Syllabus for PHY 416 Quantum Mechanics

Dr. Christensen

2011 Fall Semester: MWF 8:43–9:50, S226
Textbook: "Quantum Physics" (3e) Gasiorowicz

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PHY 416 (4-0) Prerequisites:  PHY 242, MAT 202, MAT 302
A course covering dual nature of matter and radiation, development of quantum mechanics,
uncertainty principle, wave function and Schrödinger equation, representation theory, Hilbert
space, Dirac notation, Eigenvalue problems, potential well and barrier problems, solution to the
Schrödinger equation in simple systems, motion in three dimensions, elements of approximation
methods, introduction to scattering theory and other special topics.
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1 Departmental Goals

Through the class discussion and lecture, you will be exposed to *the principles and foundations of classical and modern physics* as they apply to quantum mechanics at an *advanced* level. Solving the homework problems will help you to incorporate these principles into your general understanding of the world. In the homework problems, you will be asked *to generalize and extend foundational theories in complex applications* of quantum mechanics at an *advanced* level.

Your grades on the homework and exams will reflect your knowledge of the principles and foundations and your ability to generalize and extend these. The point of turning in work is to show me how well you understand the material. The point of grading work is to show you how well you understand as well as how well you communicate your understanding. Please review returned homework to learn what you didn't understand.

On every exam, you will be asked, in addition to problems analogous to the homework problems, questions that reveal your attention to the big picture of the class, as expressed in the following.

Central Question The central question of this course is **"How do physicists describe quantum mechanical systems?"** With every chapter, we will revisit this question and incorporate the new information into a gradually more academically-mature characterization of how professional physicists describe the quantum world.

Fundamental and Powerful Concepts In order to *generalize and extend foundational theories in complex applications* at an *advanced* level, you need to be aware of how the details of your work fit into the big picture of quantum mechanics. There are several fundamental ideas that, if understood well, are also powerful in the sense that they will allow you to figure out concepts that we have not discussed in the course. For my presentation of this course, these F&PC are: the particle-wave duality, Schrodinger's wave equation, and Observable Variables.

2 Course Policies

Attendance: Physical attendance is mandatory. Mental attendance is appreciated (not to mention helpful). If "something comes up," contact me (note, email, voice mail, courier, same-day word-of-mouth) **beforehand**.

Athletics: It is your personal responsibility to inform me if you will miss class **before** you miss class. Even if an email is being sent on your behalf, see me before or after class so that I can inform you of variations from the syllabus. It is your responsibility to inform me of incoming report cards before you bring them so that I can have a grade available.

Late Policy: No credit will be given for problems worked in class regardless of attendance in the class. Late homework loses 5 points per day (not per class period). Sat & Sun together count as 1 day.

Missed Exams: Make up exams **must** be scheduled before regular exam time. Documented, unforeseen events will be dealt with on a case-by-case basis.

Office Hour Policy My schedule (with office hours) is posted on my office door. I expect to be in my office most days from about 8:00am to about 4:30pm. You are welcome to stop by whenever you have a question. Be aware that my posted schedule also lists times which I will *probably* be in my office. I am also available by appointment.

Expectations: Grades are tied to numerical scores according to the following criterion. I consider a mid-C to be average for physics majors who are going on to graduate school.

"A"	Outstanding	> 90
"B"	Above Average	80-90
"C"	Average	70-80
"D"	Below Average	60-70
"F"	Did not successfully complete requirements	< 60

"+" is the upper half of the range.

2.1 Campus Policies and Services

Policy	Page of Catalog, by academic year			
	10-11	09-10	08-09	07-08
Disability Services (344-3521)	23	20	25	See Student Handbook
Tutoring Services (344-3363)	23	20	25	See Student Handbook
Attendance	33	29	36	35
Academic Honesty	34	31	38	36

3 Grading

20% **Homework:** You will have two assignments from most chapters, due on the "boxed days" on the schedule: First, easy problems due before class discussion and, second, more difficult problems due after class discussion. The point is encourage you to familiarize yourself with the straightforward material before class time. Solutions will be posted after the assignment is collected.

3x20% **Exams:** There will be three tests and a comprehensive final exam. Each exam will have an in-class, closed-book
+20% portion. They may also have an open-book and/or take-home portion.

100% **Grades:** Final grades will be reported as a percentage of the sum of the adjusted earned points.

4 Schedule

The following is an approximation to the actual schedule.

Although we will likely fall behind, I have schedule three "review" days at the end of the term to absorb the anticipated delays, since I cannot yet predict where we will need to spend extra time, based on your individual strengths. When we get off-track the tests will be over the material stated and come within a week of the dates set.

I am also hoping to finish Chapter 1 a day ahead of this schedule to give us breathing room when we decide to spend a little more time on a later topic.

† - 10/17: Midterm Reports. and ∗ - 10/25: Last day to withdraw-passing

Date	Day	Topic	Pre-class Readings
8/22	M	(No Class)	
	W	1. Blackbody Radiation, PhotoElectric Effect	1-1,2
	F	2. Compton Effect	1-3
8/29	M	3. Wave Nature & Diffraction	1-4
	W	4. The Bohr Atom	1-5
	F	5. The Bohr Atom	1-5
9/5	M	========== **Labor Day** ==========	
	$\boxed{W_1}$	6. Waves, Wave Packets, and Heisenberg	2-1,2,5
	F	7. Probability and Schrödinger's Equation	2-3,4
9/12	M	8. Scrödinger, Fourier, and Heisenberg	2-4,5
	W	9. Probability Current	2-6
	F	10. Expectation Values	2-7
9/19	$\boxed{M_2}$	11. Math Methods as Applied to Quantum Mechanics: (Sep of Var, t-indep Schröd., Eigenfunctions, Eigenvalues, Fourier)	3-1,2,4
	W	12. Eigenvalue Example: Particle in an Infinite Well	3-3
	F	13. $\boxed{\Rightarrow \textbf{Test 1} \Leftarrow}$	Chap. 1–2
9/26	M	14. Eigenfunction Example: Particle in an Infinite Well	3-4
	W	15. Momentum Space, Momentum Eigenfunctions, Free Particles	3-4,5
	F	16. Parity	3-6
10/3	$\boxed{M_3}$	17. QM PDE: The Potential Step, The (Finite) Potential Barrier, Quantum Tunneling	4-1,3,4

. . . Continued. . .

Date	Day	Topic	Pre-class Readings
	W	18. QM PDE: The (Finite) Potential Well, Bound States	4-2,5
	F	19. QM PDE: Finish	4-1,2,3,4,5
10/10	M	20. Delta Function Potentials	4-6
	W	21. The Harmonic Oscillator	4-7
	F	========== **Fall Break** ==========	
† 10/17	$\boxed{M_4}$	22. Eigenfunctions, Eigenvalues, and Observables	5-1,2
	W	23. Vector Spaces and Operators	5-3
	F	24. $\boxed{\Rightarrow$ **Test 2** $\Leftarrow}$	Chap. 3–4
10/24	M	25. Degenerate Vector Spaces, Simultaneous Observables	5-4
∗	W	26. Vector Spaces and Function Spaces	5-1,2,3,4
	F	27. Time Dependence and Classical Limit	5-5
10/31	$\boxed{M_5}$	28. Bra-ket notation, Projections, Harmonic Oscillator	6-1,2
	W	29. Harmonic Oscillator in Bras and Kets	6-2,3,4
	F	30. Angular Momentum	7-1
11/7	$\boxed{M_6}$	31. Raising and Lowering Operators	7-2
	W	32. $\|l, m\rangle$ in Spherical Coordinates	7-3
	F	33. Spherical Harmonics	7-3
11/14	$\boxed{M_7}$	34. 3-D Schrödinger, Sep of Var	8-1,2
	W	35. The Hydrogen Energy Spectrum	8-3
	F	36. $\boxed{\Rightarrow$ **Test 3** $\Leftarrow}$	Chap. 5–7
11/21	M	37. The Hydrogen Energy Spectrum	8-3
	W	========== **Thanksgiving Break** ==========	
	F	========== **Thanksgiving Break** ==========	
11/28	M	38. The Free Particle	8-4
	W	39. Infinite *Spherical* Well	8-5
	F	40. Review: **BRING QUESTIONS**	Chap. 1–8
12/5	$\boxed{M_8}$	41. Review: **BRING QUESTIONS**	Chap. 1–8
	W	43. Review: **BRING QUESTIONS**	Chap. 1–8
	F	========== **Study Day** ==========	
12/13	T	44. **Final Exam**: 8:30–10:30	Comprehensive