Fall 2026 **Syllabus**
Physics 621: Quantum Mechanics I

TTh 11:00-12:20 in Small Hall room 122

Prerequisite: undergraduate quantum mechanics (two semesters)

Instructors

Prof. Seth Aubin
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Russell Kamback
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Office hours: Aubin: Wednesday, 4-5 pm, and open office hours policy.
Kamback: Wednesday, noon – 1 pm.

Course Objectives

The primary purpose of this course is to cover the physical and mathematical foundations of quantum mechanics and to use these for basic calculations of the behavior of particles/waves.

The course will cover the following topics:

- Postulates of quantum mechanics.
- Canonical quantization procedure.
- Wavefunctions, Hilbert spaces, Dirac notation (bras & kets).
- Schrodinger, Heisenberg, and interactions representations.
- Commutators and uncertainty relations.
- Hamiltonian formalism, Schrodinger's equation.
- 2-level systems: avoided crossings, time evolution.
- Generators of translations, rotations, and time evolution.
- Theory of angular momentum, spin.
- Addition of angular momenta, Clebsch-Gordan coefficients.
- Identical particles, bosons, fermions (tentative).
- Gauge transformations, canonical momentum (tentative)
- Hydrogen atom.
- Density matrix, statistical mixtures, decoherence.
- Entanglement.
- Feynman path integral approach.

Course Materials

Text: Most of the course materials and problem sets will be taken from the following required text for the course:

Modern Quantum Mechanics, by J. J. Sakurai and J. Napolitano (3rd ed., 2021).

Some course materials will also be taken from the following texts:

Quantum Mechanics, by L. D. Landau and E. M. Lifshitz (3rd ed., 2003).

Quantum Mechanics, by C. Cohen-Tannoudji, B. Diu, and F. Laloë (1st ed., 1992).

Quantum Mechanics, by L. I. Schiff (3rd ed, 1968).

Introduction to Quantum Mechanics, by D. J. Griffiths (1995).

Evaluations

Your final grade for the course will be determined from the following grading weight distribution:

Problem sets:	15%	(all problem sets must be turned in)
Participation:	15%	
Midterms:	40%	
Final Exam:	30%	

Problem sets: The problem sets are the main mechanism for earning in this course. Students are expected to do the problems on their own (not as a team effort with other students), though discussion and limited oral consultation with other students is encouraged. Artificial intelligence generated solutions are NOT an acceptable method for solving homework problems.

Participation: The classroom presentation of course material will involve class discussions. All students are expected to participate in these discussions, since they will help elucidate the course material. Participation also reflects class attendance and quizzes.

Midterms: There will be two midterm tests to assess your learning of course concepts and problem-solving skills.

Final exam: The final exam will cover all the material in the course.

Important academic deadlines

Add/drop deadline: Friday, September 4, 2026
Withdraw deadline: Monday, October 26, 2026

Weekly Schedule (tentative)

Week 0: 8/27 **Review of basic quantum mechanics**
Foundational experiments, interference, superposition, particles & waves.

Week 1: 9/1-3 **Mathematical foundation of QM**
Vector spaces, Bra-Ket notation, Hilbert spaces, Hermitian operators.

Week 2: 9/8-10 **Postulates of QM**
Postulates of QM, wavefunctions, probabilities, q-p representations, Schrodinger eq.

Week 3: 9/15-17 **Observables, position, momentum, time, energy**
Generator of translations, generator of time evolution, Hamiltonian, Heisenberg picture.

Week 4: 9/22-24 **QM basics: 2-state systems**
Eigenenergies, eigenstates, avoided crossings, time evolution, Josephson oscillations.

Week 5: 9/29-10/1 **Schrodinger equation in 1D**
Midterm #1, free particle, scattering by a barrier, tunneling, square well potential.

Week 6: 10/6 **Quantum harmonic oscillator**
Creation and annihilation operators, Foch states, coherent states.

---------- *Fall Mini-Break* ----------

Week 7: 10/13-15 **Angular Momentum 1**
Orbital angular momentum, spin, commutators, raising & lowering operators.

Week 8: 10/20-22 **Angular momentum 2**
Generator of rotations, spherical harmonics, Euler angles,

Week 9: 10/27-29 **Addition of angular momenta**
Addition of operators, Clebsch-Gordan coefficients.

Week 10: 11/3-5 **Schrodinger equation in 3D**
Central potential, spherical square well, hydrogen atom.

Week 11: 11/10-12 **Hydrogen atom**
Midterm #2, Hydrogen atom, spin-orbit coupling, hyperfine Hamiltonian.

Week 12: 11/17-19 **Particle+EM Field OR Identical Particles (tentative)**
Gauge transformations, canonical momentum, bosons and fermions.

Week 13: 11/24 **Density matrix and decoherence**
Entanglement, statistical mixtures, coherence, decoherence, density matrix.

---------- *Thanksgiving Break* ----------

Week 14: 12/1-3 **Feynman path integral formulation**
Propagators, Feynman path integral picture, semi-classical picture of QM.

December 7, 2026, 2-5 pm **Final Exam**

E-mail policy

Feel free to communicate with S. Aubin or R. Kamback via e-mail. We cannot guarantee that we will read e-mails sent in the evening until the next day.

Student Accessibility Services

William & Mary accommodates students with disabilities in accordance with federal laws and university policy. Any student who feels that's/he/they may need an accommodation based on the impact of a learning, psychiatric, physical, or chronic health diagnosis should contact Student Accessibility Services staff at 757-221-2512 or at sas@wm.edu to determine if accommodations are warranted and to obtain an official letter of accommodation. For more information, please see www.wm.edu/sas.

Honor Code (from W&M website)

William & Mary has had an honor code since at least 1779. Academic integrity is at the heart of the university, and we all are responsible for upholding the ideals of honor and integrity. The student-led honor system is responsible for resolving any suspected violations of the Honor Code, and I will report all suspected instances of academic dishonesty to the honor system. The Student Handbook (www.wm.edu/studenthandbook) includes your responsibilities as a student. Your full participation and observance of the Honor Code is expected. To read the Honor Code, see www.wm.edu/honor.

Academic dishonesty includes cheating, plagiarism, unauthorized collaboration, and the use of unauthorized materials, as well as the use artificial intelligence systems for generating solutions to homework problems or similar (e.g., ChatGPT, Claude, etc).

Mental and Physical Well-Being

W&M recognizes that students juggle different responsibilities and can face challenges that make learning difficult. There are many resources at W&M to help students navigate emotional/psychological, physical/medical, material/accessibility concerns. Asking for help is a sign of pro-action. If you or someone you know is experiencing any of these challenges, we encourage you to reach out to the following offices:

• For psychological/emotional stress, please consider reaching out to the W&M Counseling Center https://www.wm.edu/offices/wellness/counselingcenter/; or (757) 221-3620, 240 Gooch Dr., 2nd floor. Services are free and confidential.

• For physical/medical concerns, consider reaching out to the W&M Health Center at https://www.wm.edu/offices/wellness/healthcenter/; or (757) 221-4386, 240 Gooch Drive.

• For additional support or resources, please contact the Dean of Students by submitting a Care Report at https://www.wm.edu/offices/deanofstudents/services/caresupportservices/index.php; or by calling 757-221-2510, or by emailing deanofstudents@wm.edu.