

Physics 486/686 - Quantum Mechanics II (3 cr)

Session: Spring 2023

Instructor: Prof. John B. Buncher

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Office Hours: MTWTh 10 AM – 11 AM, or by appointment

Class Meetings: TTh 12:30 PM – 1:45 PM

Location: South Engineering 221

Final: Monday, May 8, 2023, 1:00 PM – 3:00 PM

Prerequisites: PHYS 485

Course Materials

- The primary text for the course will be “Introduction to Quantum Mechanics”, by David J. Griffiths, published by Cambridge University Press, 3rd Edition.

Course Description

From the NDSU Catalog Course Description: Continuation of PHYS 485. Perturbation theory, angular momentum addition, variational schemes, WKB method, scattering theory, time dependent problems. Prereq: PHYS 485

Course Objectives

The primary goal of this course is to build on the foundational knowledge students will have acquired in Quantum Mechanics I. This will involve some new foundational knowledge, as well as approximation methods to solve problems that cannot be solved exactly. 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.

Additionally, for students enrolled in Phys 686, they will acquire a deeper knowledge of the material by “taking charge” of the course for one of the content sections, where they will be responsible (under the supervision of the instructor) for presentation of the material as well as appropriate assessments.

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

While masks are not required as we begin the 2023 spring semester, NDSU administration has determined that faculty may request mask use in their classroom. For now, I will not require masks in our classroom, but I may change that as the pandemic evolves.

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 assignments when you are no longer ill, and scheduling a time to make up any missed quizzes and exams.

If you were exposed to COVID-19, please follow CDC guidance available at <https://www.cdc.gov/coronavirus/2019-ncov/your-health/if-you-were-exposed.html>.

If you tested positive for COVID-19, please follow CDC guidance available at <https://www.cdc.gov/coronavirus/2019-ncov/your-health/isolation.html>.

Free testing kits can be picked up at the NDSU Bookstore, Library or Student Health Service. Rapid and PCR testing is available at the Student Health Service by appointment Monday through Friday during regular business hours for both symptomatic and asymptomatic students.

If public health conditions and directives from NDSU administration change, I will let you know in writing the expectations for our class moving forward.

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](http://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

Students in Phys 486 will have their final grade determined according to the following weights and cutoffs:

Homework	25%
Quizzes	15%
Exams	40% (20% each)
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.

Students enrolled in Phys 686 will have their final grade determined according to the following weights and cutoffs:

Homework	20%
Quizzes	10%
Instructional Project	10%
Exams	40% (20% each)
Final	20%

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

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.

NO CREDIT WILL BE GIVEN FOR ASSIGNMENTS TURNED IN 2 WEEKS AFTER THE DEADLINE

The purpose of homework is for you to *learn* the material via *practice* and to receive *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 spending more time doing the *physics* than you are dealing with formatting issues!

Quizzes

Quizzes will be given occasionally, covering topics that you have practiced on the homework. They will be roughly 15 minutes long. Similar to the 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.

Instructional Project (686 students only)

One of the best ways to learn material at a deeper level is to teach it to someone else. Towards that goal, you will take charge (with supervision from the instructor) of the instruction and assessment for one content area of the course. This will include: presenting an appropriate lecture (however you prefer) to engage the students in the material, identifying appropriate homework questions to assign to students, and writing a quiz question for the students to take. In the first few weeks of the course, you should meet with the instructor to identify potential topics that you are interested in.

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.

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 ??, roughly as follows

	Week	Topic
1/10	1	Two-Particle Systems (5.1)
1/17	2	Atoms & Solids (5.2, 5.3)
1/24	3	Perturbation Theory (7.1, 7.2)
1/31	4	Fine Structure & Zeeman Effect (7.3, 7.4)
2/07	5	Variational Principle & Helium (8.1, 8.2)
2/14	6	Hydrogen Molecule (8.3, 8.4)
2/21	7	Introduction to Scattering (10.1) & EXAM 1
2/28	8	Partial Wave Analysis & Phase Shifts (10.2, 10.3)
3/07	9	The Born Approximation (10.4)
3/14	10	SPRING BREAK - NO CLASSES
3/21	11	Two-Level Systems (11.1)
3/28	12	Emission & Absorption of Radiation (11.2) & EXAM 2
4/04	13	Spontaneous Emission & Fermi's Golden Rule (11.3, 11.4)
4/11	14	I'm sure we'll..
4/18	15	..go slower than planned..
4/25	16	..and need these weeks..
5/02	17	Adiabatic Approximation (11.5)
5/08	18	FINAL EXAM - Monday 1 PM

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.