Physics 660   Quantum Mechanics I   Fall

I. Schrodinger Wave Mechanics
      1.1. Introduction
      1.2. Postulates
            1.2.1. States and Wavefunctions
            1.2.2. Probability density
            1.2.3. Observables and Spectral Decomposition
            1.2.4. Time Evolution: The Schrodinger Equation
      1.3. Consequences and Physical Interpretation
            1.3.1. Continuity Equation
            1.3.2. Free Particle Wave Functions
                 a. Plane Waves
                 b. Gaussian Wave Packets
            1.3.3. Expectation Values
            1.3.4. Canonical Commutation Relations
            1.3.5. Ehrenfest's Theorem and Classical Mechanics
            1.3.6. Heisenberg Uncertainty Principle
            1.3.7. Stationary States, Hermitian Operators, eigenvalues and eigenfunctions
            1.3.8. Boundary Conditions on the Wavefunction
            1.3.9. Feynman's Path Integral Formulation of Quantum Mechanics

II. Applications In One-Dimension
      2.1. Scattering off a Potential Step
            2.1.1. Reflection and Transmission Coefficients
            2.1.2. Barrier penetration
      2.2. Bound States
            2.2.1. Square Well
            2.2.2. Simple Harmonic Oscillator
            2.2.3. Periodic Potentials and Bloch's Theorem, the Kronig-Penny Model and
                     conduction bands in solids

III. Central Potential Problem
      3.1. The Two Body Problem, the center of momentum frame
      3.2. Spherical Polar Coordinates, Separation of Variables and Spherical Harmonics
      3.3. Orbital Angular Momentum and the Spherical Harmonic Eigenfunctions
      3.4. The Radial Equation and Bound States
      3.5. The Hydrogen Atom

V. Symmetry in Quantum Mechanics
    5.1. Transformations between physically equivalent quantum descriptions and Wigner's Theorem
    5.2. Space-Time Symmetries
        5.2.1. The Principle of Galilean Relativity and the Galilean Group
    5.3. Spatial Rotations, the Rotation Group and the Angular Momentum Operators
        5.3.1. Geometry of rotations and the rotation group
        5.3.2. The Angular Momentum operators and their commutation relations
        5.3.3. Physical Description of Spin
        5.3.4. Angular Momentum Commutation Relations and the "Standard Basis"
        5.3.5. Angular Momentum Operator Matrix Representation in the Standard Basis
        5.3.6. Spin and Orbital Angular Momentum Revisited
        5.3.7. Addition of angular momentum and Clebsch-Gordon coefficients
        5.3.8. The Wigner-Eckhardt theorem and Irreducible Tensor Operators
        5.3.9. Parity and Time Reversal Transformations

VI. Approximation Methods For Bound States
    6.1. Rayleigh-Schrodinger Stationary State Perturbation Theory
        6.1.1. Non-Degenerate Perturbation Theory
        6.1.2. Degenerate Perturbation Theory
    6.2. Brillouin-Wigner Stationary State Perturbation Theory
    6.3. The Rayleigh-Ritz Variational Method
    6.4. Fine Structure of the Hydrogen Atom Spectrum
    6.5. The Hydrogen Atom in Electric and Magnetic Fields
        6.5.1. Constant, Uniform External Magnetic Field **B**: The Zeeman Effect
        6.5.2. Constant, Uniform External Electric Field **E**: The Stark Effect

VII. Approximation Methods for Continuous Energy Eigenvalues: Potential (Elastic) Scattering Theory
    7.1. Potential Scattering
        7.1.1. The Scattering Green Function
        7.1.2. The Born Approximation
        7.1.3. Examples of Scattering from Potentials
    7.2. Scattering by a Central Potential and the Partial Wave Analysis
        7.2.1. Scattering by Complex Potentials
        7.2.2. Bound States and the Lippman-Schwinger Integral Equation
        7.2.3. The Born Approximation for the Partial Wave Analysis
        7.2.4. Examples of Partial Wave Analysis

VIII. Time Dependent Perturbation Theory
    8.1. Dirac Perturbation Theory
    8.2. Fermi's Golden Rule
    8.3. Semi-Classical Treatment of Electromagnetic Radiation: The Interaction of Bound States of Charge Particles with Photons
    8.4. The Formal Theory of Scattering

IX. Identical Particles
    9.1. Hartree-Fock Approximation
    9.2. Exchange Effects in Elastic Scattering