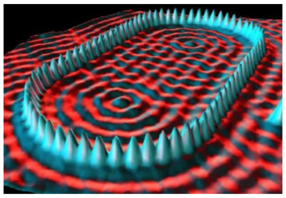
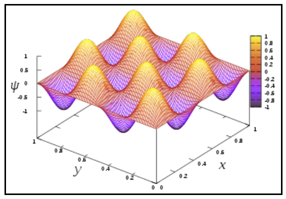
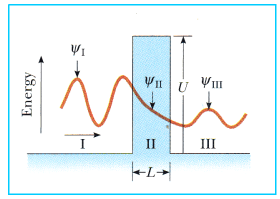
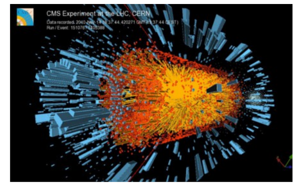
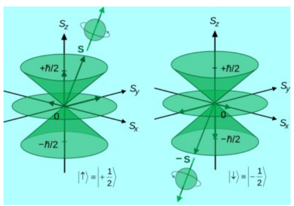
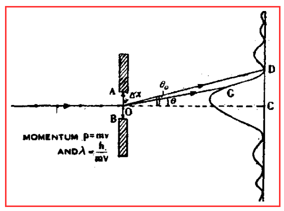
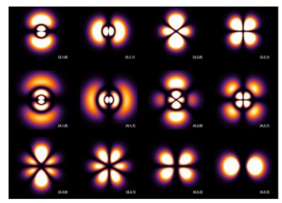
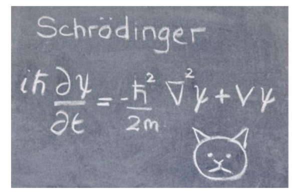
   

Physics 351
Quantum Theory

Fall Semester, 2016

Instructor:

Brooks Thomas
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Office: Hugel 020
Phone: (610) 330-5207

General Course Information

If you are already enrolled in this course, its central topic – quantum mechanics – is a subject about which you already know a great deal. In particular, in your Phys 215 course ("Introduction to Quantum Mechanics"), you followed the historical development of quantum mechanics and explored how phenomena like the photoelectric effect and the patterns of emission/absorption lines in atomic spectra compelled us to accept its strange and often counterintuitive implications. You also explored many of the *applications* of quantum mechanics – from the structure of chemical bonds to the radioactive decay of heavy elements to the bulk properties of matter in the solid state.

In this course, you will delve even deeper into quantum mechanics – from a *theoretical* perspective. In the process, you will be introduced, piece by piece, the full mathematical machinery necessary to characterize the dynamics of the wavefunction. For your efforts, you will be rewarded with a host of new insights into the way the world works at its most fundamental level. In particular, by the end of this course, you'll understand the fundamental differences between classical and quantum mechanics. You'll be able to formulate the equation of motion (the Schrödinger Equation) for different physical systems and solve this equation in order to describe the state of the system and predict how (and whether) it will evolve in time. In addition, you will also get a chance to hone some of the universal skills that transcend the subject matter and are crucial in practically *any* science field. For example, by the end of this course, you'll be able to reason through problems at a more sophisticated level, to communicate your reasoning to an audience of your peers, and to apply computational tools such as Mathematica and Python in order to solve problems numerically that cannot be solved analytically.

The requirements for this course include Phys 215 ("Introduction to Quantum Mechanics") and Phys 218 ("Oscillatory and Wave Phenomena"), as well as an understanding of multi-variable calculus, linear algebra, and the strategies for solving differential equations at the level of Math 264. However, we will also review many of the mathematical topics along these lines when we need them.

Components of the Course

The course will consist of class meetings, reading assignments in the text, problems, two mid-term exams, and a final exam. These are described more fully below.

Class Meetings:

Class meetings will be held from 8:00 AM – 8:50 AM in Hugel 017 each Monday, Wednesday, and Friday during the semester. A schedule of topics to be covered each day is listed on the course web page. Much of the material covered in this course – and many of the homework problems that you'll be working through – are quite challenging. It is therefore important that you come to class prepared to ask questions and to engage in discussions. You should be aware that class meetings will involve not only my lecturing to you about the material covered in the readings (which is not necessarily the best way for me to help you learn the material), but a variety of other activities as well – the benefit you get out of which is directly proportional to the effort you put in.

Textbook:

The required textbook for this course is

- David J. Griffiths, *Introduction to Quantum Mechanics*, 2nd Ed. (Cambridge University Press, 2016).

In addition to this textbook, you may also find the following references useful for getting additional perspectives on the material we'll be covering in this course:

- John S. Townsend, *A Modern Approach to Quantum Mechanics*, 2nd Ed. (Univ Science Books, 2012).
- R. Shankar, *Principles of Quantum Mechanics*, 2nd Ed. (Plenum Press, 1994).
- Richard P. Feynman, Robert B. Leighton, and Matthew Sands, *The Feynman Lectures, Vol. III* (Addison Wesley, 1971).
- J. J. Sakurai, *Modern Quantum Mechanics*, Revised Ed. (Addison Wesley, 1993).

The first two texts are written at roughly the same level as Griffiths's textbook, but simply take different approaches. The Feynman Lectures (the full text of which has also been made available for free online by Caltech) provide an unique and engaging approach to the subject from one of the greatest teachers of physics who ever lived. Sakurai's book is more advanced (it's a graduate-level text), but it's also very well written.

Finally, given the mathematical nature of the subject material and the variety of special functions we will encounter over the course of the semester, you may want to have a good reference volume on mathematical methods in physics on hand. For this, I recommend the following:

- Mary L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Ed. (Wiley, 2005).
- George B. Arfken, Hans J. Weber, and Frank E. Harris, *Mathematical Methods for Physicists*, 7th Ed. (Academic Press, 2012).

Homework Assignments:

Working through problems is an essential part of this course. There's no way of truly understanding quantum mechanics without delving in and *doing* quantum mechanics. For this reason, I will be assigning a number of homework problems each week which I feel provide practice with the most crucial aspects of the material we're covering in the course – or else, in certain cases, introduce new concepts altogether. A list of the problems included in each problem set will be provided on the course web page, and each problem set is due at the beginning of class on the day indicated on the schedule on that web page. Some of these problems will require nothing more than pen, paper, and a lot of careful thought; others will require computational resources like Mathematica or Python.

Each homework assignment is due at the beginning of class on the day indicated on the course web page. In addition, I will sometimes ask one of you to present your solution to one of the homework problems on the blackboard on the day it's due (you'll be given a heads-up about this a class meeting in advance, however). Being able to explain your reasoning to others – often on the spur of the moment – is a valuable skill in any field, and the goal here is to give you some practice with this. For this reason, and because we will frequently discuss homework problems in class even when no one is formally presenting one, late homework will not be accepted.

I encourage you to work together on homework problems with other students in the class. This can be a very productive way of expanding your own knowledge, and working with other people to solve problems is a big part of how science is really done. However, the written work that you turn in to me must be your own work: it should reflect your own understanding and should be written up independently after all discussion between you and your peers is complete.

Mid-block Tests and Final Exam**:**

There will be two mid-exams given during the course, both of which will take-home exams. These tests are designed give you the opportunity to demonstrate how well you understand the material. The first exam will be distributed at the end of class on Oct. 5th and is due at 5:00 PM on Oct. 7th. The second will be distributed at the end of class on Nov. 18th and is due at the beginning of class on Nov. 21st. In addition, there will also be a final exam at a date and time to be determined by the Registrar.

Final Presentation:

In addition to the homework and the exams, I also want you to have the opportunity to explore your own interests and to gain a deeper appreciation of the quantum-mechanical principles that we're covering in this course. To that end, you will be undertaking a final presentation in this course in which you will delve more deeply into a of your own choosing. Public presentations are a part of just about every career in science and engineering – and in a lot of other situations in life as well – so getting practice preparing and giving one will be valuable no matter what you want to do.

Your presentation topic must be related to the quantum-mechanical principles we're covering in class. It can focus on an application of those principles to a particular physical system, for example, or on an alternative mathematical approach to a particular problem. It also must be a topic which lends itself to a sophisticated mathematical treatment at a level appropriate for this course. Beyond that, you are free to choose whatever presentation topic interests you. You will need to approve your presentation topic with me by Monday, Oct. 31st. If you're not sure what topic you'd like to pursue, I would be happy to meet with you and discuss possible ideas before that date.

Your presentation will be delivered to other members of the class during class meeting on Friday, Dec. 9th. It must be a slide-based presentation (created using PowerPoint, OOImpress, Beamer, etc.), and should be approximately 15 minutes in length. You should be sure to include a bibliography or list of works cited on your final slide. In addition to the presentation itself, you will also need to submit a formal abstract for your presentation, which will be due on Nov. 28th. I strongly encourage you to meet with me ahead of time to discuss both your presentation and your abstract.

Grading and the Honor Code

Course Grade:

Your grade in the course will be determined by the following criteria (Note: See Tests section above for exceptions):

Homework (including problem presentations)	25%
Mid-Term Exam 1	18%
Mid-Term Exam 2	18%
Final Presentation	15%
Final Exam	24%

Office Hours:

You are encouraged to stop by my office at any time if you have questions about any aspect of the course. You may not always find me, however, if you drop by unannounced. My official office hours, during which you can count on my being in my office (except under extraordinary circumstances), will be held **Monday, Wednesday, and Friday from 2:00 – 4:00 PM** unless otherwise noted on the course web page. If you are unable to drop by during these official office hours, you may also call or email me to make an appointment for some other time.

Intellectual Honesty:

When studying, or working on homework problems, I encourage you to work with other students. However, you may not consult a solutions manual or any other source for answers to the problems, and the final problem write-ups should be your own work. You are not permitted to work together on the take-home exams or to consult with anyone else about them until all exams have been turned in. However, while working on a take-home exam, you may freely refer to the textbook (Griffiths's *Introduction to Quantum Mechanics*), your notes, all handouts and other materials distributed in class, and a table of integrals. You may also use a graphing calculator and Wolfram Mathematica.

As always, you are expected to abide by the principles of intellectual honesty and academic integrity outlined in the Lafayette Student Handbook, which can be found at

- http://studentlife.lafayette.edu/resources/

Other Useful Information

Accessibility Services:

In compliance with Lafayette College policy and equal access laws, I am available to discuss appropriate academic accommodations that you may require as a student with a disability. If you are requesting accommodations, you must register with the Disability Services Office (administered by ATTIC) for disability verification and for the determination of reasonable academic accommodations. It is **your responsibility** to provide me with an official letter from Disability Services which clearly outlines what those accommodations are. I cannot provide accommodations until you provide me with such a letter. Requests for academic accommodations must be made within the first two weeks of the semester, except in unusual circumstances, so that suitable arrangements can be made in a timely manner.

Informal Surveys:

Over the course of the semester, I want to hear from you how you feel the course is going, what you like, what you don't like, what your concerns are, and how you think the course could be improved. Therefore, at regular intervals throughout the semester, you'll have the opportunity to fill out a short, informal course evaluation so that we can get feedback from you.

Course Communication:

This syllabus, a list of assigned readings and problem sets, and other course materials will be posted on the course web page, which can be found at

- http://workbench.lafayette.edu/~thomasbd/Phys351-QuantumTheory-Fall-2016/Phys351-QuantumTheory-Fall-2016.html

In addition to the course web page, there is also a Moodle page for this course which I will frequently use in distributing course materials, communicating with the class, etc. The Moodle page can be found at

- https://moodle.lafayette.edu/course/view.php?id=9259/

Occasionally, it may be necessary for me to communicate additional information (scheduling changes, clarifications about homework problems, etc.) to the class as a whole. When I do so, I will use your official Lafayette email addresses for all course-related correspondence, so make sure to check your Lafayette email regularly.

Moodle Privacy Statement:

Please note that Moodle contains student information that is protected by the Family Educational Right to Privacy Act (FERPA). Disclosure to unauthorized parties violates federal privacy laws. Courses using Moodle will make student information visible to other students in this class. Please remember that this information is protected by these federal privacy laws and must not be shared with anyone outside the class. Questions can be referred to the Registrar's Office.

Mandatory Credit-Hour Statement:

The student work in this course is in full compliance with the federal definition of a four-credit-hour course. The full policy and practice statement can be found on the Registrar's Office website at

- http://registrar.lafayette.edu/additional-resources/cep-course-proposal/

In Closing

If you have any questions about this syllabus, or about any aspect of the course, please don't hesitate to contact me. True, the material we will be covering is challenging and quite abstract; however, it is also immensely rewarding. Quantum mechanics is the foundation upon which particle physics, solid-state physics, modern optics, and many other subfields of physics are built, and the basic philosophical questions it raises are as intriguing as its practical applications.