Physics 485/685 - Quantum Mechanics I (3 cr)

Session: Fall 2024
Instructor: Prof. John B. Buncher
Office: South Engineering 317
Email: john.buncher@ndsu.edu
Office Hours: MTWTh 11 AM – Noon, or by appointment
Class Meetings: TTh 9:30 AM – 10:45 AM
Location: South Engineering 221
Final: Thursday, December 17, 2024, 8:00 AM – 10:00 AM
Prerequisites: PHYS 350, MATH 266

Course Materials

- The primary text for the course will be "Quantum Mechanics - A Paradigms Approach", by David H. McIntyre, published by Cambridge University Press, 1st Edition.

Course Description

From the NDSU Catalog Course Description: Operators, one-dimensional wells and barriers, Schroedinger equation, uncertainty, duality, Born interpretation, unstable states, bosons and fermions, central force problems, angular momentum, spin. Prereq: PHYS 350, MATH 266.

Course Objectives

The primary goal of this course is to provide the students with an more sophisticated understanding of quantum mechanics and the associated mathematical tools that will aid them in their careers in any techcnical field. The students will further refine their conceptual understanding and problem-solving ability such that they can readily apply their knowledge to novel problems and situations. Specifically, students shall be able to:

- Translate between the physical description of a senior-level quantum mechanics problem and the mathematical equations needed to solve it.
- Visualize the physical parameters of a problem, through plots and sketches.
- Justify and explain their thinking and/or approach to a problem or physical situation, in either written or oral form.
- Choose and apply the appropriate problem-solving technique for a given problem, including but not limited to: effective use of approximations, series expansions, exploiting symmetries, integration, and superposition.
- Check the validity and plausibility of a solution by examining limiting cases.
- Graduate students (those enrolled in PHYS 685) are also expected synthesize their understanding of one of the course topics through the design, implementation, and execution of both a lesson (lecture session), assosciated in-class activities, and an associated assessment.

Feedback

If you have any concerns about the course or suggestions on how it may improve, please let me know! I am happy to consider and implement student suggestions, and I have had success implementing such suggestions in previous courses.

Course Policies

COVID-Related Policies

Please **do not come to class**

- if you are feeling ill, particularly if you are experiencing COVID-19 symptoms, or
- if you are infected, during your five-day isolation period.

You will still need to complete the assignments, exams, reading, etc. necessary to meet class learning objectives. You can complete missed work by turning in assigments when you are no longer ill, and scheduling a time to make up any missed quizzes and exams.

Attendance & Participation

Within the limits outlined in the COVID section, you are expected to come prepared each day and to participate in the discussion and problem-solving. If you miss a class, it is your responsibility to get the missed notes (from a classmate) and any assignments given.

According to NDSU Policy 333 www.ndsu.edu/fileadmin/policy/333.pdf, attendance in classes is expected. Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

Grades

Your final grade will be determined according to the following weights and cutoffs:

Phys 485	
Homework	25%
Quizzes	15%
Exams	$2 \times 20\%$
Final	20%

Phys 685	
Project	10%
Homework	15%
Quizzes	15%
Exams	$2 \times 20\%$
Final	20%

A	90 %
B	80 %
C	70 %
D	60 %
F	< 60 %

Note that exams make up 60% of your final score! It is crucial that you prepare and study accordingly.

NOTE: You must satisfactorily complete 80% of the homework assignments in order to receive a passing grade in the course.

Homework

Homework will be given roughly once per week throughout the semester. Unless prior arrangements have been made, all homework is due at the **beginning** of class on the due date. That being said, I try to treat due dates as *guidelines* for you - they give you a rough idea of how you should be progressing in the course to be ready for the exam. Unless I note otherwise, turning in an assignment a day or so late will not result in any penalty, but please notify me that you need to do so.

The purpose of homework is for you to *learn* the material via *practice* and to recieve *feedback* on that practice. To that end, you are encouraged to re-submit any homework that you are not happy with your performance on, incorporating feedback and detailing how your new submission is improved, for re-evaluation.

All of your assignments that you turn in must meet the following "formatting" requirements:

1. It should be neat and presentable.
2. It is to be written on loose-leaf, perforated, or plain paper (no notebook "frillies").
3. Each problem should be started on a separate page.
4. The pages must be stapled. The staple **must** be positioned vertically in the upper-left corner of the page, less than half an inch from the left side of the page.
5. All pages must be numbered in the upper-right hand corner, and put in order.
6. You must re-state the problem which you are attempting to solve, at least briefly.
7. Answers should be clearly labeled (boxed, highlighted, bold, etc.).
8. If you worked with anyone else on your assignment (which you are encouraged to do!), you must indicated key contributions that your other group members made.
9. You may also typeset your assignments using any program that you prefer (LaTeX, *Mathematica*, LibreOffice, Word, etc.), if you wish. If you decide to do this, make sure you are spening more time doing the *physics* than you are dealing with formatting issues!

Quizzes

Quizzes will be given roughly every other week, covering topics that you have practiced on the homework. They will be roughly 15 minutes long. Simlar to homework, you will have an opportunity to be re-evaluated on any quizzes that you are not happy with your performance on by coming in and presenting the solution in person and answering follow-up questions.

Exams

Exams will be timed, either in-class or in the evening if schedules permit. You are not allowed to work with other students on the exams.

Project

For graduate credit, those enrolled in PHYS 685 need to do something "extra" compared to those in PHYS 485 that demonstrates the additional learning for the 600-level course. Rather than just doing "more" or "harder" problems/exams, you will prepare a *lesson* on an appropriate number of sections in the book (roughly one lecture's worth). Not only will you design the lesson including the in-class activities, but you will also design an appropriate assessment of that material. To help you do so, I will meet with each graduate student one-on-one frequently starting early in the semester to select appropriate topics/sections to cover, in-class activities, and how to think about designing the assessment. Further details will be provided.

Office Hours

See the front page for office hours. If you need to meet outside of those times, email me and we should be able to work something out. During office hours, we can discuss anything that you wish (homework, grading, concepts, exams, topics of interest, etc.) If there is something of a personal nature, it would be best to make a separate appointment.

Accommodations

Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Disability Services Office http://www.ndsu.edu/disabilityservices/ as soon as possible.

On Academic Dishonesty

The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

You are highly encouraged to work with your fellow students, and to seek out their assistance or the assistance of the instructor, in all of your studies. Working with another person is highly beneficial for both people when there is a healthy working relationship. However, whatever you turn in must be your own work and words. Copying someone else's work and turning it in as your own is a case of academic dishonesty. You are not permitted to collaborate with anyone else on exams.

If you have any questions about what constitutes academic dishonesty it is your responsibility to ask before the assignment is due.

Course Schedule

I intend to cover Chapters 1–5, roughly as follows

	Week	Topic
8/26	1	Stern-Gerlach Experiments, State Vectors, & Bra-ket Notation
9/02	2	General QM Systems, Postulates, & Measurement
9/09	3	Commuting Observables, Uncertainty Principle, & $\vec{S}^2$ operator
9/16	4	Schrödinger equation & Time Evolution
9/23	5	Oscillations & **EXAM 1**
9/30	6	Paradoxes, Energy Eigenvalue Equation
10/07	7	Infinite & Finite Square Wells
10/14	8	Superposition, Free Particle
10/21	9	Wave Packets
10/28	10	Unbound States & **EXAM 2**
11/04	11	Harmonic Oscillator
11/11	12	Harmonic Oscillator
11/18	13	Angular Momentum & Separation of Variables
11/25	14	Systems in Spherical Coords
12/02	15	Hydrogen - Radial Equation, Energies, Spectra
12/09	16	Hydrogen - Wave Functions
12/17	17	**FINAL EXAM - Tuesday Dec 17th 8 AM**

Advice

Here are some helpful tips for success in the course, from my own personal experience and suggestions of other professors.

1. If you are having trouble, ask for help! Help is available through me via my office hours (or other appointment), other faculty in the department, and your fellow students.
2. When reading the text, be sure to read *critically*. That is, ask questions and take notes! If something is not clear, make a note of it so you can ask in class. You should also be working through steps done (or omitted) in class and the text. As a friend of mine once said "The exam will NOT ask if you agree with our solution, but will asked you to come up with your OWN solution."
3. This course will likely take a significantly greater amount of time than your previous courses, both in completing the homework and understanding the concepts. It is critical that you start your homework assignments as early as possible, as you may need a few days to solve the problem sets.
4. Don't work for more than a few hours on a problem if you're stuck! Switch to another problem (which may cause you to think about the troublesome one in a different way), and find assistance. That being said, do not despair if it is not obvious what to do after 5 minutes of thinking. These problems will require some extra thought.
5. Don't panic. Physics is hard. Like anything else worthwhile, it will take practice and perseverance to succeed, but the rewards are well worth it.