Quantum Mechanics

Class Times: Monday/Thursday 10:00am – 11:50am

Me
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Office Hours: Tuesdays 2-3:30pm, Wednesday 1-2:30pm, *or by appointment*

Texts: Quantum Physics: A Fundamental Approach to Modern Physics, by J.S. Townsend
(*optional*) The Feynman Lectures on Physics, Volume III (*a different perspective*)
(*optional*) Modern Physics by K. Krane (*a lower-level book, but good on the things it covers*)

Course Page: Course material will be posted at https://crowl.bennington.edu/qm/

Course Overview: The microscopic world is fundamentally different from the macroscopic one we encounter on a daily basis. The classical view of particles, mass, and even location break down at the smallest scales. The development of quantum mechanics as a field in the 1920s was a fundamental leap forward for our understanding of atomic physics. Countless current technologies and scientific disciplines rely on the principles predicted by the quantum model. Despite this, quantum mechanics is deeply weird. Particles do not exist solely as particles, but also as waves. Fundamental physical properties such as position, momentum, energy, and time are subject to uncertainties that have nothing to do with measurement precision and everything to do with fundamental universal limits. In this course, we will discuss atomic physics, the wave-particle duality, the uncertainty principle, the application of the Schrödinger equation, and quantum mechanical models of atoms.

On the Quantitative Nature of this Class: This class is highly quantitative. This means that you should feel very comfortable working on quantitative problems. It is expected that you have already taken calculus and are comfortable with both differential and integral calculus. While calculus is a prerequisite, much like the math in Intro Physics, it's often not actually **doing** the math that's the hard thing – it's figuring out how to apply the math to the physical situations.

Problem Sets: You will be assigned a problem sets regularly throughout the term. These problem sets will take different forms, but will usually contain a mix of qualitative short answer questions and quantitative problems. **On the quantitative problems, you are required to show your work and state any assumptions you make**. This allows me to award partial credit where warranted, and to know that you understand the steps you took to reach the answer. Given that the answers to the odd problems are in the back of the book, getting the correct answer is unimpressive; demonstrating ***how*** to get to the correct answer is critical.

A note on collaboration: Collaboration on problem sets is welcome and, in fact, encouraged (and, perhaps, ***necessary****). One of the best ways to learn something difficult is to work through it with others. I recommend that you* ***work on problem sets together and write them up individually****. This work method is one of the best ways to ensure that you understand the material. While it is in your best interest to make sure that you understand the material on the problem sets,* ***the problem sets are for you to understand the material****. For this reason, you can complete the problem sets in any way that works for you – individually or working in groups.* ***However, as with any work you do, it is important to acknowledge colleagues that contributed to the work. For this reason, please list your collaborators on your problem sets.***

Class Participation: There is a huge amount of educational research showing that lecture alone is ineffective in ensuring a deep understanding. In the last couple decades, interactive lecturing has found its way into large lecture classrooms. We're really lucky here at Bennington that we don't need to figure out how to lecture to 200-person classes, but it still makes sense to employ many of the techniques used for those larger classes.

Voting Cards
I will give you a card at the beginning of the term, which allows you to represent one of four choices. There will be several opportunities to vote and confer with your neighbors. These discussions and participating in class voting are an important part of your class participation grade.

Active Participation in Class
This is a small, upper-level class. I expect everyone in class to ask questions, participate in discussions, help to work on problems, and generally contribute to a positive classroom environment. I recognize that some students are more comfortable doing this than others, but my expectations are that you will contribute to the best of your ability.

Please **do not use laptops, tablets, phones, etc.** in class. Taking physics notes using a keyboard is close-to-impossible and these devices can be a distraction. I'm open to individual exceptions where appropriate; please come talk to me.

Please note that *class attendance is mandatory*. Missing even one class can seriously affect your class participation grade. Missing more than 2 classes during the semester may lead to you failing the class. See me in extraordinary circumstances.

Exams: There will be two exams: a midterm and a final. The final will be cumulative, but will focus on the second half of the semester. The exams will be a mix of qualitative short answer questions and quantitative problems.

Resources for Help: Developing an understanding of advanced physics topics can be challenging. It is likely you will need help. There are a number of options for getting help:

- *Work with each other*: In general, I expect you will collaborate in this class (with one another, and with me!). You are strongly encouraged to help each other out, commiserate, etc.
- *Ask questions at the start of class:* The first part of each class session is generally reserved for questions/discussions about currently assigned problem sets. Please come to class with any questions you have.
- *Come to Office Hours*: Please make a plan to attend my office hours. While I do have set office hours (see beginning of syllabus), I am also happy to meet with you at other times that work for both of us. We can either meet in person or find a time for a Zoom meeting. Talk to me or send me an email to set up a time.

Academic Accommodations: Bennington College provides reasonable accommodations to students with documented disabilities when such accommodations are requested and necessary to ensure equal access to College programs and facilities. If you believe you are entitled to an accommodation speak with Katy Evans, the Academic Services and Accommodations Advisor, about any disability-related needs. If approved, you will receive a memo detailing your specific accommodations; it is your responsibility to provide me with the memo and discuss the implementation of accommodations. Note that I will not be aware of your needs if you do not share this memo with me. Accommodations are not retroactive, so the sooner we meet to discuss your needs, the better. Also, students experiencing mental and/or physical health challenges that are significantly impacting their academic work are encouraged to speak with their faculty advisor and member of Academic Services (academicservices@bennington.edu or 440-4400) about the impact and to connect with resources through health and psychological services (440-4426 or 440-4451).

Evaluation/Grading (subject to tweaking)**:**

40% Problem Sets 15% Class Participation 20% Midterm Exam 25% Final Exam

Tentative Schedule (likely to change)

Week of	**Topic**	**Reading**
February 17	Foundations/Waves	Townsend Ch. 1.1
February 24	Light as Waves and Particles	Townsend Ch. 1.2-1.8, 7.6
March 3	Matter as Waves and Particles	Townsend Ch. 2.1-2.2
March 10	The Schrödinger Equation (*No Thursday Class)*	Townsend Ch. 2.3-2.4
March 17	Quantization of Matter / The Uncertainty Principle	Townsend Ch. 2.4-2.10
March 24	Particle in a Box	Townsend Ch. 3.1-3.2
March 31	Review (Monday) / Midterm Exam (Thursday)	
April 7	Eigenvalues and Eigenstates (*No Monday Class)*	Townsend Ch. 3.3-3.4
April 14	One Dimensional Potentials	Townsend Ch. 4
April 21	One Dimensional Potentials	Townsend Ch. 4
April 28	Principles of Quantum Mechanics	Townsend Ch. 5
May 5	Principles of Quantum Mechanics	Townsend Ch. 5
May 12	Quantum Mechanics in 3D	Townsend Ch. 6
May 19	Quantum Mechanics in 3D	Townsend Ch. 6
May 26	Final Exam (Monday, May 26)	