

# Physics 521, Graduate Quantum Mechanics II – Spring 2008

Lecturer: Prof. Lincoln D. Carr  
Lecture location: Meyer Hall 347  
Lecture times: 8:30 - 9:50 Monday, Wednesday  
Course website: <http://www.mines.edu/Academic/courses/physics/phgn521/>  
Office location: Meyer Hall 342  
E-mail address: lcarr (at) mines.edu  
Office hours: Monday 1:30-4:00, Tuesday 1:30-4:00  
Phone: (303) 273-3759 (in person during office hours preferred)  
Course Text: Kurt Gottfried and Tung-Mow Yan,  
*Quantum Mechanics: Fundamentals, Second Edition* (Springer, 2004)

## 1 Course Outline

Quantum mechanics is the most prominent physical theory of the twentieth century. It underlies all solid state technology, among other things. It is the working language of theoretical physicists. Lately, we have begun to gain experimental understanding of new and radical aspects of quantum mechanics, such as quantum teleportation, quantum information, and the gradual breakdown of quantum coherence for high temperatures and/or large, complex systems.

This course focuses on quantum mechanics as used by professional physicists in cutting-edge research. Therefore, it covers quantum theory up through the 21<sup>st</sup> century (note the publication date of your textbook!). Last semester we studied the two-state system, quantum dynamics, entanglement, and symmetries in depth. This semester we will move on to the atom, scattering theory, the harmonic oscillator, and quantized fields.

The official list of topics from the Colorado School of Mines course catalog is as follows: review of angular momentum; central potentials and applications; spin; rotations in quantum mechanics; formal scattering theory; Born series; partial wave analysis; addition of angular momenta; Wigner-Eckart theorem; selection rules; identical particles. As was the case last semester, the official description is in fact a small subset of our actual course material. Gottfried and Yan's text is a good guide to lectures, but I will not be parroting the text at you.

## 2 Course Evaluation

### 2.1 Homework

Problem sets will normally be assigned on Wednesday and will be due the following Wednesday at the beginning of class, 8:30 a.m. There will be one final project due at the end of the semester, to be discussed in class.

### 2.2 Exams

Two fifty minute mid-term examinations will be given during the normal lecture times. The final will be two hours long. The date for the final will be announced as soon as the administration informs me of it.

## 2.3 Final Grade

Homeworks:	30%
Mid-terms:	30%
Final:	40%

## 2.4 Physics Education Research

In addition to the mid-terms and final, there will also be two conceptual exams. Any grading of these exams will be extra credit; however, taking the exams will be required to pass the course. These go towards improving quantum mechanics education locally and nationally, as well as letting me know how the class is doing generally. The results will be retained anonymously.

## 3 Important Class Policies

1. It is not reasonable, or indeed, mathematically correct, to grade on a curve for this small a number of students and graduate material. The basic criteria for grades is as follows:
  - A: Superior comprehension of course material. High exam scores, consistently high homework scores, participates in class.
  - B: Good comprehension of course material. Mid-level exam scores, made serious effort at every homework but perhaps did not do so well, participates in class, comes to office hours.
  - C: Inadequate comprehension of course material. Has succeeded in obtaining mid-level scores on exams or homework but not both. Shows up to class but does not participate or come to office hours.
  - D,F: You have to work hard to get these grades – not show up to class, bomb more than one of your exams, not do your homework, etc.
2. As indicated in the grading scheme, participation in class, not just attendance, is an integral part of your grade. This takes the form of answering questions I pose to you individually or collectively, as well as asking questions.
3. Copies of class notes will be provided for you, either via the web or in hard copy form. Make sure to check the web the evening before class. Have a hard or soft copy of the notes on your desk when you attend class. The main reason I provide you with my notes is so that, instead of spending your time copying from the board, you can think about the material as it is presented.
4. I will expect you to read the book before lecture. I will not present every detail of every subject in class. You will find that I tend to sketch proofs, for example. Midterms will cover both the text and the lecture notes, as well as all homework and solution sets. Therefore, you should plan to study the text thoroughly.
5. I will expect you to learn both concepts and calculation methods. Conceptual questions will count for a good portion of each exam. The focus is on understanding, not on solving canned problems – though of course you should know how to do the latter, too.
6. Homework will be collected at the beginning of the Wednesday class session. Late students will not be permitted to turn in homework. Under no circumstances of any kind will late

homework be accepted. If you are attending a conference, plan to turn in your homework early.

7. Make-up exams are offered only if you are attending a professional conference, inform me in person in advance, and can provide documentation demonstrating that you have done so. Make-up exams are not offered under any other circumstances.
8. I do not give incompletes under any circumstances.
9. Review sessions for exams will be provided if requested by the majority of the class.
10. When taking exams, anyone found cheating will be given a failing grade for the course, without exception. This includes writing on your exam after I have announced it is ended, or any other unfair advantage taken over other students.
11. Plagiarism of any kind will not be tolerated. If you use a source, you must quote it. Working together on homework does not count as plagiarism. A line by line copy of another student's homework does. Use of internet material or any other media without citation is plagiarism. For the purposes of this course, this includes non-copyrighted material. Students who do not quote their sources will be issued a failing grade, without exception.
12. I am not available outside of office hours except by special appointment. Please notify me at the conclusion of the lecture hour, at least one day before you wish to meet with me. Alternatively, you can request an appointment 24 hours in advance via e-mail. I check my e-mail once per day at 5:00 p.m., Monday through Friday.
13. From time to time I will offer extra credit material. Extra credit can, for instance, bring you from a B to an A if your other work is on the border between those two categories. However, the main point of extra credit is to satisfy those who have an interest in theoretical physics and/or plan to go on to pursue a Ph.D. in physics. If you are in one or both of these categories, you should do the extra credit. If you are a graduate student, you are in at least one of them.
14. You are always welcome to come speak with me about physics and/or general science topics outside the course material.

## 4 Suggestions

1. Work hard from the very beginning. If you find it easy at first then read ahead. It will get difficult rapidly. We will go at a fast pace. This is an indication of my confidence in your dedication and ability.
2. If you have difficulties, see me right away. *Do not* wait until you are completely lost and there is no hope of catching up. Everything will only get more and more difficult. You cannot afford to not understand any concept. In physics every new concept relies crucially on the previous ones.
3. Interrupt me in class and ask lots of questions. Remember that if you do not understand something, chances are neither do most of your classmates, so it is likely not an obvious question. If you don't ask questions, I will assume that you all understand perfectly and continue at a fast pace.

4. You can work together on homework, but your success in the course will depend on how much time you put in carefully and completely doing all the homework problems.
5. The best researchers are not necessarily the ones who get A's. The best researchers are the ones who understand the problems they solve and think about them creatively. So focus more on understanding than on grades.

## 5 Supplementary References

You may want to refer to the following references from time to time for clarification or for a different perspective. They are available in the library and I have additional copies in my office.

1. *Quantum Mechanics: Non-Relativistic Theory*, L. D. Landau and E. M. Lifshitz, Second or later edition.
2. *Quantum Mechanics*, Leonard I. Schiff, Third or later edition.
3. *Modern Quantum Mechanics*, Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë.
4. *Principles of Quantum Mechanics*, Ramamurti Shankar.
5. *Modern Quantum Mechanics*, J. J. Sakurai, Second edition.
6. *Quantum Mechanics*, Jean-Louis Basdevant and Jean Dalibard.
7. *Quantum Physics*, Michel Le Bellac.

## 6 Nominal Course Outline

Mr. Laith Haddad will cover lectures for me when I am away. These will include the first week of April: a lecture on 3/31 and Midterm II on 4/2.

Please note that some assignments this semester will be numerical in nature and you will therefore be required to write code.

Week 1: Completion of Basic Tools from last semester, G & Y Chap. 3

*Homework 1, due Wed., Jan. 16*

Week 2: Path Integrals, G & Y Chap. 2.6-2.7

*Homework 2, due Wed., Jan. 23*

Week 3: Low-Dimensional Systems

*Homework 3, due Wed., Jan. 30*

Week 4: Low-Dimensional Systems, G & Y Chap. 4

*Homework 4, due Wed., Feb. 6*

Week 5: Hydrogenic Atoms, G & Y Chap. 5

*Homework 5, due Wed., Feb. 13*

Week 6: Hydrogenic Atoms

*Midterm I, Wed., Feb. 20*

Week 7: Symmetries, G & Y Chap. 7

*Homework 6, due Wed., Feb. 27*

Week 8: Symmetries

*Homework 7, due Wed., Mar. 5*

Week 9: Spring break, March 10-14

Week 10: Symmetries

*Homework 8, due Fri., Mar. 21*

Week 11: Elastic Scattering, G & Y Chap. 8

*Homework 9, due Wed., Mar. 26*

Week 12: Elastic Scattering

*Midterm II, Wed., Apr. 2*

Week 13: Elastic Scattering

*Final Project Complete Rough Draft, due Wed., Apr. 9*

Week 14: Electrodynamics, G & Y Chap. 10

*Homework 10, due Wed., Apr. 16*

Week 15: Electrodynamics

*Homework 11, due Wed., Apr. 23*

Week 16: Systems of Identical Particles, G & Y Chap. 11

*Homework 12 and Final Project Final Draft, due Wed., Apr. 30*

Week 17: *Final Exam, precise date to be announced*