Advanced Quantum Mechanics, Spring 2012

Month	Monday	Wednesday	Friday
January	2 Two-Particle Systems Chapter 5	4 Exchange Forces	6 Atoms
January	9 **PS1** The Periodic Table	11 Solids	13 Band Structure
January	16 M. L. King Day	18 **PS2** Perturbation Theory Chapter 6	20 Degenerate P.T.
January	23 Fine Structure of Hydrogen	25 Zeeman Effect	27 **PS3** Hyperfine Splitting
January / February	30 **Review Session and Test** (Chapters 5, 6)	1 Variational Method Chapter 7	3 Helium Ground State
February	6 **PS4** Hydrogen Molecule Ion	8 WKB Approximation Chapter 8	10 Tunneling
February	13 Alpha Decay	15 **PS5** Time-Dependent P.T. Chapter 9	17 Sinusoidal Perturbations
February	20 Presidents Day	22 Radiation	24 **PS6** Spontaneous Emission
February / March	27 **Review Session and Test** (Chapters 7-9)	29 Adiabatic Approximation Chapter 10	2 Berry's Phase
March	5 Scattering Chapter 11	7 **PS7** Partial Wave Analysis	9 Phase Shifts
March	12	14 Spring Break	16
March	19 Born Approximation	21 Scattering Examples	23 **PS8** EPR Paradox Chapter 12
March	26 Entanglement	28 Bell's Theorem	30 **PS9** No-Clone Theorem
April	2 Quantum Cryptography	4 Quantum Computing	6 **PS10** Quantum Computing, cont.
April	9 **Review Session and Test** (Chapters 10-12)	11 The Black Hole War work on projects	13 Schroedinger's Cat work on projects
April	16 Interpretations of Q.M. work on projects	18 Final Project Presentations during final exam time	20

Physics 4620 General Information

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Office hours: MWF 9:30–10:20, TTh 1:30–2:30. I'll often be around at other times as well; my full schedule is posted next to my office door. Feel free to make an appointment if you like.

Course Description. This course is a continuation of Quantum Mechanics, Physics 4610.

Last semester you learned the basic principles of quantum mechanics, and applied these principles to a variety of simple systems for which the Schrödinger equation can be solved exactly. Yet the most complicated of these systems was the very simplest of atoms—hydrogen.

This semester we will develop the technology to attack harder problems in quantum mechanics. First we'll learn the fundamentals of how to treat systems of more than one quantum mechanical particle, and qualitatively explore the implications for multi-electron atoms. Then we'll develop several approximation methods and use these methods to get a quantative understanding of many aspects of atomic physics (and of other systems as well). Finally, at the end of the course, we will explore the growing field of quantum information theory, focusing on systems of multiple, entangled "qbits". These systems can help us sharpen our understanding of the basic principles of quantum mechanics, and may also have several practical applications that are now a subject of active research.

Textbook: Griffiths, *Introduction to Quantum Mechanics* (2nd edition, Prentice Hall, 2004). This book is terse but otherwise very well written, and I encourage you to spend lots of time with it. Its treatment of quantum information theory isn't very extensive, so I'll provide some supplemental reading for the last portion of the course.

Problem sets will be assigned roughly once a week, and due by 4:00 p.m. on the days indicated on the syllabus ("PS1" for the first problem set, and so on). Late problem sets will not be accepted. Your homework grade will be based on only your 9 highest problem set scores (out of 10), so you may miss one problem set without penalty. This policy should give you enough flexibility to deal with most scheduled absences, illnesses, family emergencies, term papers, unexpected romances, and the like; exceptions will be granted only in the case of extended illness or other long-term exigency.

I *strongly* encourage you to talk with your classmates as you work on the problem sets. This gives you an opportunity to learn from each other, to prevent careless errors, to practice putting ideas into words, and to work in an environment more like the "real world". Don't think of the homework as a "test" of what you can do on your own—it is rather an opportunity for you to *learn*, and most of us learn better from other people than from a book. It is unethical, however, to simply copy someone else's work or to borrow an idea that you don't understand yourself. Never look at another person's written solution before finishing your own. When you do receive significant help from someone on a problem, you should give that person credit in your written solution.

I will grade each problem set on a scale of 0 to 5, with the score based not only on your getting the right answers but also on the completeness of your solutions and on how well you communicate on paper. Your solutions should be written so that any classmate could read and understand them. Solutions that are incomplete, illegible, or poorly organized will receive significantly less credit, even if the answer is correct. I will make official solutions to each problem set available soon after the due date.

Tests (three of them) will be closed-book, given in the Science testing center (SL 228) with a 90-minute time limit. You will have a two-day window within which to take each test: the date indicated on the course schedule and the following day. You may use a calculator on tests to do arithmetic, but not to store information. There will be no comprehensive final exam.

No make-up tests will be given without *advance* permission.

Projects. As you read the textbook you'll notice that it contains many more problems than you would ever have time to work in a single course. However, in addition to the assigned problems, you will have an opportunity to work another problem (or group of related problems) of your choosing. You will then write up your solution in the format of a formal journal article, and give a brief oral presentation of the problem and its solution to your classmates.

The most suitable problems for this project are those in Griffiths that are labeled with three stars (most lengthy or difficult). A few of the two-star problems are actually just as hard, or can be combined with related problems (or extended in some way) to make a suitable project. You may also wish to browse other quantum mechanics textbooks, including those at the graduate level, looking for suitable problems to solve for your project. In all cases, you must obtain my approval of your project topic before you proceed.

Grades will be computed according to the following weights:

problem sets (highest 9)	45%
tests (3 weighted equally)	45%
project	10%

If you choose a harder-than-average project topic, and do a good job on it, you may earn some extra credit.

In deciding borderline grades I will also consider class attendance and participation. (It is the *effort* at participation that matters; how much knowledge you demonstrate makes no difference at all.)

Academic dishonesty, though rare, occasionally does occur in physics classes, so the following policies are necessary. Inappropriate collaboration on homework will result in a zero grade for that problem set on the first occurrence and failure in the course thereafter. Dishonesty of any sort on a test, if clearly documented, will result in automatic failure in the course. In serious cases, evidence of dishonesty may also be presented to the appropriate hearing committee for possible further sanctions.

Special notice: Any student requiring accommodations or services due to a disability must contact Services for Students with Disabilities (SSD) in room 181 of the Student

Service Center. SSD can also arrange to provide course materials (including this syllabus) in alternative formats if necessary.

Hints and Suggestions

This is probably the most advanced course in the Physics curriculum at WSU—and it's definitely the course with the most prerequisites. Congratulations for making it this far!

By now you've noticed that as physics courses get more advanced, the assigned problems get not only harder but also longer. (Fortunately, we compensate a bit by assigning fewer of them!) Nobody expects you to be able to solve most of these problems in a single sitting, so you'll need to start early and plan on pondering each problem over the course of a few days. Discuss the problems with your classmates. Think about them during lectures. Dream about them, and you just might wake up with an inspiration!

Since the ideas of quantum mechanics are closely linked to each other, the material of this course will be highly sequential. It is therefore crucial that you not fall behind. Class attendance is not required, but is strongly recommended. If you ever have a question during class, ask immediately—don't just write it down and hope that you'll figure it out later.

Extensive research has shown that the students who do best in physics (and other subjects) are those who involve themselves *actively* in the learning process. This involvement can take many forms: writing lots of questions in the margins of the book; asking questions in class or during my office hours or by email; discussing physics with classmates; inventing your own examples; writing careful English explanations in homework assignments. Try to do things like these as often as possible!

A Final Word . . .

Physics is not so much a collection of facts as a *way* of looking at the world. My hope is that this course will not only teach you many of the *ideas* of quantum physics, but will also improve your *skills* in careful thinking, problem solving, and precise communication. In this course you will gain lots of experience with qualitative explanations, rough numerical estimates, and careful quantitative problem solving. When you understand a phenomenon on all of these levels, and can describe it clearly to others, you are "thinking like a physicist" (as we like to say). Even if you eventually forget every fact learned in this course, these skills will serve you well for the rest of your life.