Physics 390: Quantum Mechanics

Fall 2019

Meeting: Trexler 272 Time: MWF 12 - Ipm

Instructor: Matthew C. Fleenor Office: Trexler 2661)

email: fleenor@roanoke.edu Office Hours: MW 2.00-4.301)

webspace: http://faculty.roanoke.edu/flecnor or by appt.

Required Textbook: Introduction to Quantum Mechanics, 3rd ed., David J. Griffiths Required

Prerequisites: Physics 203

Aspiration: It was the unequivocal and unpredictable (and Nobel laureate in quantum mechanics) Richard Feynman who said, "I think it is safò to say that no one understands quantum mechanics" (Character of Physical Law). Rather than passing the statement off as complete false humility on Feynman's part (a possibility), I think the statement at least reveals how anti-intuitive the results of quantum mechanics can be for anyone, even an expert. I am excited about the opportunity to build on the conceptual understanding obtained from previous reading and coursework. Please ask yourself after every section and every problem, "What does this mean?" I think you will get more out of the class with that kind of mentality.

I remember the first time I realized where the 4 quantum numbers that I learned in chemistry actually came from. It was exhilarating. I hope you will have some moments like that this semester. Let's don't miss the vision of the physical beauty for the mathematical minutia. For these reasons, I will draw attention to the "takeaways" and "upshots" of the mathematical treatment without sidestepping the intriguing connection between mathematics and physical reality.

Expected Learning Objectives: Below is a broad list of intended course objectives for PHYS 390. These objectives will be infused into every chapter, class, and assignment that is associated with this course. Therefore, the following objectives are a concrete example of the course aspiration given above.

At the end of the course, successful students will:

(1) construct solutions that incorporate the correct boundary conditions for the problem;

(2) predict the correct periodic solutions for differential equations that arise;

(3) calculate the quantized energies and wave functions for the infinite square well;

(4) understand the connection between matrix algebra operators and observable, physical quantities;

(5) Synthesize numerical information, physical assumptions, and previous concepts to correctly solve problems for the hydrogen atom;

(6) Analyze the historical application of some aspect of quantum mechanics to better understand the process of science.

Attendance: Although roll will not be taken, daily attendance is expected. Due to the mathematically rigorous nature of the course, you may not miss more than four classes without a legal excuse (court, hospital, police, etc.). Late arrivals greater than 10 minutes will constitute an official absence. The fifth absence for which there is no legal excuse will constitute your (forced) withdrawal from the course.

Office Hours: Please take advantage of the office hours prescribed above, or make an appointment with me. Drop-ins are at the total mercy of my daily schedule.

Inquire (NQR): The information found within the NQR environment is an essential component to the course itself. Notes, announcements, assignments (and solutions), links, and course documents will all be

placed within the course NQR. Please do NOT forget to check NQR before you come to class or if you have a question about previous assignments.

Academic Integrity: I want to foster a mutual respect for the classroom hours that we have together. Please remember to turn off cell phones, PDAs, etc. during the class and come prepared. Refer to the "Academic Integrity" page on the RC website— http : //roanoke.edu/A—Z-Index/Registrar/P01icies-and-Information/Academic-lntegrity . htm

Included here is an explanation of how violations of the College's academic integrity policy are handled.

Subject Tutoring: Subject Tutoring, located on the lower level of Fintel Library (Room 5), is open 4 pm—9 pm, Sunday—Thursday. We are a Level Il Internationally Certified Training Center through the College Reading and Learning Association (CRLA). Subject Tutors are highly trained Roanoke College students who offer one-on-one tutorials in a variety of general education and major courses such as: Business, Economics, Mathematics, INQ 240, Modern Languages, Lab Sciences, INQ 250, and Social Sciences (see all available subjects at www.roanoke.edu/tutoring). Tutoring sessions are available in 15, 30, or 45-minute appointments. Feel free to drop by for a quick question or make an appointment at www.roanoke.edu/tutoring for a longer one-on-one appointment. For questions or concerns, please contact us at 540-375-2590 or sub-ject-tutoring@roanoke.edu.

Accessible Education Services: Accessible Education Services (AES) is located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library. AES provides reasonable accommodations to students with documented disabilities. To register for services, students must self-identify to AES, complete the registration process, and provide current documentation of a disability along with recommendations from the qualified specialist. Please contact Laura Leonard, Assistant Director of Academic Services for Accessible Education, at 540-375-2247 or by e-mail at aes@roanoke.edu to schedule an appointment. If you have registered with AES in the past and would like to receive academic accommodations for this semester, please contact Laura Leonard at your earliest convenience to schedule an appointment.

Diversity: I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment fbr every other member of the class.

Preferred Name/Pronoun: I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records.

Grades: For better and for worse, you will receive a letter grade for this course. Basic letter grades (A— F) are assigned according to the following scale: "A" (91—100), "B+" (88—90), "B" (83—87), "B—" (80—82), "C+" (78-79), "C" (74-78), (70-73), "D" (60-69), "F" 60).

Modes of Instruction: Your grade is determined according to the following distribution:

Exams (3)	Problem Sets 30%
Final	History/Bio 5%
Quiz (weekly) 10%	Participation 5%

Exams: All exams are designed for completion within the class hour. However, I will arrive on test days ASAP to administer the test. Furthermore, you may include the 5—10 minutes after the class hour is complete. Exam 3 will be given on the day of the final, and so, you will have two different exams during that period. Make-up exams will only be allowed as a result of a discussion with me beforehand or a note related to the emergency (death, hospitalization, misdemeanor, etc.) signed by a governing official (medical doctor, parent, law enforcer, etc.).

Problem Sets: Un-/assigned problems (like those in the problem sets) are "when and where" you will learn the course material. For better and for worse, there is no way to learn the depth of EOM within the one-hour sessions that we will have together. Due to the nature of problem solving, I expect that you will work together toward a solution. However, I also expect that you will create an original solution to each assigned problem. Substitutions and simplifications should NOT be left to the "reader" (that's me) to figure out. If necessary, words and phrases need to be properly placed so that I can fòllow your train of thought. Problem sets are your final draft essays and/or compositions that display the fruit of your higher-level critical thinking skills, so you need to view them in that light.

Life (and therefore, this course) is NOT about obtaining the correct answer. The questions that need answering are 'Do you understand how the answer was/is obtained?' and 'Are you able to apply the answer to other questions and applications and within other contexts?'

Quizzes: Bi-/weekly quizzes (FRIs) are completed individually in class and graded. These are test-prep opportunities. The quiz will consist of one problem from the problem set and/or class discussion, which contain the more important concepts and/or phenomena.

History/Bio: Physics has a significant history with tie-ins into many other scientific fields (biology, astronomy, chemistry, economics) and philosophical thought (relativity, empiricism, pacifism). You will choose a particular personality, topic, or issue related to the physical principles/phenomena that the course covers. I will list some potential topics within the NQR pages, OR you may suggest one to me. Each student will complete a written report C02 pages) discussing your topic/personality.

Course Outline: Please see the Outline on the following page for the exact dates of meeting for the course. The Outline also shows the daily activity and course content for our educational experience. If you have questions about scheduling, please refer to this Outline first.

PHYS 390: Course Outline Fall 2019

Week	Date	Section	Topic	HW/ Problem
1	a-Aug 30-Aug		Tools of Your Past (Things that Will Help) Quiz 0/ Weird Ideas from the Quantum World	
2	2-sep 4-Sep 6-sep	1.2 1.3 1.4	Statistical Interpretation Probability Quiz 1/ Normalization	 1.1 1 .3
3	9-Sep Il-Sep 13-Sep	1 .5 1.6 2.1	Ensembles, Operators & Expectation Uncertainty Principle Quiz 2/ Stationary States	1 .5 1 .9

4	16-Sep 18-Sep 20-Sep	2.2 2.2 - 2.3 2.3.1	Infinite Square Well Infinite Square Well Quiz 3/ Harmonic Oscillator	2.1 2.4, 2.5
5	23-Sep 25-Sep 27-Sep	2.3.1 2.4 2.4	Harmonic Oscillator Free Particle Quiz 4/ Free Particle	2.1 1 2.22
6	30-Sep 2-Oct 4-0ct	2.5 2.6	Delta-function Potential Finite Square Well Quiz 5/ Transmission & Reflection	2.23
7	7-Oct 9-Oct Il-Oct	3.1 - 3.2.1 3.2.2 - 3.3	Hilbert Space & Hermitian Operators Eigenfunctions and Eigenvectors In-class Exam 1 (Chap. 1 & 2) + Take-home	
8	14-0ct 16-0ct 18-Oct	No Classes — Fall Break		
9	21 -Oct 23-0ct 25-0ct	3.22 - 3.3 3.4 3.5	Eigenfunctions and Eigenvectors Statistical Interpretation Quiz 6/ Uncertainty Principles (revisited)	3.3
10	28-0ct 30-0ct 1 -Nov	3.5 3.6	Uncertainty Principles (revisited) Dirac Notation & Review Quiz 7/ Dirac Notation	3.8, 3.10 3.13
11	4-Nov 6-Nov 8-Nov	4.1 — 4.1.2 4.1.3 – 4.2.1	Separation of Variables & Angular Equation Radial Equation & Function In-class Exam 2 (Chap. 3) + Take-home	3.17
12	Il-Nov 13-Nov 15-Nov	4.2•1 4.21 — 4.22	Radial Equation & Function Radial Solutions & Hydrogen Spectrum Quiz 8/ Hydrogen Spectrum	4.5
13	18-Nov 20-Nov 22-Nov	4.3 4.4	Angular Momentum Quiz 9/ Spin	4.13
14	25-Nov 27-Nov 29-Nov	Take-home Quiz (Chap 4) No class — Thanksgiving Break		4.19
15	2-Dec 4-Dec	4.3 — 4.4 5.2	Stern-Gerlach Experiment (Revisited) Atoms	

	6-Dec			
	13-Dec		Final Exam — Parts I and Il, 2-5p	