Quantum Mechanics I
Physics 369

Department of Physics at Lehigh University

Spring 2018

Instructor: Gary G. DeLeo

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Text: Concepts in Quantum Mechanics, Vishnu Swarup Mathur and Surendra Singh, CRC Press (2009)

General Course Requirements:

Requirements include: (i) reading assigned materials prior to class, (ii) attending all lectures, (iii) completing all homework problems on time, (iv) seeing the instructor if you are having trouble.

Grading:

Your numerical grade will be determined as follows:

Hour Exam 1	20%
Hour Exam 2	20%
Final Examination	30%
Homework	20%
Attendance	10%
TOTAL	**100%**

Primary Topics:

Review of Basics
Quantum Mechanical Formalism
Selected Time-Dependent and Time-Independent Applications
Symmetries and Conservation Laws
Angular Momentum Formalism and Applications
Time-Independent Perturbation Theory and Applications

As Time Permits:

Quantum Weirdness
Other Applications

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.*

Some Other Textbooks

Quantum Mechanics, 3rd ed., E. Merzbacher, Wiley (1998)

Modern Quantum Mechanics, revised, J. J. Sakuri, Addison Wesley Longman (1994)

Quantum Mechanics with Basic Field Theory, B. R. Desai, Cambridge (2009)

Quantum Mechanics, C. Cohen-Tannoudji, B. Diu, and F. Laloe, Vols. 1 & 2, Wiley (1977, 2006)

A Modern Approach to Quantum Mechanics, J. S. Townsend, McGraw Hill (1992)

Quantum Mechanics, L. I. Schiff, McGraw Hill (1968)

Quantum Mechanics (Two Volumes in One), A. Messiah, Dover (reprint 1999)

Quantum Mechanics, K. T. Hecht, Springer (2000)

Quantum Mechanics: A Modern Introduction, A. Das and A. C. Melissinos, Gordon & Breach (1986)

Quantum Mechanics, 2nd ed., B. H. Bransden and C. J. Joachain, Pearson/Prentice Hall (2000)

Quantum Mechanics, D. H. McIntyre, Pearson (2012)

Introduction to Quantum Mechanics, 2nd ed., D. J. Griffiths, Pearson/Prentice Hall (2005)

Quantum Mechanics: The Theoretical Minimum, L. Susskind and A. Friedman, Basic Books (2014)

Lectures on Quantum Mechanics, S. Weinberg, Cambridge (2013)

Quantum Mechanics in a Nutshell, G. H. Mahan, Princeton (2009)

Final Competencies:

Prior to this class, students have been exposed to quantum mechanics in the context of wave functions and the Schrodinger equation, with applications to atomic and molecular systems. In this class, we expand the development of quantum mechanics using the more general Dirac formalism as a framework.

Framework of Quantum Mechanics. Students develop a working knowledge of quantum mechanics in the Dirac formalism (primarily in the Schrodinger picture) including the construction and manipulation of state vectors and operators representing physical dynamical quantities. Students will be able to develop the rules governing the manipulation of vectors and operators from a basic framework of postulates (e.g., to demonstrate that eigenvectors of Hermitian operators belonging to different eigenvalues are orthogonal, etc.). Students will be able to express operators in terms of vector outer products, expand states and express operators in alternative basis sets, and make transitions between basis sets. Students will be able to construct matrix representations of states and operators and transform between the matrix representations appropriate to different basis sets. In any of these representations, students will learn to construct operators representing classical dynamical quantities, and use them to determine the possible outcomes of measurements and their corresponding probabilities, and understand these in relation to the commutator properties of operators. All of this includes stationary states as well systems evolving in time.

Translations, Translational Symmetry, and Coordinate and Momentum Representations. Students will be able to move from the abstract vector space to coordinate or momentum representations when appropriate to the physical system. The relationships between position, linear momentum, and translation are extended from the classical to the quantum domain, enabling students to transition from the abstract vector space to the coordinate representation of wave functions familiar from their earlier experiences in quantum mechanics (i.e., with differential forms for operator equivalents).

Rotations, Rotational Symmetry, and Angular Momentum. Students develop a working knowledge of angular momentum operators in the context of rotations and rotational symmetry. This is developed in the frameworks of orbital angular momentum, in both the abstract Dirac space and in coordinate space. This is then extended to a development of a complete framework for generalized angular momentum. Students will be able to move between different representations in the abstract and matrix spaces, enabling applications to systems with half-integral angular momentum, such as electron spin. Students will be able to determine the outcomes of spin measurements with detectors in various sequences and with various orientations. They will use angular momentum raising and lowering operators in various applications.

Harmonic Oscillators, and Raising and Lowering Operators. Students develop a working knowledge of simple harmonic oscillators in the coordinate representation and in the abstract vector space. Raising and lowering operators are developed. Students will be able to apply these concepts to facilitate the generation of matrix elements, and appreciate their generalizations in the context of field theories.

Time-Independent Perturbation Theory. Students will learn to generate approximate solutions to problems involving the addition of small, static perturbations to otherwise manageable systems. This includes both non-degenerate and degenerate systems. Students will also learn to generate approximate solutions in cases where the problem cannot be divided into large and small parts (e.g., variational method).

This list is relatively general and may in places suggest expectations greater than those I had in mind, and in some cases the opposite. In addition, I may have omitted something important. However, prior to each exam, I will provide more-specific lists of expectations appropriate to that exam.