Physics 390 Quantum Mechanics Fall 2021

Instructor:	Daniel Robb	Class Mtgs:	MWF 1:10-2:10 (TREX 272)
Office:	Massengill 243	Office Hrs:	T/Th 1:00-3:00 (15 min Zoom appts) (Make appts at calendly.com/daniel_robb)
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Course Description:

Introductory examination of the wave formulation and notation in solving the time-dependent and time-independent Schrodinger equations including reflection/transmission, barriers, and the hydrogen atom.

Textbook:

• *Introduction to Quantum Mechanics,* David Griffiths, 3rd edition (2018). ISBN-13: 978-1107189638

Purpose of the Course:

Near the end of the nineteenth century, many prominent physicists thought the main conceptual theories of physics – mechanics, electricity and magnetism, and thermal physics -- were complete, and that all that remained was to apply and perhaps refine these theories. For example, Kirchhoff asked of a bright young student, "Why do you want to come into physics? All is done and understood." Nature had more surprises in store for physicists, however, and the early twentieth century brought two conceptual revolutions in the theory of relativity (both special and general) and the theory of quantum mechanics. You have already been introduced in your Modern Physics course to the key experiments that led to the development of quantum mechanics, and to some of its main ideas. In this course you will learn the theory of quantum mechanics in more conceptual depth and generality. You will strengthen your both your grasp of the foundations of quantum mechanics and your ability to apply quantum mechanics to physical systems. You will also consider how classical behavior emerges from quantum behavior at the scale of everyday objects, and contemplate the mysteries of nonlocality and entanglement.

Specific Goals of the Course:

1. Learn the mathematical postulates of quantum mechanics
2. Understand the concepts of quantum mechanics via application to a variety of physical systems
3. Actively construct your understanding in class via small-group problem-solving
4. Extend the material presented in an interesting direction via a substantial group project

Feedback and Evaluation:

I will assign numerical grades to all your work. I may curve your final grades (upward), but otherwise you can expect to receive an "A" for 90-100, a "B" for 80-89, etc. I will assign +/- to your final grades by examining the distribution of grades. These are the categories and percentages that will be used:

Preparation:	10%	Tests:	30%
Participation:	25%	Final Project:	10%
Problem Sets:	25%		

Preparation will consist of watching a pre-recorded lecture, and will be evaluated via a straightforward quiz given at the beginning of each class period. Preparation is important because it enables you to participate actively in the collective group problem-solving (see next item).

Participation will consist mainly of collective group problem-solving on several problems per class. I will be lecturing very little during class, and relying on your viewing of the pre-recorded lectures and your collective work on these problems to absorb the material. You will rotate through groups of two or three as the semester progresses, getting to work with all (or nearly all) other members in the class – valuable experience in learning to work with others with different problem-solving styles and personalities. You are not required to solve each problem in the time allotted, but to put in a strong effort, at which point the solution will be revealed and discussed. Note that MCSP write-ups (see below) also form a small portion of the participation grade (5 of the 25%).

Problem sets should reflect your individual effort, with collaboration only at the level of general concepts. They will be returned within one week, and solutions will be posted online.

The first two tests will involve problems similar in difficulty to those in the problem sets. These first two tests will also include several conceptual questions, in short-answer format. The third test (final exam) will involve general conceptual questions regarding all of the group projects presented during the last section of the course.

The final project will consist of an oral presentation on an extension of the course material to a related and/or more advanced topic, in groups of four students. Two class periods will be devoted to researching the project, and three class periods to the oral presentations. Each group member should speak approximately an equal amount during the presentation. Again, for the final exam, the class is responsible for general conceptual understanding of the material presented within the final projects, at the level of clarity with which they are presented.

MCSP Colloquium Series:
The MCSP department offers a series of discussions related to math, computer science and physics. Members of this class are invited to attend all of these meetings; however participation in at least two of these sessions is mandatory. Within one week of attending a colloquium you must submit (via a link on Inquire) a one-page single-spaced paper reflecting on the discussion. This should be not only a summary of the content, but also a personal reflection on the experience of the talk.

Expected Hours of Work
You are expected to spend at least 12 hours per week inside and outside of class.

Mask Policy
The College has issued a mask mandate for the start of the semester that requires masks to be worn in indoor common spaces such as our classroom. You must wear a mask in this class. If you arrive without a mask, you will not be allowed to stay and may lose credit for attendance or in-class work. The Bookstore sells masks if you need to make a quick purchase. If the mandate is extended, you will be required to continue to wear a mask.

Attendance Policy:
Attendance in this class is important, especially given the interactive nature of the in-class experience. If you have a temperature of 100.4 or higher or other COVID symptoms, don't come to class. Call Health Services IMMEDIATELY. Do not come to class or go to any public area on campus. In order for your absence to be excused, you must give Health Services permission to notify me that you have consulted them about COVID symptoms. If Health Services informs you that you should isolate and not attend class for multiple days, inform me so that we can make a plan to keep you current in the course. All absences caused by consultation with Health Services about coronavirus symptoms or isolation ordered by Health Services will be excused but you will need to do the work and graded assignments even if we extend a deadline for you.

The policy for all other absences is as follows: You must notify me in advance if you must miss class for a valid reason (an excused absence). Any student who misses a total of five classes unexcused will be dropped from the course with a grade of DF. A warning email (cc'd to your advisor and the registrar) will be sent after the fourth unexcused absence occurs. If a student shows up for class 20 or more minutes late, walks out in the middle of class, or is caught repeatedly texting/checking emails/browsing the Internet during class, that student will be given an unexcused absence.

Policy on Late Work:
For problem sets, I will grade an assignment with a 10% lateness deduction if turned in by 5:00PM on the due date. Following that, assignments will receive a further 10% lateness deduction for each successive school day late (with days considered to end at 5:00 PM).

Make-up Tests:
Make-up tests may be given only under unusual circumstances. If you miss a test, and have an official college excuse for that absence, then I will generally be willing to arrange for a make-up test, but I reserve the right to have your overall test average substitute for the missed test.

Academic Integrity:
The College academic integrity policies are enforced. Although you are encouraged to work in groups on problem sets, at a general conceptual level, all specific problem-solving work turned in for a grade must be your own. Please familiarize yourself with the College's academic integrity policies.

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 Becky Harman, 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 Becky Harman at your earliest convenience to schedule an appointment and/or obtain your accommodation letter for the current semester.

Course schedule

#	Date	Topic	Section(s)	Due
1	Sept. 1	Intro; Shrodinger equation and its interpretation	1.1-1.4	
2	3	Momentum and the uncertainty principle	1.5-1.6	
3	6	TISE: Infinite Square Well	2.1-2.2	
4	8	TISE: Harmonic oscillator I	2.3.1	
5	10	TISE: Harmonic oscillator II	2.3.2	
6	13	TISE: Free particle	2.4	
7	15	TISE: Potential wells and scattering	2.5-2.6	
8	17	Hilbert space	3.1-3.3	Problem Set 1
9	20	More uncertainty principle	3.4-3.5	
10	22	Bases and Dirac notation	3.6	
11	24	The hydrogen atom I	4.1	
12	27	The hydrogen atom II	4.2	Problem Set 2
13	29	Angular momentum	4.3	
14	Oct. 1	**TEST 1**		
15	4	Spin	4.4	
16	6	Bosons and fermions	5.1	
17	8	Helium and the periodic table	5.2	
18	11	Solid lattices	5.3	
19	13	Nondegenerate perturbation theory	7.1	Problem Set 3
20	15	Degenerate perturbation theory (Dr. Robb out of town)	7.2	
	16-24	**FALL BREAK**		
21	25	Fine structure of hydrogen	7.3	
22	27	Zeeman effect and hyperfine structure	7.4-7.5	
23	29	The WKB approximation	9.1-9.3	
24	Nov. 1	Scattering and partial waves	10.1-10.2	
25	3	Phase shifts and the Born approximation	10.3-10.4	
26	5	Time-dependent perturbation theory	11.1	Problem Set 4
27	8	Emission and absorption of radiation	11.2-11.3	
28	10	Fermi's golden rule and the adiabatic approximation	11.4-11.5	
29	12	EPR Paradox and Bell's Theorem	12.1-12.2	
30	15	Mixed States and the Density Matrix	12.3	
31	17	The No-Clone Theorem and Schrodinger's Cat	12.4-12.5	Problem Set 5
32	19	Classical Limit and Ehrenfest's Theorem	TBD	
33	22	**TEST 2**		
	24-28	**THANKSGIVING BREAK**		
34	29	Entanglement and Nonlocality	TBD	
35	1	Group projects		
36	3	Group projects		
37	6	Group presentations		
38	8	Group presentations		
39	10	Group presentations		
		FINAL: Wednesday, December 15, 2:00-5:00pm		