Phys 451: Introduction to Quantum Mechanics

Fall 2023, MWF 09:00 – 09:50, Lewis 104

"The paradox is only a conflict between reality and your feeling of what reality 'ought to be'". Richard Feynman, physicist

Course Information

Instructor: Dr. Cecille Labuda
Office: [Lewis 202, NCPA 1031]
Office Hours: MF 14:30 – 17:00. T 14:00 – 14:45 Lewis 202. By appointment NCPA 1031.
Email: cpembert@olemiss.edu I typically respond to emails on weekdays within 24 hours.

Course Description

The Bohr model of the hydrogen atom was perhaps the first realistic physical system where quantum mechanics was put to work. Quite simply, Bohr's model was a serendipitous combination of classical and quantum mechanics which was developed long before Schrödinger came up his wave equation which is now used to model the atom purely quantum mechanically. In this course, we will apply Schrödinger's equation to study simple physical systems culminating with the Bohr model in order to develop an understanding of how quantum mechanics works. We will study the fundamental differences between quantum mechanical systems and classical systems. Course instruction will be primarily lecture style with some in-class learning activities. Homework problems will mostly require analytical solutions with about 10 – 15% of problems requiring numerical solutions for which we will use Matlab. Course prerequisites are Math 353, Phys 308 and Phys 318.

Course Learning Outcomes

By the end of this course, you will be able to:

- Use a set of standard techniques for solving introductory quantum mechanical problems
- State the uncertainty principle, explain what it means and how it is applied
- Calculate expectation values for quantities and explain the physical meaning of these values
- Solve Schrodinger's equation for various quantum physical systems and determine the behaviour of these systems
- Describe and discuss various interpretations of quantum mechanics

Course Texts and Materials

Griffiths and Schroeter. Introduction to Quantum Mechanics 3rd Edition. Cambridge University Press, ISBN: 978-1107189638.

Course Assignments and Evaluation

Class Exercises and Summaries (5%) [c]

In-class exercises, class summaries and blackboard presentations of problem solutions during class meetings. Graded for completion; no make-ups.

Written exams (45%) [i]

3 closed-book exams weighted as follows:

- 2 exams highest grades: 17.5%+17.5%=35%
- 1 exam lowest grade: 10%

Oral exam [5%][i]

A short list of fundamental quantum mechanics systems will be given. Students will be asked to present one of the problems on the list, selected by the instructor, on the board. Questions will be asked after the presentation.

Homework (20%) [c]. Note that the homework grade will only count if the exam average is >50%. *Otherwise the homework grade will be computed as zero.*

- Homework sets must be turned in at the beginning of class when due. [c]
- Students are encouraged to work together to solve the homework problems. However, students may not copy homework solutions, in particular, from each other, from solutions manuals or from any source whatsoever. Copied homework will be given a grade of zero.
- Homework solutions must be presented according to the homework rubric or it may not be graded.

Final exam (25%) [i]

- The final exam will be comprehensive. The format will be similar to the tests.

Course Grading

Plus-minus grades may be assigned if they benefit the student.

- $90\% \leq \mathbf{A} \leq 100\%$
- $80\% \leq \mathbf{B} < 90\%$
- $70\% \leq \mathbf{C} < 80\%$
- $50\% \leq \mathbf{D} < 70\%$
- $\mathbf{F} < 50\%$

Attendance

Class attendance is required. If a student is absent for more than 3 classes during the semester, the final calculated grade will be reduced by a letter grade at the time grades are officially assigned. If you must be absent for exams, you must speak to me before the exam to determine whether the absence will be excused and whether the exam will be rescheduled. For unexpected exam absences, you must contact me by email or telephone within 24 hours after the absence or the exam will not be rescheduled. Allowances will be made for personal emergencies, university obligations, religious observances, and other circumstances if these are deemed to be reasonable by the instructor. The University requires students to attend the first meeting of every course and that their attendance be verified by the instructor. Verification will take place during the first week of class.

Academic Integrity

We share a responsibility to maintain academic integrity in our work and will follow the procedures outlined in the Academic Conduct and Discipline Policy and the M Book for any instance of academic misconduct. By choosing to be part of the University of Mississippi community, every student agrees to abide by the University of Mississippi Creed and the UM Academic Integrity Policy. Cheating is forbidden and, in this course, will result in a zero grade on the given assignment. If a second case of cheating occurs, this will result in an F for the entire course. Unless explicitly permitted by the instructor, distribution of materials provided in this class via the internet or otherwise. Accessing such materials for your own use is also in violation of the UM Academic Conduct Code. Additionally, the distribution of your own class notes is strongly discouraged except for occasional loaning of notes to students also enrolled in the class.

Disability Access and Inclusion Policy

The University of Mississippi is committed to the creation of inclusive learning environments for all students. If there are aspects of the instruction or design of this course that result in barriers to your full inclusion and participation, or to accurate assessment of your achievement, please contact the course instructor as soon as possible. Barriers may include, but are not necessarily limited to, timed exams and in-class assignments, difficulty with the acquisition of lecture content, inaccessible web content, and the use of non-captioned or non-transcribed video and audio files. University Student Disabilities Services (SDS) will complete a comprehensive review to determine your eligibility for accommodations. Contact SDS at 662-915-7128 or **sds@olemiss.edu**.

Use of Generative AI Not Permitted

Generative AI refers to artificial intelligence technologies, like those used for ChatGPT that can draw on a large body of data to create new written, visual, or audio content. In this course, we'll be developing skills that are important to practice on your own. Because use of generative AI may inhibit the development of those skills, the use of generative AI for working on assignments is not permitted. Using such tools for any purposes, or attempting to pass off AI-generated work as your own, will violate our academic integrity policy.

Technology in the Classroom

Laptops and other computing devices may sometimes be used in class as learning resources, and at some points I may request that you put them away to give the class activity your undivided attention. Students who wish to take notes using electronic devices may only use devices with lay-flat screens.

Schedule of Topics (subject to change; updated 08/20/2022)

Week	Topic		Textbook Sections
01: 08/21 – 08/25	Schrödinger's equation, the wave function, normalization		Ch 1
02: 08/28 – 09/01	Normalization, expectation values, the time-dependent wave function		Ch 1, Ch 2
03: 09/04 – 09/08	The time-independent wave function, infinite square well potential		Ch 2
04: 09/11 – 09/15	The infinite square well potential		Ch 2
05: 09/18 – 09/22	Harmonic oscillator potential	**09/20: TEST 1**	Ch 2
06: 09/25 – 09/29	Harmonic oscillator potential, free particle potential		Ch 2
07: 10/02 – 10/06	Free particle potential, delta function potential, finite square well potential		Ch 2
08: 10/09 – 10/13	Finite square well potential, Hilbert space, Hermitian operators		Ch 2, 3
09: 10/16 – 10/20	Generalized statistical interpretation, uncertainty principle	**10/18: TEST 2**	Ch 3
10: 10/23 – 10/27	Schrödinger's equation in 3D		Ch 4
11: 10/30 – 11/03	Angular equation, radial equation, hydrogen atom	**Oral Exam (scheduled out of class period)**	Ch 4
12: 11/06 – 11/10	Hydrogen atom		Ch 4
13: 11/13 – 11/17	Hydrogen atom	**11/15: TEST 3**	Ch 4
14: 11/20 – 11/24	**THANKSGIVING BREAK**		
15: 11/27 – 12/01	Angular momentum, interpretations of quantum mechanics; Entanglement		