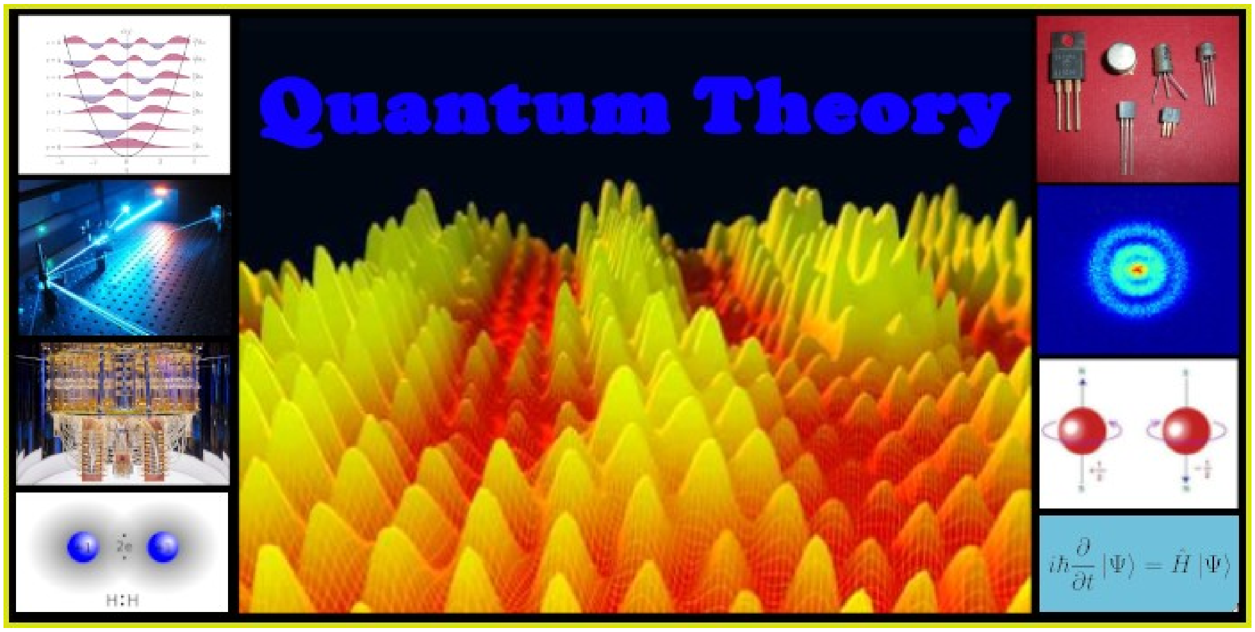

Quantum Theory (PHYS 351)

Fall Semester, 2026

Instructor:

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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. You'll also gain an understanding of how information works in quantum systems and be able to analyze the output of such systems through use of the density matrix. Furthermore, 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 in order to solve problems numerically that cannot be solved analytically.

The requirements for this course include Phys 215 ("Introduction to Quantum Mechanics") and an understanding of multi-variable calculus, linear algebra, and the strategies for solving differential equations at the level of Math 264 ("Differential Equations with Linear Algebra"). 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, problem sets, two mid-term exams, a final exam, and a final presentation. These are described more fully below.

Class Meetings and Fourth Hour:

In accord with federal guidelines, Physics courses at Lafayette which do not have a laboratory component have an additional "Fourth Hour" scheduled outside of the normal class-meeting time for additional course-related activities. This semester, we are fortunate to have the entire time block **from 1:15 – 2:30 PM each Monday, Wednesday, and Friday** at our disposal for both class meetings and "Fourth-Hour" activities, and we will make use of it. All class meetings and "Fourth-Hour" activities will take place **in Hugel 017** during this time block each Monday, Wednesday, ad Friday during the semester. 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.

Attendance Policy:

You are expected to attend all class meetings and participate fully in the activities which take place during them. **Your attendance at class meetings and "Fourth-Hour" activities will be recorded on an attendance sheet and will have an impact on your final grade**. If you have a valid reason for missing a class meeting or "Fourth-Hour" activity (e.g., an illness, a family emergency, a religious holiday, participation in a College-sanctioned athletic event), it is your responsibility to inform me as far in advance as possible so that we can arrange a time for you to make up what you missed. In situations in which a Dean's Absence Verification is available, it is also your responsibility to provide me with that document. If you miss a class meeting or "Fourth-Hour" activity without a valid reason, you will receive an attendance/participation grade of zero for that event. If you are physically present for only part of that meeting – e.g., you arrive more than 10 minutes late – your grade for these activities will be multiplied the fraction of the period for which you were present. The lowest two attendance grades are dropped, which means that you may miss up to two class meetings this semester without any impact on your final grade.

Textbook:

The one required textbook for this course is

- David J. Griffiths and Darrell F. Schroeter, *Introduction to Quantum Mechanics*, 3nd Ed. (Cambridge University Press, 2018).

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).
- Michael A. Nielsen and Isaac L. Chuang, *Quantum Computation and Quantum Information* (Cambridge University Press, 2010).

The first two texts are written at roughly the same level as Griffiths & Schroeter'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 a 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. Nielsen & Chuang's textbook focuses on topics in quantum information and quantum computing, and I will be drawing heavily from this book during the last couple of weeks of the semester, when we will be focusing on these topics.

In addition to these supplementary texts, I will be posting a set of learning modules on the course Moodle which are designed to prepare you for each class meeting – often by providing you with a first look at the material we'll be covering at the beginning of that class meeting. Each of these modules will consist of a short prerecorded lecture and some activities designed to give you a chance to check your understanding of the material presented. These modules are optional and do not count toward your grade in this course, but I recommend them for members of the class who want to get a jump-start on any given day's material.

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).

<u>Homework Assignments</u>:

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 Moodle. 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 5:00 PM Eastern on the day indicated on the course web page** (usually a Wednesday). Your work should be submitted in PDF format using the appropriate upload link on the course Moodle page. However, you do not need to typeset your homework in a fancy way. Writing your work out by hand on paper, scanning or photographing the pages, and converting the images to PDF format is perfectly acceptable, provided that the PDF is legible. You may still turn in late homework for reduced credit (a 10% penalty for every 24 hours it is overdue) up until the beginning of the next class meeting. However, because we will frequently discuss homework problems during this class meeting, late homework will not be accepted after that time.

I strongly 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 work that you upload and turn in to me must be your own: it should reflect your own understanding and should be written up independently after all discussion between you and your peers is complete.

<u>Midterm and Final Exams</u>**:**

There will be two midterm exams given during the course. **The first will be held on Sept. 30th, the second on Nov. 4th**. These exams are designed give you the opportunity to demonstrate how well you understand the material. Each midterm will take place during our usual class-meeting time, and you will have the full period from 1:15 – 2:30 PM to complete it. In addition, there will also be a final exam at a date and time to be determined by the Registrar.

<u>In-Class Presentation:</u>

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 topic 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'll be covering in this course. 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. **During the week of Oct. 5th**, you'll be meeting with me individually in order to discuss ideas for your presentation topic. You will need to obtain my formal approval for your topic **by Friday, Oct. 16th**.

Our "Fourth Hour" during the last few weeks of the semester will be broken into three 20-minute presentation slots, each of which will directly follow one of our usual 50-minute class meetings. You will sign up for one of these slots in advance and deliver your presentation to the class during your designated slot. The first 15 minutes of each slot will be allotted for the presentation itself, which should at least 12 and no more than 15 minutes in length. The remaining five minutes will be allotted for audience questions. Your presentation should be a formal slide presentation (designed using a software package such as PowerPoint, Keynote, Beamer, or LibreOffice Impress). You should be sure to include a bibliography or list of works cited on your final slide of your presentation. In addition to the presentation itself, you will also need to submit a formal abstract for it, which will you will submit via an upload link on the course Moodle by **Friday, Oct. 30th at 5:00 PM Eastern**.

<u>Instructor Drop-In Hours:</u>

My official instructor drop-in hours this semester will be held on **Mondays from 11:40 AM – 12:40 PM**, on **Tuesdays from 12:00 noon – 1:15 PM**, and on **Wednesdays from 3:00 – 4:00 PM** unless otherwise noted on the course web page. These drop-in hours (sometimes called "office hours," but in this case, that's a misnomer, since they will not take place in my office) will be **held in Hugel 125**. If you and other students in the course have the same question, you are welcome – and in fact encouraged – to meet with me during my drop-in hours as a group.

The default assumption is that my drop-in hours will take place in person. However, if the need arises for you to attend drop-in hours virtually at any point during the semester (e.g., because of a winter-weather emergency or an illness), please email me in advance to schedule a virtual drop-in-hours meeting. Such meetings will take place over my drop-in-hours Zoom link, which is

- https://lafayette.zoom.us/j/89137906511

The password is provided on the course Moodle.

If you are unable to make it to these official drop-in hours either virtually or in person, you may also email me to make an appointment to meet at some other time. However, I recommend that you do this as far in advance as possible in order to ensure that we can find a time to meet.

Grading and the Honor Code

<u>Course Grade:</u>

Your grade in the course will be determined by the following criteria:

Homework	20%
Midterm Exam 1	20%

Midterm Exam 2	20%
In-Class Presentation (Including Abstract)	15%
Participation in Fourth-Hour Activities	5%
Final Exam	20%

Intellectual Honesty:

All exams in this class are closed-book. Calculators are permitted, including graphing calculators (e.g., calculators similar to the Texas Instruments TI-84), but the use of cell phones and cell-phone-based calculator-emulator apps is not permitted on exams. You will also be provided with a sheet of useful equations and fundamental constants at the start of each exam. However, the use of any other resources is not permitted.

By contrast, 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 write-up that you submit to me for each problem should be your own work. The use of generative AI resources (ChatGPT, Claude, etc.) on homework assignments is not permitted. These assignments are designed to help you develop the physical understanding and problem-solving skills that you'll need in order to succeed on the exams – exams which collectively constitute 60% of your grade in this course. Ceding your opportunity to hone that understanding and practice those skills to an AI agent is not in your best interest.

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

- https://conduct.lafayette.edu/student-handbook/

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 Accessibility Services (administered by the Academic Resource Hub) for disability verification and for the determination of reasonable academic accommodations. Accessibility Services will then provide me with a document which outlines what those accommodations are. I cannot provide accommodations until I receive 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:

As the semester progresses, 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, throughout the semester, you'll have the opportunity to fill out short surveys and informal evaluations on the course Moodle so I can get your feedback.

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

- hhttps://workbench.lafayette.edu/~thomasbd/Phys351-QuantumTheory-Fall-2026/Phys351-QuantumTheory-Fall-2026.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=33305

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.

Health Protocols:

At the moment, masking is not required during class meetings or during my office hours under normal circumstances, though I encourage you to wear a mask if it makes you feel more comfortable. However, this policy may change at any point during the semester is circumstances change. In any event, if you are experiencing symptoms (cough, chills, fever, sore throat, etc.) typically associated with communicable respiratory illnesses, you are required to wear a mask while your symptoms persist, even if those symptoms are mild. If you do not feel well enough to attend class meeting, inform me of the situation by email and do not come to class. You are of course also required to abide by all campus-wide health protocols established by Lafayette College while they remain in effect.

Contingency Procedures for Virtual Class Meetings:

The default expectation is that all class meetings this semester will be held in person in Hugel 017. However, under certain circumstances (e.g., the campus closes due to a winter-weather emergency) we may temporarily be compelled to move those meetings online. If this should occur, the Zoom link that we will use for these class meetings is

- https://lafayette.zoom.us/j/89393594179

The password is provided on the course Moodle. I will notify all members of the class by email as far in advance as possible if we need to switch to a virtual classroom environment at any point during the semester. The assumption is that if this should even happen, we will return to an in-person learning environment as soon as circumstances permit.

If we are ever temporarily forced to move to a virtual format, I would like us to be able to simulate the atmosphere of a physical classroom to whatever extent we can. For this reason, I would like to ask that you have your camera on during any virtual class meetings we end up having and to use the "gallery view" option on Zoom so that we can all see each other and respond to each other's visual cues. I will do the same. That said, if there are extenuating circumstances which would make having your camera on an issue for you, please reach out to me and we will work out an equitable solution. Please mute yourself when you are not speaking in order to reduce background noise. Please raise your actual hand in order to take part in the discussion. If I do not see your actual hand, please raise your "digital hand."

Privacy Statement Concerning Course Materials and Classroom Recordings:

At Lafayette College, all course materials are proprietary and for class purposes only. This includes posted recordings of lectures, worksheets, discussion prompts, and other course items. Reposting such materials or distributing them through any means is prohibited. Such materials should not be reposted or distributed through any means. You must request my permission prior to creating your own recordings of class materials, and any recordings are not to be shared or posted online even when permission is granted to record. Permission will be granted only when sanctioned as an academic accommodation in an official letter from the Accessibility Services Office. If you have any questions about proper usage of course materials please ask me. Please also be in contact with me if you have any concerns with being recorded during the course.

Online discussions in Moodle occurring during synchronous class sessions should also remain private and not be shared outside of the course. Courses using Moodle will make student information visible to other students in this class. Student information in courses is protected by the Family Educational Right to Privacy Act (FERPA). Disclosure of student information to unauthorized parties violates federal privacy laws and it 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

- https://registrar.lafayette.edu/wp-content/uploads/sites/193/2022/07/Federal-Credit-Hour-Policy-Web-Statement.pdf

In Closing

If you have any questions about this syllabus, or about any aspect of the course, please don't hesitate to contact me. We have a rewarding semester ahead of us in which we'll be grappling with the strange and often counterintuitive implications of quantum mechanics. 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, quantum information science, and many other subfields of physics are built, and the basic philosophical questions it raises are as intriguing as its practical applications.

Course Schedule

The full, up-to-date schedule for the course, including due date for all assignments is available on the course web page.

Week	Topics and Readings	Due Dates
Week 1 8/24 – 8/28	**Probability and the Wavefunction** Griffiths & Schroeter: Ch. 1.1 – 1.6	HW0 (Due 8/28) Mathematica Primer
Week 2 8/31 – 9/4	**The Schrodinger Equation in 1D** Griffiths & Schroeter: Ch. 2.1 – 2.2, 2.4, 2.6	HW1 (Due 9/2)
Week 3 9/7 – 9/11	**Potential Barriers and the Harmonic Oscillator** Griffiths & Schroeter: Ch. 2.3, 2.5	HW2 (Due 9/9)
Week 4 9/14 – 9/18	**The Generalized Statistical Interpretation** Griffiths & Schroeter: Ch. 3.1 – 3.3, Appendix A	HW3 (Due 9/16) Tutorial
Week 5 9/21 – 9/25	**The Uncertainty Principle** Griffiths & Schroeter: Ch. 3.4 – 3.6	HW4 (Due 9/23) Tutorial
Week 6 9/28 – 10/2	**The Schrodinger Equation in 3D** Griffiths & Schroeter: Ch. 4.1.1 – 4.1.2	Midterm I (9/30)
Week 7 10/5 – 10/9	**The Hydrogen Atom** Griffiths & Schroeter: Ch. 4.1.3 – 4.2.1	HW5 (Due 10/7)
Week 8 10/12 – 10/16	**Angular Momentum and Spin** Griffiths & Schroeter: Ch. 4.3.2 – 4.4.2	Fall Break (10/12 – 10/13), Film
Week 9 10/19 – 10/23	**Addition of Angular Momentum** Griffiths & Schroeter: Ch. 4.4.3, 5.1.1 – 5.1.3	HW6 (Due 10/21) Tutorial
Week 10 10/26 – 10/30	**Time-Independent Perturbation Theory** Griffiths & Schroeter: Ch. 7.1 – 7.4	HW7 (Due 10/28) Abstracts Due (10.30)
Week 11 11/2 – 11/6	**Fine Structure** Griffiths & Schroeter: Ch. 7.5, 8.1 – 8.2	Midterm II (11/4)
Week 12 11/9 – 11/13	**The Variational Principle and Chemical Bonds** Griffiths & Schroeter: Ch. 5.3.2, 8.3	Hw 8 (Due 11/11) In-Class Presentations
Week 13 11/16 – 11/20	**Entanglement and the Density Matrix** Griffiths & Schroeter: Ch. 9.1 – 9.2	HW 9 (Due 11/18) In-Class Presentations
Week 14 11/23 – 11/27	**Qbits** Griffiths & Schroeter: Ch. 9.3, 11.1 – 11.2	Thanksgiving Break (11/25 – 11/27)
Week 14 11/30 – 12/4	**Quantum Information and Quantum Computing** Griffiths & Schroeter: Ch. 12.1 – 12.2	HW10 (Due 12/2) In-Class Presentations
Final Exam Week		Final (TBA)