHYS 411 – Spring 2011

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The text is a serious compendium of topics and covers substantially more material than can fit into a one semester course. On the optimistic side, the text is also an excellent reference for introductions into a vast number of important topics and should prove to be a valuable resource for students. I will make no serious effort to cover even a majority of the book. The last time I taught this course using this book, I covered seven chapters. My goal will be to cover topics in depth with less concern about covering as many topics as possible. Therefore the following outline of topics ought to be taken with a grain of salt.

The basic aim will be to cover the first seven chapters with some sections skipped in the name of expediency. Although this is NOT a course in quantum mechanics, I would like to cover the solution for the Hydrogen Atom wave function, Chapter 7, in some detail since it was one of the early successes for the Schrodinger version of quantum mechanics. This will require some serious mathematics which may be new to some of the students in the class. My inclination is that it is useful to see the importance of mathematics as early and as often as possible but students will not be expected to learn the details of this particular calculation.

If time permits, we will end with a short section on Special Relativity.

My idiosyncratic slant on modern physics is that it deals primarily with the development of the “modern” worldview that happened during the period 1900 to 1930. This is the period when various experiments highlighted shortcomings of classical physics forcing physicists to develop new theories, primarily special relativity and quantum physics, to explain these experiments.

In order to appreciate the failure of classical physics it is important to understand in detail why classical physics failed and how those failures led to the new physics. Consequently the material covered will include a revisit of many topics seen early
which ought to give students the opportunity to improve their understanding of classical physics.

Physics works by comparing the result of experiments to theoretical constructs. In order to work well, the theories need to quantitatively agree with experiments. Therefore it is essential for students to be able to derive correct expressions that can be compared to experiments. That means getting all the $\sqrt{2}$’s, π’s, etc. in the correct places and being able to use those correct expressions to calculate actual numbers!!

Grading: There will be a midterm at an undetermined date and final, scheduled for Monday, May 9 at 10:10 a.m. There will also be a series of assignments that will be collected and graded.

Assignments: 30%
Midterm: 30%
Final: 40%

Assignments for PHYS 411

Assignment 1: Read Chapter 1, *Thermal Radiation and Planck’s Hypothesis*, and do the following problems at the end of the Chapter: 3, 4, 10, 14, 15, 17, and 18.

Assignment 2: Read Chapter 2, *Photons – Particle-Like Properties of Radiation*, and do the following problems at the end of the Chapter: 2, 5, 8, 9, 14, 17, 18, 27, and 30.

Assignment 3: Read Chapter 3, *De Broglie’s Postulate – Wave-Like Properties of Particles*, and do the following problems at the end of the Chapter: 1, 7, 11, 14, 16, 22, 27, 28, 31, and 34.

Assignment 4: Read Chapter 4, *Bohr’s Model of the Atom*. (Note that sections 4.9 and 4.10 will not be covered in class and none of the assigned problems involve those two sections.) Do the following problems and note that hints for some of the problems are listed below: 1, 5, 6, 10, 13, 14, 16, 23, 25, 29, 36, and 43.

Problem 1: The Thomson atom is a sphere of radius $R$ and charge $Q$. The charge is uniformly distributed throughout the sphere. Show that an electron orbiting the sphere in a circular orbit of radius $R$ has the same frequency as an electron oscillating back and forth through the atom’s center.
Problem 5: Start from equation 4.3, let r -> infinity, and use the trig identities for sin(A + B) and cos(A + B) with A = B = \( \theta/2 \) to replace sin \( \theta \) and cos \( \theta \) in terms of sine and cosine of \( \theta/2 \).

Problem 10: Calculate the numbers I, n, d\( \Omega \), and d\( \sigma/d\Omega \) separately and carefully. This problem encapsulates the quantitative details of Rutherford scattering, a pivotal experiment in the development of the nuclear atom.

**Assignment 5:** Read Chapter 5, *Schroedinger’s Theory of Quantum Mechanics*. Do the following problems: 2, 5, 7, 9, 10, 11, 12, 13, 16, 18, 19, 20, 24, 25, 27, 28, 29, and 30. The problem in bold type, 24, 25, 27, 28, 29, and 30, are particularly useful for developing some good intuition about wave functions.

**Assignment 6:** Read sections 6.1 through 6.4 and 6.7 through 6.10 in Chapter 6, *Solutions of the Time-Independent Schrodinger Equations*. Do the following problems and note that hints for some of the problems are listed below: 1, 2, 3, 4, 24, 25, 26, 27, 28, 30, 31, 32, and 34.

Problem 25: Some of the integrals required can be done by using integration by parts. This is a good time and place to hone your skills with respect to this valuable integration technique!

Problem 28: Set up the coordinate system for your box so that one corner of the cube is at the origin, (0, 0, 0) with the other corners at: (a, 0, 0), (0, a, 0), (0, 0, a), (a, a, 0), (a, 0, a), (0, a, a), and (a, a, a). The allowed energies and wave functions only depend on the size of the box and the potential, so the answers with wave functions only depend on the size of the box and the potential, so the answers with origin here are identical to the answers with the origin at the center of the box!

Problem 32: Since this problem involves a pendulum, this is a good time to review how \( F = ma \) is used to solve for the motion of pendulum swinging through “small” angles.

Problem 34: This is straightforward but messy. I set \( u = \alpha x \) and used the chain rule to differentiate \( \psi(x) \), \( d\psi/dx = (d\psi/du)(du/d\alpha) \) and waited to the end to replace \( \alpha \) with \( (cm)/h \). I think this made a transcription error less likely but it is still a messy problem!

**Assignment 7:** Read Chapter 7, *One-Electron Atoms*. The solution to this problem provides an explanation for the structure of the periodic table and the nature of the elements in various groups, i.e. understanding this chapter is very important. Do the following problems: 3, 4, 8, 11, 13, 16, and 18.
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