Physics 390 Quantum Mechanics Spring 2024

Instructor:	Daniel Robb	Class Mtgs:	MWF 1:10-2:10 (TREX 272)
Office:	Massengill 243	Office Hrs:	T/Th 9:30-11:00
			(15-min appts via 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 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 a 93-100 numerical semester average; A- for 90-92; B+ for 87-89; B for 83-86; B- for 80-82; C+ for 77-79; C for 73-76; C- for 70-72; D+ for 67-69; D for 60-66; F for 0-59. These are the categories and percentages that will be used:

Participation:	25%	Tests:	30%
Problem Sets:	35%	Final Project:	10%

Participation will consist mainly of collective group problem-solving on several problems per class. I will be lecturing very little during class, relying on your viewing of the pre-recorded lectures and your collective work on these problems to absorb the material. You are not required to solve each problem in the time allotted in class, 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 with classmates only at the level of general concepts. You may discuss problem specifics with me. Please see the section on Academic Integrity for the policy on the use of generative AI on problem sets. Problem sets 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 the final 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 2-3 students. Two class periods will be devoted to researching the project, and two 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. (Note that for recorded talks, you may submit your reflection beyond the one-week deadline.) 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.

Attendance Policy:
Attendance in this class is important, especially given the interactive nature of the in-class experience. You must notify me in advance if you must miss class for a valid reason (an excused absence). For each unexcused absence past the third, two points will be deducted from your final semester average.

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 20% lateness deduction for each successive school day late (with days considered to end at 5:00 PM). Problem sets more than three school days late will receive no credit.

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. If you are in doubt about whether a specific collaboration is allowed, please ask me.

Regarding the use of generative AI tools such as ChatGPT, you may use generative AI tools as a last resort to generate ideas on a problem on a problem set, but be aware that at this point these tools' solutions are not always fully correct. You must write up problem set solutions on your own in any case.

Accessible Education Services:
Accessible Education Services (AES) is in the Goode-Pasfield Center for Learning and Teaching in **Fintel Library**. AES provides reasonable accommodation 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 Dustin Persinger, 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 Dustin Persinger at your earliest convenience to schedule an appointment and/or obtain your accommodation letter for the current semester.

#	Date	Rdg	Topic	Due
--	15-Jan		**MLK Day: No class**	
1	17-Jan	1.1-1.4	Intro, Schrodinger equation & interpretation	
2	19-Jan	1.5-1.6	Momentum and the uncertainty principle	
3	22-Jan	2.1-2.2	TISE: Infinite square well	
4	24-Jan	2.3.1	TISE: Harmonic oscillator I	
5	26-Jan	2.3.2	TISE: Harmonic oscillator II	
6	29-Jan	2.4	TISE: Free particle	
7	31-Jan	2.5-2.6	TISE: Potential wells and scattering	Problem Set 1
8	2-Feb	3.1-3.3	Hilbert space	
9	5-Feb	3.4-3.5	More uncertainty principle	
10	7-Feb	3.6	Bases and Dirac notation	
11	9-Feb	4.1	The hydrogen atom I	
12	12-Feb	4.2	The hydrogen atom II	Problem Set 2
13	14-Feb		No class (Dr. Robb out of town)	
14	16-Feb		Study for Test 1 (Dr. Robb out of town)	
15	19-Feb	4.3	Angular momentum	
16	21-Feb		**TEST I**	
17	23-Feb	4.4	Spin	
18	26-Feb	5.1	Bosons and fermions	
19	28-Feb	5.2	Helium and the periodic table	
20	1-Mar	5.3	Solid lattices	
	4-Mar		**Spring Break: No class**	
	6-Mar		**Spring Break: No class**	
	8-Mar		**Spring Break: No class**	
21	11-Mar	7.1	Non-degenerate perturbation theory	
22	13-Mar	7.3	Fine structure of hydrogen	Problem Set 3
23	15-Mar	7.4-7.5	Zeeman effect and hyperfine structure	
24	18-Mar	9.1-9.3	The WKB approximation	
25	20-Mar	10.1-10.2	Scattering and partial waves	
26	22-Mar	10.3-10.4	Phase shifts and the Born approximation	
27	25-Mar	11.1	Time-dependent perturbation theory	Problem Set 4
28	27-Mar	11.2-11.3	Emission & absorption of radiation	
	29-Mar		**Good Friday: No Class**	
29	1-Apr	11.4-11.5	Fermi Golden rule and adiabatic approximation	
30	3-Apr	12.1-12.2	EPR paradox and Bell's theorem	
31	5-Apr	12.3	Mixed states & the density matrix	
32	8-Apr	12.4-12.4	No-clone theorem & Shrodinger's cat	
33	10-Apr	TBD	Classical limit and decoherence	Problem Set 5
34	12-Apr	TBD	Entanglement and Nonlocality	
35	15-Apr		**TEST 2**	
36	17-Apr		Group projects	
37	19-Apr		Group projects	
38	22-Apr		Group presentations	
39	23-Apr		Group presentations	
	27-Apr		Final Exam: 8:30-11:30 am	