Physics 215 - Introduction to Quantum Physics- Spring 2020
MWF 10:00 - 10:50 AM - Hugel Science Center Room 017
Professor Christopher Hawley
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Lab: 021 HSC
Office Hours: Mon. 2-4 PM and Tues. 1 PM – 3 PM
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Required Texts:

Quantum Physics: A Fundamental Approach to Modern Physics by John S. Townsend, 2010, University Science Books, ISBN 978-1-891389-62-7.

Suspended in Language, by Jim Ottaviani, illustrated by Leland Purvis (G.T. Labs, 2009)

Supplementary texts you may find useful:

The Feynman Lectures on Physics, Vol. III by Richard Feynman (Addison-Wesley, 1965) – **this is free online (**https://www.feynmanlectures.caltech.edu/)

Course Website: We will use Moodle – http://moodle.lafayette.edu. Handouts, homework assignments/solutions, supplemental articles, etc., can be downloaded from this site.

Prerequisites: The prerequisite for this course is Physics 133 or 152.

Class Overview:

Quantum mechanics was developed in the early twentieth century and revolutionized how we understand the physical world around us. To this day, many of the phenomena central to quantum mechanics seem bizarre and counterintuitive and can be challenging to students just beginning to learn the subject as well as established scientists who have been working with it their entire lives. Quantum mechanics is essential to understanding and explaining modern experiments that go beyond the macroscopic to microscopic scales. Without exaggeration, it provides the foundation for almost all advanced physics topics in the modern age; from nanotechnology to cosmology…

Student Learning Outcomes:

- Understand the experimental need for quantum mechanics
- Qualitatively and quantitatively interpret quantum mechanical wavefunctions
- Understand properties of quantum mechanical operators
- Undertake detailed quantum mechanical calculations in situations such as square-well potentials and hydrogen atoms
- Use quantum mechanical methods to analyze single- and multi-particle systems.
- Use computer-based tools such as Mathematica for physical problem solving
- Use advanced lab equipment, including a high quality optical spectrometer

Homework:

Preparing for class by doing the readings and doing the homework are critical to your success. Homework assignments will be given nearly weekly and are to be handed in **Wednesdays at the start of class** if not otherwise indicated. Late homework will be accepted ONCE up to 48 hours late with no questions asked – other than that, no late work will be accepted. If you cannot complete a homework due to illness, family emergency, or similarly compelling reason, contact me (Also see the section on "Dean's excuse policy" in the Student Handbook.). Solutions to homework will be posted on Moodle. Guidelines for writing up homeworks are listed later.

Bohr Book:

Starting midway through the semester, each **Friday**, we will spend a portion of class discussing a new chapter in *Suspended in Language* aka the "Bohr book." As preparation, you will be asked to complete a reading response prior to our meeting and be prepared to discuss your thoughts on the week's reading. Hopefully, you will start to be able to put the development of quantum mechanics in the early 1900's in context with what was occurring in other aspects of global society at the time. Appreciation of the liberal arts at Lafayette gives us the opportunity to explore this kind of material.

Labs:

You will undertake and analyze several experiments over the course of the semester. Some will be directly associated with what we are doing in class; others will be more tangentially related, but still important to your understanding of quantum mechanics.

There will be an orientation meeting at the lab time the first week of the semester

Exams:

The course has three exams, two hour-long midterms and a cumulative final, on dates specified in the Syllabus. Both exams are closed book and closed notes, no phones or laptops, but calculators are allowed. Depending on the schedule, we may use lab time for exams.

Colloquia:

From time to time, the Physics Department will have talks given by outside speakers on topics of current research. I strongly urge you to attend these talks. You will be given 20 extra credit homework points (approximately equivalent to two problems) for each colloquium you attend.

Collaboration:

Collaboration among students on homework is not only allowed, it is very much encouraged! However, any work you turn in must be written by you, in your own words, and faithfully represent your understanding of the course material. Collaboration on exam questions is **never** permitted. Directly copying homework solutions or exam answers will result in a zero for the assignment or exam to failure for the course, depending on the severity and subject of the academic violation (see Academic Honesty section below).

I encourage all of you to seek help when needed. Generally, the earlier you come the better the results. Interacting with students has been and remains a source of great satisfaction for me – please stop by!

Grading:

All grading mistakes have to be resolved within one week after the homeworks or examinations are returned to the students. Grades are determined on the following basis:

10% Lab
5% Bohr Book
30% Homework
15% Midterm Exam 1
15% Midterm Exam 2
25% Final Exam (Cumulative)

Grading follows the standard --- A:100-93%, A-: 92.99-90%, B+: 89.99-87%...

Academic Honesty:

I expect that you will abide by the "Principles of Intellectual Honesty" appearing in the Lafayette College Student Handbook. The Physics department also has an Academic Honesty policy for rules regarding collaboration with others. This document is available on the Moodle page for this class. Please feel free to ask if you have any questions about this policy.

Accommodations:

In accordance with Lafayette College policy, reasonable academic accommodation and support services are available to students who have a documented disability. It is your responsibility to provide me with the appropriate paperwork from the Accessibility Services Office. More information is available at https://hub.lafayette.edu/.

Gender Inclusion:

This is a gender-inclusive classroom. I have been provided with a class roster and your legal names. I will gladly honor any requests to be addressed by a different name or pronoun than appears on the class. Please make me aware of any preferences.

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.

Federal Credit Hour Compliance Statement:

The student work in this course is in full compliance with the federal definition of a four credit hour course. Please see the Registrar's Office web site (https://registrar.lafayette.edu/wp-content/uploads/sites/193/2013/ 04/Federal-Credit-Hour-Policy-Web-Statement.doc) for the full policy and practice statement.

Course Outline:

	Topic	Text Chapters	Exams
Week 1	Quantum mechanics overview; waves; complex numbers	1	
Week 2	Probability amplitudes and interference	1	
Week 3	Interference, continued; wavefunctions; de Broglie wavelength	2	
Week 4	Schrodinger equation; particle-in-a-box; momentum	2,3	
Week 5	Orthonormal functions; Hamiltonian	3	
Week 6	One-dimensional potentials	4	Exam 1 (Tues/Wed)
Week 7	Harmonic oscillator; Operators and observables; Dirac delta function	4	
Week 8	**Spring Break**		
Week 9	Operators, eigenfunctions; Uncertainty principle	5	
Week 10	Three-dimensional wavefunctions	6	
Week 11	Spherically symmetric potentials	6	
Week 12	Hydrogen atom; Zeeman effect	6	Exam 2 (Tues/Wed)
Week 13	Spin	6	
Week 14	Multi-particle systems	7	
Week 15	Multi-particle systems (cont'd); blackbody radiation	7	

Final Exam (Comprehensive Test) Time TBD by Registrar

Guidelines for Writing Up Homework:

It is to your advantage to do the assigned homework. I have chosen the problems to help you learn the material. Physics can be a complicated thing, but repeatedly working with it (and at it) is essential in order to gain physical intuition and get comfortable with the mathematical theory.

Feel free to use computational aids for some of the mathematics if you prefer, but note that there is some advantage to working things out by hand. Not being able to solve problems "by inspection" could end up hurting you on an exam where you will not be permitted to use all computational tools and, frequently, there are mathematical tricks you can use to easily simplify a problem that you will not appreciate if you ask a program to do the work.

I encourage you to work on these problem sets collaboratively, though I do expect you to take 10-15 minutes to give a problem "the old college try" on your own so you enter into discussion with others having some ideas to contribute. You will make your life easier as well as improve your understanding if you work with others (either by explaining it or having it explained to you). I expect solutions to be written up individually (or, if your handwriting is illegible, typed), and all collaboration should be properly acknowledged.

I expect your problem sets to be clearly and logically organized. This means that:

- Each problem should start **on a new page**.
- Write out the problem (or an abbreviated version containing all relevant information). Draw a picture/diagram if useful.
- Clearly work out the problem, commenting your work as you go. Problem sets should never contain just the math; use words to describe what you are doing and to reference where in the text an equation came from and why it is relevant.
- Remember to keep track of units (by writing them out with all your calculations)! Do the units work out as you expect they ought to at the end of a problem? Dimensional analysis is the easiest check to ensure you have tackled the problem correctly.
- Box your final solutions or major milestones as you do the problem. This makes it easier to grade and also for you to follow your own work when you look it over.
- Comment on the significance of your answer. (Does it make sense? Is it what you expected? Why or why not?)
- Attach a cover page to your problem set. This can be the problem sheet or something else, but it should have your name and a clear acknowledgement of all those you have collaborated with on the assignment. This includes fellow students, faculty, etc. (anyone who you consulted or worked with).
- Please see me if you have any questions about this! I know it seems a bit ridiculous listed out like this, but I promise that it will serve you well in the long run. Writing in science is different from the traditional humanities paper, but the point is the same: to clearly and effectively communicate something. This will help you to accomplish that.