PHY4604, **Introduction to Quantum Mechanics**

Syllabus

Fall 2004

- **Instructor:** Peter Hirschfeld, Professor of Physics with interests in superconductivity and low temperature physics.

  Office Hours: NPB 2156, Wed. 7th (1:55pm) Thursday 7th (1:55pm); Appointments will gladly be scheduled for those students who cannot make official hours.

- **Text:** D. Griffiths, Introduction to Quantum Mechanics, Prentice-Hall, 2004.

- **Recommended Supplementary Texts:**

  1. M. Horbatsch, Quantum Mechanics Using Maple, Springer Publishing, (NY), 1995.
  2. R.P.Feynman, R. B. Leighton and M. Sands, The Feynman Lectures on Physics, California Institute of Technology, 1966, VIII.

- **Other Useful Quantum Mechanics Texts:**

  1. P.J.E. Peebles, Quantum Mechanics
  2. S. Gasiorowicz, Quantum Physics Wiley, 1996.
  3. C. Cohen-Tanoudji, B. Diu, and F. Laloë, Quantum Mechanics, Wiley, 1977.
  4. A. Messiah,  Quantum Mechanics, North-Holland, 1961.
  5. R. Shankar, Principles of Quantum Mechanics, Plenum, 1994.

- **Other References on Symbolic Manipulation Program Maple**

  1. Essential Maple 7 by Robert M. Corless
  2. Introduction to Maple by Andre Heck

- **Course Description:**

  An introduction to the quantum theory, as formulated in the 1920's and 1930's by Born, Bohr, Schrödinger, Heisenberg, and others. First, we'll discuss how quantum theory arose in the face of certain discrepancies between 19th-century classical theory and experiment. Then, I'll try to impart a set of mathematical tools needed to formulate problems in quantum mechanics, introducing methods of theoretical physics required to solve them as needed. Topics covered will range from the practical, like the basics of atomic spectroscopy, to the abstract, e.g. measurement theory and quantum "paradoxes" like Schrödinger's cat. For a more detailed set of topics see schedule below. I intend to stretch your mind.

- **Prerequisites:**

  One year of general physics with calculus, or permission from a department undergraduate advisor is required. It is recommended –but not required–that before taking PHY4604, students take Physics C (Modern Physics) complete the calculus sequence, and have had some exposure to ordinary differential and partial differential equations, as well as matrix/linear algebra.

- **Required Work:**

**Homework:**

The weekly problem sets represent by far the most important element of the course, and where you will learn the most. I encourage you to work on them in groups if you like; the problems will occasionally be difficult and may require more than one head! *However, be convinced in the depths of your soul that letting others do the work for you will lead to disaster at test time.* A good technique for many students is to try all the problems individually, then get together in a group for the tough ones.

Problem sets will be posted on the web every Monday, and be due the following Monday. Some (not all) will contain problems which are to be solved using Maple (see below). Each problem set will be worth a total of 10 points, and your grade will decay 4 points for the first day it is late after the solutions are posted, plus a further 1/2 point for each subsequent week. I will drop the lowest two homework grades at the end of the course. My goal will be to hand the problem sets back Monday one week after receiving them, but occasionally other considerations will interfere, and I ask for your understanding.

**Tests:**

There will be three required tests and a final examination administered in class on the following dates:

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|---|---|
| **In-class test 1** | NPB 1101, Fri., Oct. 8 |
| **In-class test 2** | NPB 1101, Fri., Nov. 5 |
| **In-class test 3** | NPB 1101, Fri., Dec. 3 |
| **Final** | NPB 1101, Time TBA, Dec. 16 |

You must bring writing instruments and a student identification card with a photo for all tests and the final. All necessary paper will be provided, and calculators will not be allowed or needed.

The lowest absolute score of the 3 tests will be dropped. Due to this policy, no makeup tests will be allowed.

**Makeup policy:** Since the policy of dropping tests and homeworks is very generous, no makeups are allowed.

**Grading Policy:** The various components of your final grade will be weighted as follows:

| | |
|---|---|
| **Tests 1-3** | 40% |
| **Final** | 20% |
| **Homework** | 40% |

There will be *no* "extra credit" under any circumstances.

Letter grades will be assigned according to a "curved" distribution. However, the following minimum scores will guarantee the following grades: 85-A, 80-B+, 72-B, 65-C+, 60-C, 55-D+, 50-D. For example, depending on the "curve", a score of 72% may be sufficient for a B+. Your actual raw percentage score should not be compared to those you receive in other courses. Because physics involves very different kinds of skills from other science and mathematics courses, even very good students will generally not solve all parts of most problems correctly. Demonstrating that you understand a problem even if you cannot solve all its parts will result in partial credit.

If you feel your test has been unfairly or improperly graded, you are welcome to present your test booklet for regrading. However, the entire exam is then subject to regrading, and the final grade may be lower! You

are responsible for all material covered in the textbook and in lecture, including any announcements made or special handouts distributed in lecture. If you must be absent during a given lecture, check with a friend to make sure you know what was covered.

- **Maple Problems**

  One of my secondary goals in this course is to teach you Maple, a computer environment for doing mathematics. Maple or something like it will be as basic a tool in a few years as a pocket calculator is now for all quantitative scientists and engineers. I am not an expert; while teaching you I intend to learn myself. I expect there are those among you who know Maple pretty well, and would like to ask you to make your expertise available to me and the class so we can all learn.

  Because of the expected diversity in students' computer backgrounds, I will start out slowly with the Maple exercises. However if you are not familiar with Maple, you need to get started quickly by doing the following:

  1. Purchase one of the Maple books listed on page 1 of this syllabus and learn on your own, and/or attend weekly Maple help sessions. The recommended text by Horbatsch is *not* a book which will teach you Maple. If you don't want to buy a Maple book, the software itself does come with extensive tutorials and an excellent help system.

  2. Find a way to use Maple. It is installed on machines in the physics department computing lab, as well as on the physics dept. network accessible via machines in the undergrad lounge.

- **Review Sessions:**

  In addition, I will hold optional weekly review sessions, location and time to be announced. In some weeks, the first few minutes will be devoted to Maple or mathematical techniques; in others, the week's physics material. Most of the time will be devoted to problems of the students' choosing.

- **How to succeed in Physics 4604:**

  1. *It is expected that a successful student in this course will invest twelve hours of studying and problem-solving per week outside of class. Do not expect a good grade if you are not prepared to work this much.*

  2. Read the assigned text before coming to lecture. The importance of this cannot be overemphasized.

  3. Study with your fellow students.

  4. Get help if necessary. I encourage you to visit my office hours and those of the TA for this course regularly.

- World Wide Web page

  Course announcements, schedule and this syllabus in its entirety will be posted on

  http://www.phys.ufl.edu/~pjh/teaching/phy4604

# PHY4604--Course Schedule Fall 2004

| Week | Topic(s) | Reading | Homework | Notes |
|---|---|---|---|---|
| Aug. 23 | **Dilemmas of classical physics**<br><br>• Energy quantization<br>• Boltzmann distribution<br>• Energy of harmonic oscillator<br>• Equipartition<br>• Specific heat of solids<br>• Blackbody radiation | PH Notes | None | [Dilemmas](#) |
| Aug. 30 | **Quantization of normal modes**<br><br>• Wave equation<br>• Normal modes of cavity<br>• Periodic boundary conditions<br>• Counting modes<br>• Planck law | Notes | [Prob. Set 1](#)<br><br>due Sept. 10 | [Blackbody](#) |
| Sept. 6<br><br>Monday<br>Sept. 6 is<br>Labor Day | **Other early evidence for quantum behavior**<br><br>• Photoelectric effect<br>• Ritz principle<br>• Bohr model<br>• Motion of wave packet<br>• Electrons as waves | Notes | [Prob. Set 2](#)<br><br>due Sept. 15 | [Otherevidence](#) |
| Sept. 13 | **Schrödinger equation I**<br><br>• Dynamics of Schrödinger's $\psi$-fctn.<br>• Spherically symmetric potential (H-atom)<br>• 1D simple harmonic oscillator<br>• Particle in electromagnetic field | Notes,<br>Chs. 1, 2 | [Prob. Set 3](#)<br><br>due Sept. 22 | [SchroedingerI](#) |
| Sept. 20 | **Schrödinger equation II**<br><br>• Probabilistic interpretation of $\psi$-fctn.<br>• Fourier transform<br>• Measuring a particle's momentum<br>• Uncertainty principle | Notes,<br>Ch. 1,2 | [Prob. Set 4](#)<br><br>due Sept. 29 | [SchroedingerII](#) |
| Sept. 27 | **Operator formalism I**<br><br>• Momentum operator<br>• Expectation values<br>• Inner products<br>• Hermitian adjoint<br>• Eigenstates and eigenvalues | Notes,<br>Ch. 3 | | [OperatorI](#) |

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| Oct. 4 | **Operator Formalism II**<br><br>• Completeness<br>• Measurement<br>• Parity | Notes, Ch. 3 | Prob. Set 5<br><br>due Oct. 11 | Operator II |
| Friday, Oct. 8 | **Test 1** on 1st 6 weeks | - | - | - |
| Oct. 18 | **Hilbert space and matrix mechanics**<br><br>• Dirac's bra and ket notation<br>• Postulates and probability<br>• Position representation | Notes, Ch. 3 | Prob. Set 6<br><br>due Oct. 18 | HilbertI |
| Oct. 25 | **Angular Momentum I**<br><br>• Orbital angular momentum operators<br>• $L$-eigenvalues from ladder operators<br>• Eigenvalues from Schr\"odinger Eqn<br>• Commutation rels. -- spherical potential<br>• $L$ generates rotations | Notes, Ch. 4 | None | AMI |
| Nov. 1 | **Angular momentum II**<br><br>• Central forces & pseudopotential<br>• H-atom bound states<br>• QM 2-body problem<br>• Reduction to 1-body problem | Notes, Ch. 4 | Prob. Set 7<br><br>due Nov. 1 | AMII |
| Friday Nov. 5 | **Test 2** on next 4 weeks | - | - | |
| Nov. 8<br><br>No class Nov. 12<br><br>(Homecoming) | **Spin I**<br><br>• Electron spin<br>• Pauli spin matrices<br>• 2 spin-1/2 particles<br>• Many particles<br>• Electron magnetic moment, precession | Notes, Chs. 4,5 | Prob. Set. 8<br><br>due Nov. 8 | SpinI |
| Nov. 15 | **Spin II**<br><br>• Absprption<br>• Resonant scattering<br>• t-matrix | Notes, Chs. 4,5 | Prob. Set 9<br><br>due Nov. 15 | SpinII |

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| Nov. 22<br><br>No class Wed. or Friday (Thanksgiving) | **Measurement I**<br><br>• Superposition<br>• Collapse of wave function<br>• Role of observer | - | None | Measurement |
| Nov. 29 | **Measurement II**<br><br>• Superposition<br>• Collapse of wave function | - | Prob. Set 10<br><br>due Nov. 29 | |
| Friday  Dec. 3 | **Test 3 on spin** | - | - | - |
| Dec. 6 | Review | - | None | |
| Dec. 16 | **Final exam** (comprehensive) | | | |