0 Syllabus: Quantum Mechanics I

Course: NYU PHYS-UA 123 Quantum Mechanics I
Semester: Fall 2026
Instructor: Jesse Liu (jesse.liu2 [at] nyu [dot] edu)
Lectures: Tuesday and Thursdays, 11:00am–12:15pm, Meyer 122
Office hours: Thursday, 2:00–3:00pm, 726 Broadway Room 852

Recitations:
Section 002: Broadway 1045 Mondays 2:00–3:15pm. Recitation leader: Jaewoo Lee (jl6264 [at] nyu [dot] edu)
Section 003: Broadway 1045 Tuesdays 2:00–3:15pm. Recitation leader: Jaewoo Lee
Section 004: Meyer 264 Tuesdays 4:55–6:10pm. Recitation leader: Paul John Balderston (pjb9896 [at] nyu [dot] edu)

Undergraduate Program Administrator: Bill LePage (wlp1 [at] nyu [dot] edu)

0.1 Course overview

This is an upper-division undergraduate introduction to quantum mechanics. The course is primarily aimed at physics majors who have taken a calculus-based sequence of physics classes. The course covers the topics listed in the official NYU Bulletin:

> *foundational experiments; wave-particle duality; wave functions; the uncertainty principle; the time-independent Schrödinger equation and its applications to one-dimensional problems and the hydrogen atom; angular momentum; spin; Hilbert Space, operators, and observables; time independent perturbation theory; atomic spectra.*

Lecture and homework schedule

Lecture and recitation attendance is expected. In case of absences, it is the student's responsibility to catch up by reading the relevant lecture notes. Tentative lecture and exam schedule (subject to change) along with homework (HW) due dates are:

Introduction

1. Sep 3: Foundational experiments. Wave-particle duality. **Set HW1: due Sep 10**.
2. Sep 8: Atomic spectra. Radioactivity and nucleus. Bohr model.
3. Sep 10: Wavefunction, probability amplitudes. **Set HW2: due Sep 17**.

4. Sep 15: Schrödinger equation. Probability conservation. Stationary states.

Wave mechanics

5. Sep 17: Infinite well and Dirac delta potential. **Set HW3: due Sep 24**.
6. Sep 22: Bound states in finite well.
7. Sep 24: Fourier transform. Gaussian wavepacket. **Set HW4: due Oct 1**.
8. Sep 29: Scattering and tunnelling.

Operator formalism

9. Oct 1: State vectors. Dirac notation. Inner product. **Set HW5: due Oct 8**.
10. Oct 6: Hermitian operators and observables.
11. Oct 8: Measurement. Commutation relations. **Set HW6: due Oct 15**.
12. Oct 13: Harmonic oscillator. Ladder operators.
13. Oct 15: Uncertainty principle. Ehrenfest theorem. **HW: study for mid-term 1**.
14. Oct 20: Mid-course review.
15. Oct 22: ***Mid-term exam 1 (lectures 1–11).*** **Set HW7: due Oct 29**

Spherical systems

16. Oct 27: Orbital angular momentum.
17. Oct 29: Quantizing angular momentum. **Set HW8: due Nov 5**.
18. Nov 3: Spherical harmonics.
19. Nov 5: Hydrogen radial equation. **Set HW9: due Nov 12**.
20. Nov 10: Stern-Gerlach experiment. Spin half.
21. Nov 12: Spin algebra. Magnetic precession. **HW: study for mid-term 2**.
22. Nov 17: Identical particles. Two spin-half particles.
23. Nov 19: ***Mid-term exam 2 (lectures 12–21)***.

Atomic spectra

24. Nov 24: Hydrogen gross structure. **Set HW10: due Dec 3**.

    Nov 26: No class — Thanksgiving recess.
25. Dec 1: Time-independent perturbation theory.
26. Dec 3: Fine structure. Spin-orbit coupling.
27. Dec 8: Helium. If time permits: Bell's inequality (optional). **HW: study for final**.
28. Dec 10: Comprehensive review of course.

    Dec 17 (tentative): ***Final exam*. 12pm–1:50pm following Albert schedule TBC.**

Recitation schedule

Recitation sections on Monday/Tuesdays discuss solutions to homework problems and corresponding lectures, with a tentative schedule below as guidance, but recitation leaders have discretion on content and how they are run:

Sep 7/8: No recitations (Labor Day).

1. Sep 14/15: Discuss homework 1 and lecture 1.
2. Sep 21/22: Discuss homework 2 and lectures 2–3.
3. Sep 28/29: Discuss homework 3 and lectures 4–5.
4. Oct 5/6: Discuss homework 4 and lectures 6–7.

   Oct 13/14: No recitations (Fall break; Oct 14 is Legislative Monday).
5. Oct 19/20: Discuss homework 5 and lectures 8–9.
6. Oct 26/27: Discuss homework 6 and lectures 10–11.
7. Nov 2/3: Discuss homework 7 and lecture 12.
8. Nov 9/10: Discuss homework 8 and lectures 15–16.
9. Nov 16/17: Discuss homework 9 and lectures 17–18.

   Nov 23/24: No recitations (Thanksgiving week).

   Nov 30/Dec 1: No recitations (no homework due week before).
10. Dec 7/8: Discuss homework 10 and lectures 19–23.

Prerequisites

Mathematical Physics (PHYS-UA 106)
Dynamics (PHYS-UA 120)
Calculus III (MATH-UA 123)

Assessment

Assessed coursework components are:

- Homework assignments (40%). These are due at 11:59pm on the Thursday noted at the assignment header. Solutions are presented in the recitations.
- Two in-class midterm exams (25% each).
- In-person final exam (30%). Date and time follows the university schedule on Albert.

Assessed component weights sum to 120%, but you will only be graded out of 100%. For example, if you complete all coursework but miss one mid-term exam, this incomplete mid-term scores zero but drops 5% rather than 25% of your final grade. This generous policy is designed to accommodate brief illness or unexpected absences during the semester. It means that out of fairness to every student, there are strictly **no make-up exams and no extra credit** for this class. All exams are closed book. Final assigned letter grades are not negotiable.

All homework assignments are made available at the start of the semester to accommodate flexibility in their completion. Assignment "set" dates reflect one week before they are due, but students requiring more time can start them well in advance. Therefore, **no extensions are granted** beyond the due date and **late homework submissions receive zero credit**. Submitted work is assessed by these guidelines at the grader's discretion:

- 4: Excellent; complete, accurate solutions; easy to follow working that is clearly and logically organized; sound explanations and physical justifications.
- 3: Good; mostly complete solutions with minor inaccuracies; organized working; some explanations and physical justifications.
- 2: Fair; partly complete solutions with some inaccuracies; working requires effort to follow; few explanations and physical justifications given.
- 1: Poor; partial attempts with inaccurate solutions; no working or explanations given.
- 0: Late or incomplete submissions.

Academic integrity

You should attempt assignments yourself first before collaborating with others in the class. You must show all your working and **hand write** your own assignments that represent ***your* original work** before turning in scans on Brightspace. Your work must be legible at the grader's discretion to receive credit. You may not share with others or upload course materials, problem sets or solutions to online forums or artificial intelligence software.

In completing homework assignments, you may use textbooks, lecture notes, scientific calculators and software with equivalent functionality, such as `Mathematica` or `Python`, to aid and check numerical calculations. However, copying directly from other students or tutors, solutions manuals, online forums, artificial intelligence software or any other source is prohibited and conflicts with academic integrity policy. Generative artificial intelligence may be appropriate in some courses, but its use is beyond the scope of this class. Just as we still learn vocabulary or arithmetic by heart and hand despite the invention of spellcheck and calculators, learning quantum physics requires thinking and problem solving by hand.

0.2 Literature

Textbooks While I provide lecture notes and there is no required textbook, I recommend picking one or two to read alongside from Bobst Library: QC174 on 9th floor or many are available online marked [NYU library] below via NYU login. Undergraduate textbooks I found useful in preparing this course include:

- James Binney and David Skinner, *The Physics of Quantum Mechanics*, Oxford University Press (2013). An exacting book from the course I took, which emphasizes operator methods. Oxford recorded Prof Binney's lectures online. [NYU library]
- Ana María Cetto and Luis de la Peña, *Quantum Mechanics: A Physical Approach*. Cambridge University Press (2025). New insightful textbook published open access.
- David Griffiths and Darrell Schroeter, *Introduction to Quantum Mechanics*, 3rd Edition, Cambridge University Press (2018). Popular textbook. [NYU library]
- David McIntyre, Corinne Manogue and Janet Tate, *Quantum Mechanics: A Paradigms Approach*. Educators encouraging "spins first" use this standard. [NYU library]
- Alastair Rae and Jim Napolitano, Quantum Mechanics, 6th Edition, CRC Press (2015). Well-regarded textbook I used as an undergraduate. [NYU library]
- Ramamurti Shankar, *Principles of Quantum Mechanics*, 2nd Edition, Springer (1996). I found the discussion on vector spaces clear as an undergraduate. [NYU library]
- David Tong, *Quantum Mechanics*, Cambridge University Press (2025). New textbook in a series based on the Cambridge theoretical physics course.
- John Townsend, *A Modern Approach to Quantum Mechanics*, 2nd edition, University Science Books (2012). Classic textbook I found illuminating as a student.

Mathematical methods This course is mathematical so have a standard review on hand:

- George Arfken, Hans Weber and Frank Harris, Mathematical Methods for Physicists, 7th Edition, Academic Press (2012). [NYU library]
- Mary Boas, Mathematical Methods in the Physical Sciences, 3rd Edition, Wiley (2006).

Online materials There is also high-quality literature online, for example:

- James Binney and David Skinner. Robust lecture notes I used as an undergraduate.
- Henning Schomerus. High quality notes in web friendly format.

- Daniel Schroeder. Insightful `Mathematica` approach with beautiful diagrams.
- Ben Simon. For advanced quantum mechanics course with experimental perspectives.
- David Tong and its advanced sequel. Theoretical yet lucid and engaging.
- LibreTexts Quantum Mechanics. Collection of open access online textbooks.

0.3 Structure and approach

Quantum mechanics is profound yet practical science. It defies intuition but the payoff is enormous: chemistry, astronomy, subatomic physics, materials, lasers, solar cells, phones, cameras, computers, transistors, light emitting diodes, medical imaging, atomic clocks, superconducting magnets. There are no surprises in the standard topics for this course, but textbooks still debate ordering, whether to teach waves, operators, spins, postulates, experiments, or history first. Mathematical methods at the level of PHYS-UA 106 is assumed.

The course has five parts. *Introduction* unabashedly underscores empiricism in the discovery of quantum mechanics, starting with the Davisson-Germer experiment both because it took place in New York and the electron is the protagonist of this class. *Wave mechanics* builds intuition by solving the time-independent Schrödinger equation in one dimension with step potentials to introduce quantization, uncertainty principle, and tunnelling. *Operator formalism* generalizes wavefunction intuition with Dirac notation into theoretical postulates then solves the harmonic oscillator via ladder operators. *Spherical systems* extends to the three-dimensional two-body problem of hydrogen before introducing spin via the Stern-Gerlach experiment and identical particles. *Atomic spectra* presents hydrogen gross structure before introducing time-independent perturbation theory up to fine structure as stepping stones for Quantum Mechanics II (PHYS-UA 124). Interpretations and Bell inequalities are not on syllabus, but optional reading serves as invitations to wider literature.

The semester has 26 lectures and two in-class mid-term exams scheduled. Each 75-minute lecture typically introduces four to six pages of new material, where this pace means reading ahead is encouraged. There is also no substitute from completing the ten homework assignments and recitation participation, which are designed to consolidate learning. Two planned lectures review course material preceding the first mid-term and final exams.

Lastly, while the physics topics are standard, the notes endeavour to extend conventional textbooks in the history of quantum physics by also highlighting contributions from often-overlooked scientists beyond Nobel laureates and local New York developments.