Physics 215—Introduction to Quantum Physics
Section 1, MWF 10:00 a.m.
Lab Wednesday 2:10 p.m.
Course Description, Fall 2014

Instructor:	Andrew Dougherty
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Lab:	HSC 025 610-330-5212
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Web Page:	http://workbench.lafayette.edu/∼doughera/courses/phys215/

Office Hours: Beyond my posted office hours, I will usually be either in my office or lab during the free times indicated on my schedule. Please feel free to call, e-mail, or stop by at any time and ask a question or set up an appointment.

Classes on Snow Days and Other Emergencies: If I am unable to make it to class, I will leave a message on my voice mail (610-330-5212).

Description:

This course introduces the basic concepts needed to understand the physics of the atom, the nucleus, the solid state of matter, and elementary particles. The course begins with special relativity, the experimental basis and early development of quantum theory and then proceeds through the development of the modern quantum theory, ending with the hydrogen atom.

The availability of high-quality experimental data played an important role in the development of quantum mechanics. A significant portion of the course will be devoted to experimental exploration and verification of some of the underlying basic physics.

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 `http://registrar.lafayette.edu/additional-resources/cep-course-proposal/` for the full policy and practice statement.

Student Learning Outcomes: After completing this course, you should be able to

- Explain the need for the theory of special relativity,
- Use Lorentz transformations and spacetime diagrams to reconcile observations made in different reference frames,
- Explain counter-intuitive aspects of relativity ("paradoxes"),
- Analyze particle interactions with relativistic energy-momentum calculations,
- Explain the experimental need for quantum mechanics,
- Qualitatively and quantitatively interpret quantum mechanical wavefunctions,
- Undertake detailed quantum mechanical calculations in situations such as square-well potentials and hydrogen atoms,
- Use computer-based tools, such as Mathematica, for physical problem solving, and
- Use advanced lab equipment, including a high quality optical spectrometer, to preform experiments probing quantum-mechanical phenomena.

In addition to the outcomes listed above, this course (particularly the lab component) will promote the following outcomes from the Natural Sciences section of the Common Course of Study:

- NS1. Understand that the goal of science is to comprehend phenomena in the physical and natural world.
- NS2. Employ the fundamental elements of the scientific method:
  - NS2a. Demonstrate the ability to recognize and/or formulate a testable hypothesis based upon observations or existing scientific data;
  - NS2b. Generate, collect, and analyze evidence relevant to testing a hypothesis;
  - NS2c. Evaluate whether the evidence supports or refutes the hypothesis or leads to the development of a new line of inquiry and/or a revision of the original hypothesis.
- NS3. Create, interpret, and critically evaluate descriptions and representations of scientific data including graphs, tables, and models.
- NS4. Understand scientific uncertainty and how it is reduced with additional data acquisition and hypothesis testing.
- NS5. Distinguish the difference between scientifically testable ideas and opinion.

Prerequisites: Physics 132, 133, or 152. A familiarity with `Mathematica` and `Excel` as used in Lafayette Calculus and Physics courses will also be assumed.

Text: *Modern Physics for Scientists and Engineers* (4th. ed.) by Stephen T. Thornton and Andrew Rex.

Grades: The final grade will be determined from the homework (30%), labs (20%), tests (30%), and final exam (20%). Please feel free to ask any questions about how your grade is determined.

Your Responsibilities:

Read the text. Your text is a critical resource for this class—it is a source of definitions, facts, ideas, explanations, derivations, and worked examples. I do not intend to spend class time simply repeating the text. Instead, class time will be used to *discuss* those ideas, answer your questions, observe demonstrations, do examples, and practice applying those ideas to various physical situations.

Accordingly, you should read the text ahead of time. I have included a detailed daily syllabus so you know what the assigned readings for each day will be. Occasionally, we may have unannounced quizzes on the assigned reading material.

Ask questions. If you are confused, it is important that you stop me and try to sort it out rather than falling behind. *Please* interrupt and stop the class whenever anything isn't clear. Remember that if you are confused, there are almost certainly many others who are confused as well, and they would welcome your question.

Do all assigned work. A good rule of thumb is that you should anticipate spending approximately two hours outside of class for each hour in class for a college course. This means you should anticipate spending an average of six hours per week outside of class for physics (not including the lab). Plan ahead. I am here to help. If you start on your homework ahead of time, I will be available to help you if you get stuck. Don't wait until the night before an assignment is due before starting it.

Participate in class. Class time will be used to go beyond merely reading the text. Your active engagement during class can play an important part in helping you to master the material. Class time will also be used to announce changes to the syllabus. It is *your* responsibility to keep up.

Tests: There will be three hour-long in-class tests on the dates indicated on the syllabus. There may also be additional quizzes, either announced or unannounced.

Equation Sheet: You will receive an equation sheet with each test. I have included a copy with the course description so that you may use it as you study and do homework problems. The idea is that you will use your study time to focus on the fundamental ideas and practice doing physics rather than to memorize formulae.

Homework Problems: Homework assignments will be due at the beginning of class on the dates indicated on the syllabus.

- Problems will be due at the *beginning* of class. **Late homework will normally not be accepted**, since I will hand out solutions in class.
- For written homework, please staple your pages together. This ensures your pages don't get lost.
- **Illegible papers will not be accepted**. If I have difficulty reading or understanding your work, I may return it to you ungraded for re-submission. You may resubmit a legible version (along with the original) by the next class meeting, but that version must not have any new content—it must simply be a legible version of the original.
- Please look at the homework problems ahead of time and ask questions about them either in or out of class. I am happy to give whatever help you need, but it is important that you eventually learn to do these problems on your own—after all, that's what you will have to do on the tests.

Academic Honesty: The fabric of science, and indeed any intellectual endeavor, is built on the integrity of all involved. Accordingly, I take academic honesty very seriously. I expect that you will abide by the "Principles of Intellectual Honesty" appearing in the Lafayette College Student Handbook.

Working with others is often a helpful way to learn physics. I encourage you to collaborate with each other on homework, but unless specifically directed otherwise, all work you turn in as your own should be your own.

Academic dishonesty can hurt you in many different ways. First, of course, it is wrong to turn in someone else's work as your own. If you get caught, the penalties can be severe. Second, it hurts your grade. Learning to do problems by yourself is the best preparation for the tests. Students who take the "easy" way out and get excessive or inappropriate help from others tend to get significantly lower grades on the tests.

There are a variety of resources available to help you in your study of physics. These include my office hours, tutoring through ATTIC, and working with classmates. Some students also find it useful to consult other texts, friends, and even a variety of on-line sources. In all cases, though the principles of academic honesty apply: All collaborators must be acknowledged (apart from your instructor), and all work you turn in must be your own.

Please read the department's Academic Honesty policy for the rules regarding collaboration. Feel free to ask if you have any questions about this policy.

Laboratory: The laboratory is an essential part of this class, and successful completion of the laboratory is required in order to pass the course. You are responsible for completing all of the assigned experiments at the scheduled times.

Final Exam: There will be a comprehensive final exam at a time to be arranged by the registrar. *Please do not make travel plans that conflict with the scheduled exam time.*

Grades: Your grade will be based on homework (25%), tests (30% total), the final exam (20%), and the laboratory (25%). The lowest homework assignment will be dropped. Feel free to ask questions about how your grade is determined.

Andrew Dougherty Fall 2014
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Time	Mon.	Tues.	Wed.	Thurs.	Fri.
8:00 8:30	*prep*		*prep*		*prep*
9:00 9:30	**Phys 132** HSC 100		**Phys 132** HSC 100		**Phys 132** HSC 100
10:00 10:30	**Phys 215** HSC 017		**Phys 215** HSC 017		**Phys 215** HSC 017
11:00 11:30					
12:00 12:30					*Physics Club*
1:00 1:30					
2:00 2:30		*Office Hours*			
3:00 3:30				*Office Hours*	
4:00 4:30	Department Meeting	Committee Meeting	*Physics Club*		

Syllabus		Physics 215	Fall 2014
Aug.	25	Introduction and Review	Ch. 1
	27	Einstein's postulates; Time Dilation	Ch. 2:1–3
	29	Length Contraction; HW #1	Ch. 2:5
Sept.	1	Lorentz transformation	Ch. 2:4
	3	Velocity addition & Experimental tests	Ch. 2:6–7
	5	Paradoxes; HW #2	Ch. 2:8
	8	Spacetime; Doppler Effect	Ch. 2:9–10
	10	Relativistic Energy & Momentum	Ch. 2:11–12
	12	Applications; HW #3	
	15	Binding Energy; Reactions	Ch. 2:13
	17	Electromagnetism	Ch. 2:14
	19	**Hour Test I**	
	22	Experimental Basis	Ch. 3:1–4
	24	Blackbody Radiation	Ch. 3:5
	26	Photoelectric Effect; HW #4	Ch. 3:6
	29	X-Rays	Ch. 3:7
Oct.	1	Compton Effect; Pair production	Ch. 3:8–9
	3	Rutherford Scattering; HW #5	Ch. 4:1–3
	6	Bohr Model; Spectra	Ch. 4:4–7
	8	Wave properties of matter	Ch. 5:1–3
	10	Wave/Particle duality; HW #6	Ch. 5:4–5
	13	*Fall Break*	
	15	Uncertainty & Probability	Ch. 5:6–7
	17	Particle in a Box; HW #7	Ch. 5:8
	20	*Review*	
	22	**Hour Test II**	
	24	Schrödinger equation	Ch. 6:1
	27	Expectation Values	Ch. 6:2
	29	Infinite Square Well	Ch. 6:3
	31	Square wells; HW #8	Ch. 6:4–5
Nov.	3	Simple Harmonic Oscillator	Ch. 6:6
	5	Barriers and Tunneling;	Ch. 6:7
	7	Superposition; HW #9	
	10	Applications	
	12	Hydrogen Atom	Ch. 7:1
	14	Hydrogen Atom Solution; HW #10	Ch. 7:2
	17	Quantum Nubmers	Ch. 7:3
	19	*Review*	
	21	**Hour Test III**	
	24	Zeeman Effect	Ch. 7:4
	26–28	*Thanksgiving*	
Dec.	1	Intrinsic Spin	Ch. 7:5
	3	Fine Structure	Ch. 7:6
	5	Atomic Structure;; HW #11	Ch. 8:1
		Final Exam (cumulative)	