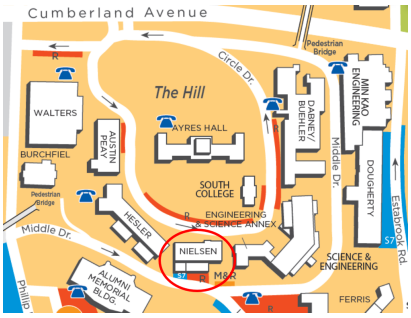
Physics 521: Quantum Physics I, Fall 2021

University of Tennessee, Knoxville

Time: TR, 1:10 PM–2:25 PM
Place: Nielsen Physics Building - 304



Instructor: Maxim O. Lavrentovich

Office location: Nielsen 406A
Office hours: MW, 3:00-4:00 PM
e-mail: `mlavrent@utk.edu`
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telephone: (865) 974-5947

Course description: First course on graduate-level quantum mechanics. Hilbert spaces. Postulates of quantum physics. Finite-dimensional and infinite-dimensional quantum mechanics. Approximation methods. Angular momentum and symmetries.
Credit Hours: 3
Course Section: 001
Notes: This is a graduate-level course! This course requires some familiarity with quantum mechanics at the undergraduate level. A minimum grade of C is required to progress to Physics 522.

Overall Goals and Learning Objectives

Quantum mechanics revolutionized our understanding of the world. To understand this revolution properly, we have to abandon classical notions and learn the principles of quantum mechanics. By the end of the course you will be able to:

- understand the postulates of quantum mechanics
- analyze basic systems quantum mechanically, including two-level systems and particle motion in a potential
- have a developed sense of the mathematical structure of quantum mechanics
- better appreciate the role of symmetries in physics
- become comfortable with the quantum mechanics of angular momentum
- appreciate the difference between infinite- and finite-dimensional Hilbert spaces
- connect the mathematical apparatus of quantum mechanics to many systems including atoms, molecules, and electromagnetic fields

How to Be Successful in This Course

Quantum mechanics by now is almost a century old. There have been countless books written on the topic, so there are many good sources for you to go to! It is important to learn how to develop your own understanding via *multiple* sources, including textbooks, scientific articles, online lecture notes, etc. The class lectures will also present topics in a unique way, so it will be important to *regularly attend class and take your own notes*. Recording your own notes will help reinforce the concepts in your memory. If you have to miss a lecture, please contact the instructor for information about what was covered. Supplemental reading material will also be provided during the course from time to time.

The majority of the learning will take place during the *completion of the homework assignments.* You should start on the assignments as early as possible, and not hesitate to ask questions about the problems. The homework should take up the majority of the work for this course outside of the classroom. You are expected to discuss with your fellow classmates, but any work you turn in should be your own. DO NOT copy solutions to problems from Internet sources. This is an act of **plagiarism** and is a serious offense as detailed in the Academic Honesty Policy.

Finally, please be sure to contact the instructor immediately about any concerns about credits earned on exams, homework, and the participation-related grade.

Materials and Textbooks

Since it is best to have some organizational principle for the topics covered, we will have a single "required" book, which is written in a modern style. However, if you find the required book unhelpful, please feel free to look at different books!

- Required textbook: *Quantum Physics* by Michel Le Bellac, Cambridge University Press; 1st Ed. ISBN: 978-1107602762. This is a nice new book on the subject that has a careful exposition. It does not cover path integration, however. I will provide different materials for this portion of the course.
- Optional textbook more popular in other versions of this course: *Modern Quantum Mechanics* by J. J. Sakurai and Jim J. Napolitano, Pearson Education; 2nd Ed. ISBN: 978-0805382914. This is a shorter book which is slightly more technical than the required. It is also a little bit more old-fashioned.
- The book I used as a graduate student is: *Quantum Mechanics* by Eugen Merzbacher, John Wiley & Sons; 3rd Ed. ISBN: 978-0471887027. The book is straightforward, but also rather technical and not particularly modern.
- You are under no obligation to follow the required book! If you do not like it, feel free to use another resource. I will be able to tell you which sections to read in your book of choice. Just ask! I recommend you search around for the resource that works best for you! I will also be posting my notes on the Canvas site.

Homework Assignments

Homeworks will be assigned roughly every two weeks. The homeworks will be due on Tuesdays at the start of class. *Electronic* copies must be turned in to the instructor on the due date before midnight. Homework submitted after the deadline *will not count.*
Exception: students who are typesetting their homework using LaTeX will receive an extra 48 hours to complete the assignments. They may turn their homework in electronically via e-mail (pdf and TeX formats).

Remember that these assignments will constitute the most important component of the course. Please take your time and put down as many details as possible for the problems. Partial credit will be awarded for demonstrating a correct train of thought. On certain homework assignments, extra credit opportunities will be available.

Quizzes

Participation is an important component of any classroom. I strongly encourage you to attend class and to ask questions! To help you motivated to come to class, short quizzes will be given in the beginning of some lectures. These are intended to make sure you are regularly attending the lectures and following the class material. The quizzes will be graded based on completion. Completing the quizzes will give me a good idea of what material requires additional review.

Exams

There will be a midterm and final exam. These exams will be open textbook and open notes. Both of the exams will be timed take-home exams where you get a 24 hour period to complete and send in the exam. The times and dates of these two exams will be announced later.

Grades

The homework is the most important component of your success in the course. The grade distribution reflects this philosophy.

Grade Distribution	
Homework	30%
Quizzes/Participation	10%
Midterm Exam	30%
Final Exam	30%

Letter Grade Distribution			
≥ 90.00	A	70.00 - 72.99	C
87.00 - 89.99	A−	67.00 - 69.99	C−
83.00 - 86.99	B+	63.00 - 66.99	D+
80.00 - 82.99	B	60.00 - 62.99	D
77.00 - 79.99	B−	57.00 - 59.99	D−
73.00 - 76.99	C+	≤ 56.99	F

Note that in some tests and homework assignments, a scaling may be applied. The scaling will not lower your grade.

Announcements

Please check the Canvas site for the course regularly for announcements and postings!

Academic Integrity

Working together on homework assignments and discussing with classmates outside of class is encouraged! However, work you turn in should be your own. Please take the time to demonstrate your own thoughts about the solutions and derivations. This is in keeping with the university honor statement:

> An essential feature of the University of Tennessee, Knoxville is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the university, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity.

COVID-19 Guidelines

With the spread of the Delta variant of COVID-19, students, faculty, and staff will be required to wear masks in classrooms, labs, and for indoor academic events required for students such as orientation. This requirement will remain in place until conditions improve and the university communicates new instructions.

The university strongly recommends that all members of the campus community be vaccinated for their own protection, to prevent disruption to the semester, and to prevent the spread of COVID-19. Vaccination information and appointment signups are available at `tiny.utk.edu/vaccine`. The Student Health Center medical staff is available to students to answer questions or discuss concerns about vaccines, and the center provides vaccines free of charge for anyone 18 years or older who would like one.

If you think you are sick or have been exposed to COVID-19, you should contact the Student Health Center or your preferred health care provider. You can also contact the university's COVID-19 support team for guidance by filling out the COVID-19 self-isolation form at `covidform.utk.edu`.

You must not attend class if you have tested positive for COVID-19 and are in the isolation period, if you have COVID-19 symptoms and have not been cleared by a medical provider, or if you are an unvaccinated close contact in the quarantine period.

If you need to miss class for illness, please contact me via Discord, e-mail, or however is convenient.

You can find more information and updates at `utk.edu/coronavirus`.

Accommodations

Please contact the instructor about any concerns or any need for accommodations! The official statement on accommodations is:

> Any student who feels s/he may need an accommodation based on the impact of a disability should contact Student Disability Services in Dunford Hall, at 865-974-6087, or by video relay at 865-622-6566, to coordinate reasonable academic accommodations.

Additional contact information:

Disability Services
915 Volunteer Blvd/100 Dunford Hall
Knoxville, TN 37996-4020
e-mail: `ods@utk.edu`
website: `http://ods.utk.edu/`

Tentative Schedule of Topics

Weeks	**Topic**	**Chapters**
1-2	foundations of quantum mechanics, finite-dimensional Hilbert spaces, qubits	1-3
3-4	postulates of quantum physics, conceptual issues, time evolution	4
5-7	infinite-dimensional Hilbert spaces, wave mechanics, harmonic oscillator	7, 9, 11 reading
8	a few applications: benzene, ammonia, NMR	5
9	entanglement, density operators, EPR paradox	6
10-11	perturbation theory, variational methods, WKB	14
12-13	degenerate perturbation theory, addition of angular momentum	14, 10
14-15	addition of angular momentum	10