Physics 424: Quantum Mechanics II
Lehigh University, Fall 2018

Instructor: Ariel Sommer
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Class: TR 9:20 – 10:35 am, Lewis 311

In this course, you will learn how to predict the time evolution and interaction of quantum systems such as electrons, atoms, photons, and spins. The material in this course has applications in most areas of physics, especially atomic, molecular, solid-state, nuclear, particle, and laser physics.

Textbooks:
N. Zettili, *Quantum Mechanics: Concepts and Applications*, Wiley, 2009
M. Le Bellac, *Quantum Physics*, Cambridge, 2006

Topics:
- Review: postulates of quantum mechanics and basic quantum systems
- Time-dependent perturbation theory
- Quantization of the electromagnetic field and spontaneous emission
- Multipartite systems and identical particles
- Angular-momentum coupling
- Scattering theory
- Density matrices, mixed states, and entanglement

Grading:
Final grades will be based on homework, three quizzes, a final exam, and class participation. The weights will be:

Homework	30%
Quizzes	30%
Final	30%
Participation	10%

Homework: Assignments will be due weekly in class. You are expected to turn in homework on time. Homework will be graded based on completeness, correctness of method, and clarity. Clarity means that the method of solution and basic equations are clearly stated, the solution is well-organized, all relevant work is shown, handwriting is readable, and graphs are labeled.

Late homework: Please contact the instructor if you would like to request an extension due to illness or other circumstances. Homework turned in late without an extension will receive partial credit.

One class after the assignment is due: 80% credit
Two classes after the assignment is due: 60% credit
More than one week late: 10% reduction for each additional class day late

Final exam: The final exam will have three parts, corresponding to the topics covered by the three quizzes. A better score on a part of the final exam than on the corresponding quiz will replace half of the quiz grade with the improved final grade. For example, if you receive a grade Q_1 on quiz 1 and F_1 on the quiz 1 part of the final, your grade for quiz 1 will be counted as $\frac{1}{2}Q_1+\frac{1}{2}\max(Q_{1,}F_1)$

Participation: Good participation includes regular attendance, engagement in in-class discussions, and taking part in in-class activities.

Learning Outcomes: After successfully completing the course, students should be able to:

A. Apply the course material in a direct way to solve problems. Examples include the following.
    1. Postulates of quantum mechanics and basic quantum systems:
        a. Represent the states of quantum systems using state vectors
        b. Compute the probabilities of measurement outcomes
        c. Find the eigenstates and eigen-energies of free particles, harmonic oscillators, a spin in a magnetic field, and the hydrogen atom
    2. Time-dependent perturbation theory:
        a. Predict approximate time-evolution of quantum states and transition probabilities
        b. Predict time-evolution of observables
        c. Apply Fermi's Golden Rule to predict transition rates into a continuum
    3. Multipartite systems and identical particles:
        a. Describe composite quantum systems using a tensor product of states
        b. Construct two-body and many-body wavefunctions for identical bosons and fermions
    4. Angular-momentum coupling:
        a. Compute eigenstates and eigenvalues of total angular momentum
        b. Apply the Wigner-Eckart Theorem to evaluate matrix elements
    5. Scattering theory:
        a. Calculate scattering amplitudes and cross sections in non-relativistic collisions
        b. Find partial-wave phase shifts for spherically symmetric potentials
    6. Quantization of the electromagnetic field and spontaneous emission:
        a. Compute spontaneous emission rates for excited states of charged-particle systems
        b. Describe the electromagnetic field in terms of ladder operators
    7. Density matrices, mixed states, and entanglement:
        a. Compute expectation values of observables for systems in mixed states
        b. Distinguish between pure and mixed quantum states
        c. Describe the time evolution of density matrices

B. Demonstrate conceptual understanding of the course material. Examples:
    1. Determine the conditions of validity for a given method
    2. Analyze limiting cases to check the validity of a solution
    3. Creatively apply the course material to unfamiliar problems
    4. Explore the physical implications of a solution to a problem

Accommodations for Students with Disabilities: If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community: Lehigh University endorses The Principles of Our Equitable Community [http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.