

Physics 404 (Fall 2020): Quantum Mechanics

(Course No. 21:750:404)

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Lecture times: M & Th 1pm – 2.20pm

Office Hours: M 12pm, or by arrangement

Location: Online, Zoom room <https://rutgers.zoom.us/my/nm169>

Pre-requisites: Mechanics 361, E&M 385 & 386

Course Description: This course is intended for students who have completed a course in modern physics that includes an introduction to concepts in quantum mechanics. Students will learn the formalism of quantum mechanics using Dirac notation, operators, and eigenfunctions; methods for solving the time-independent Schrödinger equation for both one-dimensional and three-dimensional problems; time independent and time-dependent perturbation theory; variational principle; WKB approximation. This course will give students a good working knowledge of quantum mechanics and a firm foundation to move on to more advanced graduate courses in quantum mechanics.

Learning Outcomes: After successful completion of the course, the student will have gained a basic working knowledge of non-relativistic quantum mechanics, understood the quantum mechanical axioms and matrix representations, be able to apply the principles of quantum mechanics to calculate observables on known wavefunctions, be able to solve the time-independent and time-dependent Schrödinger equation for simple potentials, be able to apply approximate methods to solve problems.

Text: The lectures will be based on a few texts that I have found useful in the past. These are listed below, and most of them are available online. Let me know if you have trouble finding.

David J. Griffiths, *Introduction to Quantum Mechanics*, 1st or 2nd ed. (Pearson Prentice Hall). (This will be the primary text, but the lectures will draw material also from the others).

B. H. Bransden and C. J. Joachain, *Quantum Mechanics*, 2nd Ed. (Pearson, 2000)

C. Cohen-Tannoudji, B. Diu, and F. Laloe, *Quantum Mechanics*, 2nd Ed. (Wiley, 1991)

Grading: There will be homework about every two weeks (15% of grade), in-class quizzes (10% of grade), two midterms (2x20% of grade), and a final exam (35% of grade). You may work collaboratively with other students on the homework provided you list the names of the students on the front page. The quizzes, midterms, and final are *not* collaborative 😊

Tentative Syllabus:

1. The Wavefunction (probabilistic interpretation, normalization, position versus momentum representation)
2. The Time-Independent Schrödinger Equation (stationary states, characteristics of solutions for general one-dimensional problems, infinite square well, harmonic oscillator, free particle, delta-function potential, finite-square well)

3. Formalism (states and operators, expansions in eigenfunctions, observables, commutators, compatibility, uncertainty relations, unitary transformations, Dirac notation, matrix representations of wavefunctions and operators, the Schrödinger and Heisenberg pictures)
4. Quantum Mechanics in Three Dimensions (Schrödinger equation in spherical coordinates, orbital angular momentum, spin, the hydrogen atom)
5. Time-Independent Perturbation Theory (non-degenerate and degenerate, fine structure of hydrogen, Zeeman effect, hyperfine splitting)
6. Time-Dependent Perturbation Theory (two-level systems, emission and absorption of radiation, spontaneous emission)
7. The Variational Principle (Rayleigh-Ritz minimization, helium atom)
8. The WKB approximation (classical region, tunneling)

Accommodation and Support Statement

Rutgers University Newark (RU-N) is committed to the creation of an inclusive and safe learning environment for all students and the University as a whole. RU-N has identified the following resources to further the mission of access and support:

For Individuals with Disabilities: The Office of Disability Services (ODS) is responsible for the determination of appropriate accommodations for students who encounter barriers due to disability. Once a student has completed the ODS process (registration, initial appointment, and submitted documentation) and reasonable accommodations are determined to be necessary and appropriate, a Letter of Accommodation (LOA) will be provided. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at ods.rutgers.edu. Contact ODS at (973)353-5375 or via email at ods@newark.rutgers.edu.

For Individuals who are Pregnant: The Office of Title IX and ADA Compliance is available to assist with any concerns or potential accommodations related to pregnancy. Students may contact the Office of Title IX and ADA Compliance at (973) 353-1906 or via email at TitleIX@newark.rutgers.edu.

For Absence Verification: The Office of the Dean of Students can provide assistance for absences related to religious observance, emergency or unavoidable conflict (e.g., illness, personal or family emergency, etc.). Students should refer to [University Policy 10.2.7](#) for information about expectations and responsibilities. The Office of the Dean of Students can be contacted by calling (973) 353-5063 or emailing deanofstudents@newark.rutgers.edu.

For Individuals with temporary conditions/injuries: The Office of the Dean of Students can assist students who are experiencing a temporary condition or injury (e.g., broken or sprained limbs, concussions, or recovery from surgery). Students experiencing a temporary condition or injury should submit a request using the following link: <https://temporaryconditions.rutgers.edu>.

For English as a Second Language (ESL): The Program in American Language Studies (PALS) can support students experiencing difficulty in courses due to English as a Second Language (ESL) and can be reached by emailing PALS@newark.rutgers.edu to discuss potential supports.

For Gender or Sex-Based Discrimination or Harassment: The Office of Title IX and ADA Compliance can assist students who are experiencing any form of gender or sex-based discrimination or harassment, including sexual assault, sexual harassment, relationship violence, or stalking. Students can report an incident to the Office of Title IX and ADA Compliance by calling (973) 353-1906 or emailing TitleIX@newark.rutgers.edu. Incidents may also be reported by using the following link: tinyurl.com/RUNReportingForm. For more information, students should refer to the University's Student Policy Prohibiting Sexual Harassment, Sexual Violence, Relationship Violence, Stalking and Related Misconduct located at <http://compliance.rutgers.edu/title-ix/about-title-ix/title-ix-policies/>.

For support related to interpersonal violence: The Office for Violence Prevention and Victim Assistance can provide any student with confidential support. The office is a **confidential resource** and does *not* have an obligation to report information to the University's Title IX Coordinator. Students can contact the office by calling (973) 353-1918 or emailing run.vpva@rutgers.edu. There is also a confidential text-based line available to students; students can text (973) 339-0734 for support.

For Crisis and Concerns: The Campus Awareness Response and Education (CARE) Team works with students in crisis to develop a support plan to address personal situations that might impact their academic performance. Students, faculty and staff may contact the CARE Team by using the following link: tinyurl.com/RUNCARE or emailing careteam@rutgers.edu.

For Stress, Worry, or Concerns about Well-being: The Counseling Center has confidential therapists available to support students. Students should reach out to the Counseling Center to schedule an appointment: counseling@newark.rutgers.edu or (973) 353-5805. If you are not quite ready to make an appointment with a therapist but are interested in self-help, check out *TAO at Rutgers-Newark* for an easy, web-based approach to self-care and support: <https://tinyurl.com/RUN-TAO>.

For emergencies, call 911 or contact Rutgers University Police Department (RUPD) by calling (973) 353-5111.