

Detailed Licensing

Overview

Title: [Quantum Tutorials \(Rioux\)](#)

Webpages: 535

All licenses found:

- [CC BY 4.0](#): 95% (508 pages)
- [Undeclared](#): 5% (27 pages)

By Page

- [Quantum Tutorials \(Rioux\)](#) - [CC BY 4.0](#)
 - [Front Matter](#) - [Undeclared](#)
 - [TitlePage](#) - [Undeclared](#)
 - [InfoPage](#) - [Undeclared](#)
 - [Table of Contents](#) - [Undeclared](#)
 - [Licensing](#) - [Undeclared](#)
 - [1: Quantum Fundamentals](#) - [CC BY 4.0](#)
 - [1.1: An Approach to Quantum Mechanics](#) - [CC BY 4.0](#)
 - [1.2: Atomic and Molecular Stability](#) - [CC BY 4.0](#)
 - [1.3: Atomic and Molecular Stability](#) - [CC BY 4.0](#)
 - [1.4: Atomic and Molecular Stability](#) - [CC BY 4.0](#)
 - [1.5: Quantum Computation - A Short Course](#) - [CC BY 4.0](#)
 - [1.6: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.7: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.8: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.9: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.10: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.11: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.12: Quantum Computation- A Short Course](#) - [CC BY 4.0](#)
 - [1.13: Quantum Mechanics and the Fourier Transform](#) - [CC BY 4.0](#)
 - [1.14: Quantum Mechanics and the Fourier Transform](#) - [CC BY 4.0](#)
 - [1.15: Quantum Mechanics and the Fourier Transform](#) - [CC BY 4.0](#)
 - [1.16: Quantum Mechanics and the Fourier Transform](#) - [CC BY 4.0](#)
 - [1.17: Quantum Mechanics and the Fourier Transform](#) - [CC BY 4.0](#)
 - [1.18: Exploring the Origin of Schrödinger's Equations](#) - [CC BY 4.0](#)
 - [1.19: Basic Quantum Mechanics in Coordinate, Momentum and Phase Space](#) - [CC BY 4.0](#)
 - [1.20: The Repackaging of Quantum Weirdness](#) - [CC BY 4.0](#)
 - [1.21: Quantum Principles Illuminated with Polarized Light](#) - [CC BY 4.0](#)
 - [1.22: Relationship Between the Coordinate and Momentum Representations](#) - [CC BY 4.0](#)
 - [1.23: Very Brief Relationship Between the Coordinate and Momentum Representations](#) - [CC BY 4.0](#)
 - [1.24: Getting Accustomed to the Superposition Principle](#) - [CC BY 4.0](#)
 - [1.25: The Dirac Delta Function](#) - [CC BY 4.0](#)
 - [1.26: Elements of Dirac Notation](#) - [CC BY 4.0](#)
 - [1.27: The Dirac Notation Applied to Variational Calculations](#) - [CC BY 4.0](#)
 - [1.28: Raising and Lowering; Creating and Annihilating](#) - [CC BY 4.0](#)
 - [1.29: Single Slit Diffraction and the Fourier Transform](#) - [CC BY 4.0](#)
 - [1.30: From Coordinate Space to Momentum Space and Back](#) - [CC BY 4.0](#)
 - [1.31: The Position and Momentum Commutation Relation in Coordinate and Momentum Space](#) - [CC BY 4.0](#)
 - [1.32: Simulating the Aharonov-Bohm Effect](#) - [CC BY 4.0](#)
 - [1.33: Basic Matrix Mechanics](#) - [CC BY 4.0](#)
 - [1.34: Rudimentary Matrix Mechanics](#) - [CC BY 4.0](#)
 - [1.35: Matrix Mechanics](#) - [CC BY 4.0](#)
 - [1.36: Aspects of Dirac's Relativistic Matrix Mechanics](#) - [CC BY 4.0](#)
 - [1.37: The Double-Slit Experiment](#) - [CC BY 4.0](#)
 - [1.38: Double-Slit Experiment with Polarized Light](#) - [CC BY 4.0](#)
 - [1.39: The Consequences of Path Information in a Mach-Zehnder Interferometer](#) - [CC BY 4.0](#)

- 1.40: Another look at the Consequences of Path Information in a Mach-Zehnder Interferometer - CC BY 4.0
- 1.41: The Double-Slit Experiment with Polarized Light - CC BY 4.0
- 1.42: The Quantum Eraser - CC BY 4.0
- 1.43: Which Way Did It Go? - The Quantum Eraser - CC BY 4.0
- 1.44: Which Path Information and the Quantum Eraser - CC BY 4.0
- 1.45: Terse Analysis of Triple-slit Diffraction with a Quantum Eraser - CC BY 4.0
- 1.46: Which Path Information and the Quantum Eraser (Brief) - CC BY 4.0
- 1.47: Terse Analysis of Triple-slit Diffraction with a Quantum Eraser - CC BY 4.0
- 1.48: Which-way Markers and Post-selection in the Double-slit Experiment - CC BY 4.0
- 1.49: A Stern-Gerlach Quantum "Eraser" - CC BY 4.0
- 1.50: Using the Mach-Zehnder Interferometer to Illustrate the Impact of Which-way Information - CC BY 4.0
- 1.51: Quantum Theory, Wave-Particle Duality and the Mach-Zehnder Interferometer - CC BY 4.0
- 1.52: Analysis of a Temporal Double-slit Experiment - CC BY 4.0
- 1.53: An Analysis of Three-Path Interference - CC BY 4.0
- 1.54: An Analysis of Three-Slit Interference - *Undeclared*
- 1.55: Using a Mach-Zehnder Interferometer to Illustrate Feynman's Sum Over Histories Approach to Quantum Mechanics - CC BY 4.0
- 1.56: The Paradox of Recombined Beams - CC BY 4.0
- 1.57: Evidence for Quantized Gravitational States of the Neutron - CC BY 4.0
- 1.58: Quantized Gravitational States A Variational Approach - CC BY 4.0
- 1.59: The Quantum Bouncer Doesn't Bounce, Unless... - CC BY 4.0
- 1.60: Kinetic Energy Is Important in the Nanoscale World - CC BY 4.0
- 1.61: Energy Expectation Values and the Origin of the Variation Principle - CC BY 4.0
- 1.62: Examining the Wigner Distribution Using Dirac Notation - CC BY 4.0
- 1.63: The Wigner Function for the Single Slit Diffraction Problem - CC BY 4.0
- 1.64: Wigner Distribution for the Double Slit Experiment - CC BY 4.0
- 1.65: Wigner Distribution for the Triple Slit Experiment - CC BY 4.0
- 1.66: Wigner Distribution for the Quadruple Slit Experiment - CC BY 4.0
- 1.67: Quantum Tunneling in Coordinate, Momentum and Phase Space - CC BY 4.0
- 1.68: Another Look at the Wigner Function - CC BY 4.0
- 1.69: The Wigner Distribution Function for the Harmonic Oscillator - CC BY 4.0
- 1.70: Wigner Distribution for the Particle in a Box - CC BY 4.0
- 1.71: The Wigner Distribution for a Particle in a One-dimensional Box - CC BY 4.0
- 1.72: Superposition vs. Mixture - CC BY 4.0
- 1.73: Time-dependent Wigner Function for Harmonic Oscillator Transitions - CC BY 4.0
- 1.74: Momentum Operator in Coordinate Space - CC BY 4.0
- 1.75: Momentum Wave Functions for the Particle in a Box - CC BY 4.0
- 1.76: A Graphical Illustration of the Heisenberg Uncertainty Relationship - CC BY 4.0
- 1.77: The Quantum Harmonic Oscillator - CC BY 4.0
- 1.78: Coherent Superpositions for the Harmonic Oscillator - CC BY 4.0
- 1.79: The Harmonic Oscillator and the Uncertainty Principle - CC BY 4.0
- 1.80: Another view of the Harmonic Oscillator and the Uncertainty Principle - CC BY 4.0
- 1.81: Hydrogen Atom and Helium Ion Spatial and Momentum Distribution Functions Illustrate the Uncertainty Principle - CC BY 4.0
- 1.82: The Position-Momentum Uncertainty Relation in the Hydrogen Atom - CC BY 4.0
- 1.83: Demonstrating the Uncertainty Principle for Angular Momentum and Angular Position - CC BY 4.0
- 1.84: A Brief Tutorial on Wavepackets - CC BY 4.0
- 1.85: The Difference Between Fermions and Bosons - CC BY 4.0
- 1.86: Quantum Corrals - Electrons within a Ring - CC BY 4.0
- 1.87: Planck's Radiation Equation Fit to Experimental Data - CC BY 4.0
- 1.88: Planck's Radiation Equation Fit to Experimental Data - Another Algorithm - CC BY 4.0
- 1.89: Fitting Einstein's Heat Capacity Equation to Experimental Data for Silver - CC BY 4.0
- 1.90: Einstein's Heat Capacity Equation Fit to Experimental Data - Another Algorithm - CC BY 4.0

- 1.91: Fitting Debye's Heat Capacity Equation to Experimental Data for Silver - CC BY 4.0
- 1.92: Debye's Heat Capacity Equation Fit to Experimental Data - Another Algorithm - CC BY 4.0
- 1.93: Wave-particle Duality and the Uncertainty Principle - CC BY 4.0
- 1.94: Wave-Particle Duality for Matter and Light - CC BY 4.0
- 1.95: What Part of the Quantum Theory Don't You Understand? - CC BY 4.0
- 1.96: Quantum Potpourri - An Attempt to Demonstrate Two Fundamental Quantum Concepts- Wave-particle Duality and The Superposition Principle - CC BY 4.0
- 1.97: Quantum Dynamics- One Step at a Time - CC BY 4.0
- 1.98: Quantum Mechanical Pressure - CC BY 4.0
- 1.99: Visualizing the Difference Between a Superposition and a Mixture - CC BY 4.0
- 1.100: Analysis of the Stern-Gerlach Experiment - CC BY 4.0
- 1.101: Related Analysis of the Stern-Gerlach Experiment - CC BY 4.0
- 1.103: Bloch Sphere - CC BY 4.0
- 1.104: 88. Related Analysis of the Stern-Gerlach Experiment - *Undeclared*
- 1.105: Bill the Cat and the Superposition Principle - *Undeclared*
- 1.106: Schroedinger's Dog - *Undeclared*
- 1.107: The Bloch Sphere - *Undeclared*
- 1.108: Density Matrix, Bloch Vector and Entropy - *Undeclared*
- 1.109: State Vectors and State Operators- Superpositions, Mixed States, and Entanglement - *Undeclared*
- 1.110: The Gram-Schmidt Procedure - *Undeclared*
- 2: Atomic Structure - CC BY 4.0
 - 2.1: The de Broglie-Bohr Model for the Hydrogen Atom - CC BY 4.0
 - 2.2: The de Broglie-Bohr Model for the Hydrogen Atom - Version 3 - CC BY 4.0
 - 2.3: The de Broglie-Bohr Model for the Hydrogen Atom - Version 3 - CC BY 4.0
 - 2.4: A de Broglie-Bohr Model for Positronium - CC BY 4.0
 - 2.5: The de Broglie-Bohr Model for the Hydrogen Atom - Version 4 - CC BY 4.0
 - 2.6: The de Broglie-Bohr Model for a Hydrogen Atom Held Together by a Gravitational Interaction - CC BY 4.0
 - 2.7: The de Broglie-Bohr Model for Positronium - CC BY 4.0
 - 2.8: The Bohr Model for the Earth-Sun System - CC BY 4.0
 - 2.9: Extracting Atomic and Molecular Parameters from the deBroglie-Bohn Model for the Atom - CC BY 4.0
 - 2.10: Electronic Structure and the Superposition Principle - CC BY 4.0
 - 2.11: Atomic Spectroscopy and the Correspondence Principle - CC BY 4.0
 - 2.12: Hydrogen-Like Calculations with Variable Lepton Mass - CC BY 4.0
 - 2.13: Atomic Stability - CC BY 4.0
 - 2.14: Quantum Mechanical Calculations for the One-Dimensional Hydrogen Atom - CC BY 4.0
 - 2.15: Quantum Mechanical Calculations for the Hydrogen Atom - CC BY 4.0
 - 2.16: Atomic Stability - CC BY 4.0
 - 2.17: Atomic Stability - Mathcad Version - CC BY 4.0
 - 2.18: 110. Critique of the Centrifugal Effect in the Hydrogen Atom - CC BY 4.0
 - 2.19: A Shorter Critique of the Centrifugal Effect in the Hydrogen Atom - CC BY 4.0
 - 2.20: Exploring the Role of Lepton Mass in the Hydrogen Atom - CC BY 4.0
 - 2.21: The Effect of Lepton Mass on the Energy and Bond Length of the Hydrogen Molecule Ion - CC BY 4.0
 - 2.22: The Hydrogen Atom with Finite Sized Nucleus - CC BY 4.0
 - 2.23: The Hyperfine Interaction in the Hydrogen Atom - CC BY 4.0
 - 2.24: Positronium Annihilation - CC BY 4.0
 - 2.25: Positronium Annihilation- Another View - CC BY 4.0
 - 2.26: Positronium Annihilation- Yet Another View - CC BY 4.0
 - 2.27: The Hyperfine Interaction in the Deutrium Atom - CC BY 4.0
 - 2.28: A Tensor Algebra Approach to Spin-Orbit Coupling - CC BY 4.0
 - 2.29: A Bohr Model for Multi-electron Atoms and Ions - CC BY 4.0
 - 2.30: Atomic Variational Calculations- Hydrogen to Boron - CC BY 4.0
 - 2.31: Some Calculations on the Lithium Atom Ground State - CC BY 4.0
 - 2.32: E. B. Wilson's Calculation on the Lithium Atom Ground State - CC BY 4.0
 - 2.33: The Importance of the Pauli Principle - CC BY 4.0
 - 2.34: Splitting the 2s-2p Degeneracy in the Lithium Atom - CC BY 4.0

- 2.35: Addition of Spin Angular Momentum- A Tensor Algebra Approach - CC BY 4.0
- 2.36: Hund's Rule - CC BY 4.0
- 2.37: Hund's Rule - Singlet-Triplet Calculations with Mathcad - CC BY 4.0
- 2.38: Electron Correlation in Two-electron Systems - CC BY 4.0
- 2.39: First Trial Wave Function - CC BY 4.0
- 2.40: Second Trial Wavefunction - CC BY 4.0
- 2.41: Third Trial Wavefunction - CC BY 4.0
- 2.42: 129.4 Fourth Trial Wavefunction - CC BY 4.0
- 2.43: Fifth Trial Wavefunction and Summary - CC BY 4.0
- 2.44: The Crucial Role of Kinetic Energy in Interpreting Ionization Energies - CC BY 4.0
- 2.45: Quantum Dots Are Artificial Atoms - CC BY 4.0
- 2.46: Calculating the Atomic Radius of Polonium - CC BY 4.0
- 2.47: Calculating the Atomic Radius of Gold - CC BY 4.0
- 2.48: How Many Bibles Can Fit on the Head of a Pin - CC BY 4.0
- 2.49: Momentum Wavefunctions and Distributions for the Hydrogen Atom - CC BY 4.0
- 2.50: The SCF Method for Two Electrons - CC BY 4.0
- 2.51: Outline of the SCF Method for Two Electrons - CC BY 4.0
- 2.52: The SCF Method for Two Electrons Using a Gaussian Wave Function - CC BY 4.0
- 2.53: An Interactive SCF Calculation for the Helium Atom - CC BY 4.0
- 2.54: Quantum Calculations on the Hydrogen Atom in Coordinate, Momentum and Phase Space - CC BY 4.0
- 2.55: The Wigner Distribution for the 1s State of the 1D Hydrogen Atom - CC BY 4.0
- 2.56: The Wigner Distribution for the 2s State of the 1D Hydrogen Atom - CC BY 4.0
- 2.57: The Wigner Distribution for the 2p State of the 1D Hydrogen Atom - CC BY 4.0
- 2.58: The Wigner Distribution for the 3s State of the 1D Hydrogen Atom - CC BY 4.0
- 2.59: The Wigner Distribution for the 3p State of the 1D Hydrogen Atom - CC BY 4.0
- 2.60: The Wigner Distribution for the 4s State of the 1D Hydrogen Atom - CC BY 4.0
- 2.61: One-dimensional H-atom with Delta Function Potential - CC BY 4.0
- 2.62: The Atomic Structure Factor in Coordinate and Momentum Space - CC BY 4.0
- 3: Chemical Bonding - CC BY 4.0
 - 3.1: The Covalent Bond and Quantum Mechanics - CC BY 4.0
 - 3.2: The Covalent Bond in the Hydrogen Molecule - CC BY 4.0
 - 3.3: The Covalent Bond Clarified Through the Use of the Virial Theorem - CC BY 4.0
 - 3.4: Brief Version of the Covalent Bond Clarified Through the Use of the Virial Theorem - CC BY 4.0
 - 3.5: The H₂ Covalent Bond and the Virial Theorem - CC BY 4.0
 - 3.6: The Covalent Bond According to Slater and Ruedenberg - CC BY 4.0
 - 3.7: Slater's Analysis of the Covalent Bond using the Virial Theorem - CC BY 4.0
 - 3.8: Two Analyses of the Covalent Bond using the Virial Theorem - CC BY 4.0
 - 3.9: A Simple Charge Cloud Model for Molecular Hydrogen- Or, Is It a DFT Model? - CC BY 4.0
 - 3.10: Three Mechanisms for Bond Formation in the Hydrogen Molecule Ion - CC BY 4.0
 - 3.11: A Mechanistic Approach to Bond Formation in the Hydrogen Molecule Ion - CC BY 4.0
 - 3.12: A Lite Version of Ruedenberg's Analysis of the Covalent Bond in the Hydrogen Molecule Ion - CC BY 4.0
 - 3.13: Molecular Orbital Analysis for the Hydrogen Molecule Ion Bond - CC BY 4.0
 - 3.14: A One-dimensional Model for the Covalent Bond in the Hydrogen Molecule Ion - CC BY 4.0
 - 3.15: Localized and Delocalized Molecular Orbitals - CC BY 4.0
 - 3.16: Two Perspectives on the Bonding in Water - CC BY 4.0
 - 3.17: Covalent Bonding in Ammonia from Several Perspectives - CC BY 4.0
 - 3.18: A Molecular Orbital Approach to Bonding in Methane - CC BY 4.0
 - 3.19: A Simple Calculation of the Lattice Energy of LiH - CC BY 4.0
 - 3.20: An Even Simpler LiH Lattice Energy Calculation - CC BY 4.0
 - 3.21: Charge Cloud Models for Some Simple Atomic, Molecular and Solid Systems - CC BY 4.0
 - 3.22: A Critique of the Valence Shell Electron Pair Repulsion Model - CC BY 4.0
 - 3.23: A Simple Electrostatic Critique of VSEPR - CC BY 4.0
 - 3.24: Another Critique of VSEPR - CC BY 4.0
 - 3.25: Why Nonbonding Electrons Occupy the Equatorial Position in Trigonal Bipyramidal Geometry - CC BY 4.0

- 3.26: A Modified Tangent Spheres Model Analysis of Trigonal Bipyramidal Geometry - CC BY 4.0
- 3.27: A Symbolic Huckel MO Calculation Using Mathcad - CC BY 4.0
- 3.28: A Numeric Huckel MO Calculation Using Mathcad - CC BY 4.0
- 3.29: A Numerical Huckel MO Calculation on C60 - CC BY 4.0
- 3.30: Chemical Bonding and Electronic Structure of Buckminsterfullerene - CC BY 4.0
- 3.31: Quantum Mechanics, Group Theory and C60 - CC BY 4.0
- 3.32: A Numerical Huckel Calculation on Anthracene and Phenanthrene - CC BY 4.0
- 3.33: A Numerical Huckel Calculation on C10H8 Isomers - CC BY 4.0
- 3.34: Semi-empirical Molecular Orbital Calculation on HF - CC BY 4.0
- 3.35: Semi-empirical Molecular Orbital Calculation on XeF2 - CC BY 4.0
- 3.36: Posch-Teller Potential Model for Metals - CC BY 4.0
- 4: Spectroscopy - CC BY 4.0
 - 4.1: Rudiments of Atomic Spectroscopy Using Mathcad - CC BY 4.0
 - 4.2: A Particle-in-a-Box Model for Color Centers - CC BY 4.0
 - 4.3: Cyanine Dyes as Two-State Electronic Systems - CC BY 4.0
 - 4.4: The Ammonia Inversion and the Maser - CC BY 4.0
 - 4.5: A Symmetric Double Well Potential Illustrating Tunneling - CC BY 4.0
 - 4.6: Analyses of the Pure Rotational Spectrum of HCl - CC BY 4.0
 - 4.7: A Rudimentary Analysis of the Vibrational-Rotational HCl Spectrum - CC BY 4.0
 - 4.8: Visualizing the Formally Forbidden Overtone Vibrational Transitions in HCl - CC BY 4.0
 - 4.9: The Quantum Jump - CC BY 4.0
 - 4.10: Another Look at the Quantum Jump - CC BY 4.0
 - 4.11: Quantum Beats - CC BY 4.0
 - 4.12: The 1s-2s Electronic Transition in the 1D Hydrogen Atom - CC BY 4.0
 - 4.13: The Quantum Jump in Momentum Space - CC BY 4.0
 - 4.14: The Harmonic Oscillator Quantum Jump - CC BY 4.0
 - 4.15: Coherent States of the Harmonic Oscillator - CC BY 4.0
 - 4.16: Analysis of the Electronic Spectrum of $\text{Ti}(\text{H}_2\text{O})_3^+$ - CC BY 4.0
 - 4.17: Quantum Jumps for an Electron on a Ring - CC BY 4.0
 - 4.18: Analysis of the Vibrational and Electronic Spectrum of Benzene - CC BY 4.0
 - 4.19: NMR - Quantum Mechanics of a Three Proton System - CC BY 4.0
 - 4.20: AB Proton NMR Using Tensor Algebra - CC BY 4.0
 - 4.21: Calculating the AB Proton NMR Using Tensor Algebra - CC BY 4.0
 - 4.22: AB Proton NMR Analysis for 2,3-dibromothiophene - CC BY 4.0
 - 4.23: ABC Proton NMR Using Tensor Algebra - CC BY 4.0
 - 4.24: AB2 Proton NMR Using Tensor Algebra - CC BY 4.0
 - 4.25: AB3 Proton NMR Using Tensor Algebra - CC BY 4.0
 - 4.26: HD-Like NMR Spectrum Calculated Using Tensor Algebra - CC BY 4.0
 - 4.27: The Michelson Interferometer and Fourier Transform Spectroscopy - CC BY 4.0
 - 4.28: A Sum Over Histories Approach to Fourier Transform Infrared Spectroscopy - CC BY 4.0
 - 4.29: Modeling the Pi-electrons of Benzene as Particles on a Ring - CC BY 4.0
 - 4.30: Modeling the Pi-electrons of Benzene as Particles on a Ring - Version 2 - CC BY 4.0
 - 4.31: Calculating the Pi-electron HOMO-LUMO Electronic Transition for Benzene - CC BY 4.0
 - 4.32: Modeling the Pi-electrons of Benzene as Particles in a Ring - CC BY 4.0
 - 4.33: Modeling the Pi-electrons of Corannulene as Particles in a Ring - CC BY 4.0
 - 4.34: The Vibrational and Electronic States of C60 - CC BY 4.0
- 5: Diffraction Phenomena - CC BY 4.0
 - 5.1: Using Optical Transforms to Teach Quantum Mechanics - CC BY 4.0
 - 5.2: Single-slit Diffraction and the Uncertainty Principle - CC BY 4.0
 - 5.3: Single-slit Diffraction and the Uncertainty Principle (Mathcad Version) - CC BY 4.0
 - 5.4: Simulating DNA's Diffraction Pattern - CC BY 4.0
 - 5.5: Simulating DNA's Diffraction Pattern with a More Realistic Model - CC BY 4.0
 - 5.6: Simulating DNA's Diffraction Pattern - Short Version - CC BY 4.0

- 5.7: A Model Graphene Diffraction Pattern - CC BY 4.0
- 5.8: Is a Two-dimensional Fibonacci Array a Quasilattice? - CC BY 4.0
- 5.9: Calculating Diffraction Patterns - CC BY 4.0
- 5.10: Modeling the C60 Diffraction Pattern - CC BY 4.0
- 5.11: Diffraction Pattern for Pentagonal Point Scatterers - CC BY 4.0
- 5.12: Diffraction Pattern for Pentagonal Finite Point Scatterers - CC BY 4.0
- 5.13: Pentagon Diffraction Pattern - CC BY 4.0
- 5.14: Model Diffraction Pattern for Naphthalene - CC BY 4.0
- 5.15: Calculating the Airy Diffraction Pattern - CC BY 4.0
- 5.16: Diffraction Pattern for Two Concentric Rings - CC BY 4.0
- 5.17: Density Operator Approach to the Double-Slit Experiment - CC BY 4.0
- 5.18: Another Look at the Double-Slit Experiment - CC BY 4.0
- 5.19: A Quantum Mechanical Interpretation of Diffraction - CC BY 4.0
- 5.20: Electron Diffraction at Multiple Slits - CC BY 4.0
- 5.21: Multiple Slit Diffraction and the Fourier Transform - CC BY 4.0
- 5.22: The Double-Slit Experiment with C60 Molecules - CC BY 4.0
- 5.23: Crystal Structure, Rotational Symmetry, and Quasicrystals - CC BY 4.0
- 5.24: X-ray Crystallography from a Quantum Mechanical Perspective - CC BY 4.0
- 5.25: Holography Involves Single Photon Interference - CC BY 4.0
- 5.26: X-ray Diffraction - CC BY 4.0
- 5.27: Holography Involves Single Photon Interference - CC BY 4.0
- 6: Group Theory with Mathcad - CC BY 4.0
 - Front Matter - Undeclared
 - TitlePage - Undeclared
 - InfoPage - Undeclared
 - 6.1: Group Theory Principles Applied to H₂O - CC BY 4.0
 - 6.2: Dodecahedrane - CC BY 4.0
 - 6.3: Xenon Tetrafluoride - CC BY 4.0
 - 6.4: Diborane - CC BY 4.0
 - 6.5: Cubane - CC BY 4.0
 - 6.5.1: Buckminsterfullerene - CC BY 4.0
 - 6.6: BCl₃ - CC BY 4.0
 - 6.7: Ti(H₂O)₆³⁺ - CC BY 4.0
 - 6.8: CH₄ - CC BY 4.0
 - 6.9: P₄ - CC BY 4.0
 - 6.10: Tetrahedrane - CC BY 4.0
 - 6.11: PH₃ - CC BY 4.0
 - 6.12: Cyclopropane - CC BY 4.0
 - 6.13: An Extensive Set of Group Theory Problems for Chemists - CC BY 4.0
 - Back Matter - Undeclared
 - Index - Undeclared
- 7: Quantum Optics - CC BY 4.0
 - Front Matter - Undeclared
 - TitlePage - Undeclared
 - InfoPage - Undeclared
 - 7.1: Single-Photon Interference - First Version - CC BY 4.0
 - 7.2: Single-Photon Interference - Second Version - CC BY 4.0
 - 7.3: Single-photon Interference - Third Version - CC BY 4.0
 - 7.4: Single Photon Interference - Fourth Version - CC BY 4.0
 - 7.5: Single Photon Interference - Mathcad version - CC BY 4.0
 - 7.6: The Polarizing Beam Splitter and the Superposition Principle - CC BY 4.0
 - 7.7: Mach-Zehner Polarization Interferometer Analyzed Using Tensor Algebra - CC BY 4.0
 - 7.8: Illustrating the Superposition Principle with Single Photon Interference - CC BY 4.0
 - 7.9: Pure States, Mixtures and the Density Operator - CC BY 4.0
 - 7.10: Using the Trace Function to Calculate Expectation Values - CC BY 4.0
 - 7.11: Polarized Light and Quantum Superposition - CC BY 4.0
 - 7.12: Polarized Light and Quantum Mechanics - CC BY 4.0
 - 7.13: The Three-Polarizer Paradox - CC BY 4.0
 - 7.14: Matrix Mechanics Approach to Polarized Light - CC BY 4.0
 - 7.15: Matrix Mechanics Approach to Polarized Light - Version 2 - CC BY 4.0
 - 7.16: Matrix Mechanics Exercises Using Polarized Light - CC BY 4.0
 - 7.17: Polarized Light and Quantum Mechanics - CC BY 4.0
 - 7.18: Neutron Interferometry with Polarized Spin States - CC BY 4.0
 - 7.19: Interaction Free Measurement - Seeing in the Dark - CC BY 4.0

- 7.20: Quantum Seeing in the Dark - A Matrix-Tensor Analysis - CC BY 4.0
- 7.21: Two Analyses of the Michelson Interferometer - CC BY 4.0
- 7.22: A Quantum Circuit for a Michelson Interferometer - CC BY 4.0
- 7.23: The Ramsey Atomic Interferometer - CC BY 4.0
- 7.24: Optical Activity - A Quantum Perspective - CC BY 4.0
- 7.25: A Quantum Optical Cheshire Cat - CC BY 4.0
- 7.26: Two Photon Interference - The Creation of an Entangled Superposition - CC BY 4.0
- 7.27: Two-particle Interference for Bosons and Fermions - CC BY 4.0
- 7.28: Analysis of a Two-photon Interferometer - CC BY 4.0
- 7.29: Two-photon Interferometry - CC BY 4.0
 - 7.29.1: Another Two Photon Interference Experiment - CC BY 4.0
- 7.30: Another Two Photon Interference Experiment - CC BY 4.0
- 7.31: Quantum Correlations Illuminated with Tensor Algebra - CC BY 4.0
- 7.32: Two Photon Entanglement - A Tensor Algebra Analysis - CC BY 4.0
- 7.33: Two Photon Interference - Matrix Mechanics Approach - CC BY 4.0
- 7.34: Two-electron Interference - CC BY 4.0
- 7.35: Bosonic and Fermionic Photon Behavior at Beam Splitters - CC BY 4.0
- 7.36: Bosonic and Fermionic Photon Behavior at Beam Splitters- A Tensor Algebra Analysis - CC BY 4.0
- 7.37: Entangled Photons Can Behave Like Fermions - CC BY 4.0
- 7.38: Analyzing Two-photon Interferometry Using Mathcad and Tensor Algebra - CC BY 4.0
- 7.39: Analysis of a Two-photon Quantum Eraser - CC BY 4.0
- 7.40: Another Example of a Two-photon Quantum Eraser - CC BY 4.0
- 7.41: A Quantum Delayed-Choice Experiment - CC BY 4.0
- 7.42: A Quantum Delayed-Choice Experiment - CC BY 4.0
- Back Matter - *Undeclared*
 - Index - *Undeclared*
- 8: Quantum Teleportation - CC BY 4.0
 - 8.1: A Single Page Summary of Quantum Teleportation - CC BY 4.0
 - 8.2: Quantum Teleportation - A Brief Introduction - CC BY 4.0
 - 8.3: Quantum Teleportation at a Glance - CC BY 4.0
 - 8.4: Another Look at Quantum Teleportation - CC BY 4.0
 - 8.5: Teleportation Using Quantum Gates - CC BY 4.0
 - 8.6: Another Example of Teleportation Using Quantum Gates - CC BY 4.0
 - 8.7: Yet Another Quantum Teleportation Circuit - CC BY 4.0
 - 8.8: Quantum Teleportation - Another Look - CC BY 4.0
 - 8.9: A Quantum Teleportation Experiment for Undergraduates - CC BY 4.0
 - 8.10: A Simple Teleportation Exercise - CC BY 4.0
 - 8.11: Teleportation as a Quantum Computation - CC BY 4.0
 - 8.12: Quantum Teleportation - Four Perspectives - CC BY 4.0
 - 8.13: Teleportation of Two Qubits - CC BY 4.0
 - 8.14: Greenberger-Horne-Zeilinger (GHZ) Entanglement and Local Realism - CC BY 4.0
 - 8.15: GHZ Math Appendix - CC BY 4.0
 - 8.16: GHZ Entanglement - A Tensor Algebra Analysis - CC BY 4.0
 - 8.17: Simulation of a GHZ Gedanken Experiment - CC BY 4.0
 - 8.18: Another Simulation of a GHZ Gedanken Experiment - CC BY 4.0
 - 8.19: A Surgical Refutation of the Local Realism Heresy - CC BY 4.0
 - 8.20: GHZ Four-Photon Entanglement Analyzed Using Tensor Algebra - CC BY 4.0
 - 8.21: Quantum v. Realism - CC BY 4.0
 - 8.22: Elements of Reality- Another GHZ Gedanken Experiment Analyzed - CC BY 4.0
 - 8.23: Brief Elements of Reality - CC BY 4.0
 - 8.24: A Brief Analysis of Mermin's GHZ Thought Experiment - CC BY 4.0
 - 8.25: Lucien Hardy's Paradox as Presented by N. David Mermin - CC BY 4.0
 - 8.26: Hardy's Paradox - An Algebraic Analysis - CC BY 4.0
 - 8.27: Quantum Entanglement Leads to Nonclassical Correlations - CC BY 4.0
 - 8.28: Nonclassical Correlations Revealed with Mermin's Pentagon - CC BY 4.0
 - 8.29: Spooky Action at a Distance- The EPR Experiment with Photons - CC BY 4.0
 - 8.30: David Bohm's EPR Gedanken Experiment - CC BY 4.0

- 8.31: An Extension of Bohm's EPR Experiment - CC BY 4.0
- 8.32: A Surgical Adjudication of the Conflict Between Quantum Theory and Local Realism - CC BY 4.0
- 8.33: A Thought Experiment Reveals the Conflict Between Quantum Theory and Local Realism - CC BY 4.0
- 8.34: Positronium Annihilation - CC BY 4.0
- 8.35: Mermin's Version of Bohm's EPR Gedanken Experiment - CC BY 4.0
- 8.36: A Concise Version of Mermin's EPR Gedanken Experiment - CC BY 4.0
- 8.37: Another Look at Mermin's EPR Gedanken Experiment - CC BY 4.0
- 8.38: Mermin's Version of Bohm's EPR Gedanken Experiment Using Tensor Algebra - CC BY 4.0
- 8.39: A GHZ Gedanken Experiment Using Spatial Degrees of Freedom and Tensor Algebra - CC BY 4.0
- 8.40: Another GHZ Example Using Spin-1/2 Particles - CC BY 4.0
- 8.41: Entanglement Reveals a Conflict Between Local Realism and Quantum Theory - CC BY 4.0
- 8.42: A Summary of Feynman's "Simulating Physics with Computers" - CC BY 4.0
- 8.43: Another Summary of Feynman's "Simulating Physics with Computers" - CC BY 4.0
- 8.44: Yet Another Assault on Local Realism - CC BY 4.0
- 8.45: Yet Another Assault on Local Realism - A Matrix/Tensor Algebra Approach - CC BY 4.0
- 8.46: Jim Baggott's Bell Theorem Analysis - CC BY 4.0
- 8.47: Another Bell Theorem Analysis - CC BY 4.0
- 8.48: Another Bell Theorem Analysis - Shorter Version - CC BY 4.0
- 8.49: EPR Analysis for a Composite Singlet Spin System - CC BY 4.0
- 8.50: EPR Analysis for a Composite Singlet Spin System - Short Version - CC BY 4.0
- 8.51: Analysis of the Stern-Gerlach Experiment - CC BY 4.0
- 8.52: Hardy's Paradox - CC BY 4.0
- 8.53: Bell State Exercises - CC BY 4.0
- 8.54: Expressing Bell and GHZ States in Vector Format Using Mathcad - CC BY 4.0
- 8.55: Quantum Circuit for the Generation of GHZ States - CC BY 4.0
- 8.56: A Brief Description of Aspect's Experiment - CC BY 4.0
- 8.57: The Kochen-Specker Theorem Illustrated Using a Three-Qubit GHZ System - CC BY 4.0
- 8.58: A Brief Introduction to Entanglement Swapping - CC BY 4.0
- 8.59: An Entanglement Swapping Protocol - CC BY 4.0
- 8.60: Quantum Correlations Simplified - CC BY 4.0
- 8.61: Simulating Quantum Correlations with a Quantum Computer - CC BY 4.0
- 8.62: Quantum Computer Simulation of Photon Correlations - CC BY 4.0
- 8.63: Quantum Correlations Illustrated with Photons - CC BY 4.0
- 8.64: Examining the Local States of an Entangled Bipartite Superposition - CC BY 4.0
- 8.65: A Brief Introduction to the Quantum Computer - CC BY 4.0
- 8.66: A Very Simple Example of Parallel Quantum Computation - CC BY 4.0
- 8.67: Another Simple Example of Parallel Quantum Computation - CC BY 4.0
- 8.68: A Simple Solution to Deutsch's Problem - CC BY 4.0
- 8.69: Another Example of Deutsch's Algorithm - CC BY 4.0
- 8.70: Evaluating a Function Using a Quantum Circuit and a Demonstration of Parallel Computation - CC BY 4.0
- 8.71: A Simple Quantum Circuit for Parallel Computation - CC BY 4.0
- 8.72: An Illustration of the Deutsch-Jozsa Algorithm - CC BY 4.0
- 8.73: Another Illustration of the Deutsch-Jozsa Algorithm - CC BY 4.0
- 8.74: Aspects of Simon's Algorithm - CC BY 4.0
- 8.75: Qubit Quantum Mechanics - CC BY 4.0
- 8.76: Implementation of Deutsch's Algorithm Using Mathcad - CC BY 4.0
- 8.77: Using Quantum Gates to Create Superpositions and Entangled States - CC BY 4.0
- 8.78: A Simple Quantum Computer - CC BY 4.0
- 8.79: Solving Equations Using a Quantum Circuit - CC BY 4.0
- 8.80: Introduction to Superdense Coding - CC BY 4.0
- 8.81: A Brief Introduction to Quantum Dense Coding - CC BY 4.0
- 8.82: The Discrete or Quantum Fourier Transform - CC BY 4.0
- 8.83: Factoring Using Shor's Quantum Algorithm - CC BY 4.0
- 8.84: Shor's Quantum Algorithm - A Summary - CC BY 4.0
- 8.85: Simulating the Deutsch-Jozsa Algorithm with a Double-Slit Apparatus - CC BY 4.0

- 8.86: Simulating a Quantum Computer with a Mach-Zehnder Interferometer - CC BY 4.0
- 8.87: Quantum Restrictions on Cloning - CC BY 4.0
- 8.88: Quantum Error Correction - CC BY 4.0
- 8.89: Matrix Mechanics Analysis of the BB84 Key Distribution - CC BY 4.0
- 8.90: 388. The Quantum Math Behind Ekert's Key Distribution Scheme - CC BY 4.0
- 8.91: A Shorter Version of the Quantum Math Behind Ekert's Key Distribution Scheme - CC BY 4.0
- 8.92: Quantum Key Distribution Using a Mach-Zehnder Interferometer - CC BY 4.0
- 8.93: Coding and Decoding Venus - CC BY 4.0
- 8.94: Grover's Quantum Search Algorithm - CC BY 4.0
- 8.95: Grover's Search Algorithm- Implementation for Two Items - CC BY 4.0
- 8.96: Grover's Search Algorithm- Four-Card Monte - CC BY 4.0
- 9: Numerical Solutions for Schrödinger's Equation - CC BY 4.0
 - 9.1: Introduction to Numerical Solutions of Schrödinger's Equation - CC BY 4.0
 - 9.2: Particle in an Infinite Potential Well - CC BY 4.0
 - 9.3: Particle in a Gravitational Field - CC BY 4.0
 - 9.4: Particle in a One-dimensional Egg Carton - CC BY 4.0
 - 9.5: Particle in a Finite Potential Well - CC BY 4.0
 - 9.6: Particle in a Semi-infinite Potential Well - CC BY 4.0
 - 9.7: Particle in a Slanted Well Potential - CC BY 4.0
 - 9.8: Numerical Solutions for a Particle in a V-Shaped Potential Well - CC BY 4.0
 - 9.9: Numerical Solutions for the Harmonic Oscillator - CC BY 4.0
 - 9.10: Numerical Solutions for a Double-Minimum Potential Well - CC BY 4.0
 - 9.11: Numerical Solutions for the Quartic Oscillator - CC BY 4.0
 - 9.12: Numerical Solutions for Morse Oscillator - CC BY 4.0
 - 9.13: Numerical Solutions for the Lennard-Jones Potential - CC BY 4.0
 - 9.14: Numerical Solutions for the Double Morse Potential - CC BY 4.0
 - 9.15: Particle in a Box with an Internal Barrier - CC BY 4.0
 - 9.16: Another Look at the in a Box with an Internal Barrier - CC BY 4.0
 - 9.17: Particle in a Box with Multiple Internal Barriers - CC BY 4.0
 - 9.18: Particle in an Infinite Spherical Potential Well - CC BY 4.0
 - 9.19: Numerical Solutions for the Two-Dimensional Harmonic Oscillator - CC BY 4.0
 - 9.20: Numerical Solutions for the Three-Dimensional Harmonic Oscillator - CC BY 4.0
 - 9.21: Numerical Solutions for the Hydrogen Atom Radial Equation - CC BY 4.0
 - 9.22: Numerical Solutions for a Modified Harmonic Potential - CC BY 4.0
- 10: Approximate Quantum Mechanical Methods - CC BY 4.0
 - 10.1: Trial Wavefunctions for Various Potentials - CC BY 4.0
 - 10.2: Energy Minimization - Four Methods Using Mathcad - CC BY 4.0
 - 10.3: The Variation Theorem in Dirac Notation - CC BY 4.0
 - 10.4: A Rudimentary Model for Alpha Particle Decay - CC BY 4.0
 - 10.5: Variational Method for a Particle in a Finite Potential Well - CC BY 4.0
 - 10.6: Variation Method for a Particle in a Symmetric 1D Potential Well - CC BY 4.0
 - 10.7: Variation Method for the Rydberg Potential - CC BY 4.0
 - 10.8: Variation Method for the Quartic Oscillator - CC BY 4.0
 - 10.9: Momentum-Space Variation Method for the Quartic Oscillator - CC BY 4.0
 - 10.10: Variation Method for a Particle in a Gravitational Field - CC BY 4.0
 - 10.11: Linear Variational Method for a Particle in a Slanted 1D Box - CC BY 4.0
 - 10.12: Variation Method for a Particle in a Semi-Infinite Potential Well - CC BY 4.0
 - 10.13: Variation Method for a Particle in a Box with an Internal Barrier - CC BY 4.0
 - 10.14: Variation Method for a Particle in a 1D Ice Cream Cone - CC BY 4.0
 - 10.15: Variation Method for a Particle in an Ice Cream Cone - CC BY 4.0
 - 10.16: Variation Method for a Particle in a Finite 3D Spherical Potential Well - CC BY 4.0
 - 10.17: Variation Method for the Harmonic Oscillator - CC BY 4.0
 - 10.18: Trigonometric Trial Wave Function for the Harmonic Potential Well - CC BY 4.0
 - 10.19: Trigonometric Trial Wave Function for the 3D Harmonic Potential Well - CC BY 4.0
 - 10.20: Gaussian Trial Wavefunction for the Hydrogen Atom - CC BY 4.0

- 10.21: Variation Calculation on the 1D Hydrogen Atom Using a Trigonometric Trial Wave Function - CC BY 4.0
- 10.22: Variation Calculation on the 1D Hydrogen Atom Using a Gaussian Trial Wavefunction - CC BY 4.0
- 10.23: Variational Calculation on the Two-dimensional Hydrogen Atom - CC BY 4.0
- 10.24: Variational Calculation on Helium Using a Hydrogenic Wavefunction - CC BY 4.0
- 10.25: Gaussian Trial Wave Function for the Helium Atom - CC BY 4.0
- 10.26: Trigonometric Trial Wavefunction for the Helium Atom - CC BY 4.0
- 10.27: Trigonometric Trial Wavefunction for the Hydrogen Atom - CC BY 4.0
- 10.28: Hydrogen Atom Calculation Assuming the Electron is a Particle in a Sphere of Radius R - CC BY 4.0
- 10.29: Electronic Structure - Variational Calculations on the Lithium Atom - CC BY 4.0
- 10.30: The Variation Method in Momentum Space - CC BY 4.0
- 10.31: Momentum-Space Variation Method for Particle in a Gravitational Field - CC BY 4.0
- 10.32: Momentum-Space Variation Method for the Abs(x) Potential - CC BY 4.0
- 10.33: Variational Method for the Feshbach Potential - CC BY 4.0
- 10.34: Numerical Solution for the Feshbach Potential - CC BY 4.0
- 10.35: First Order Degenerate Perturbation Theory - the Stark Effect of the Hydrogen Atom - CC BY 4.0
- 10.36: Variational Calculation for the Polarizability of the Hydrogen Atom - CC BY 4.0
- 10.37: Hybrid Variational Calculation for the 1D Hydrogen Atom with Delta Function Potential - CC BY 4.0
- 10.38: Variation Method Using the Wigner Function-Finite Potential Well - CC BY 4.0
- 10.39: 455. Variation Method Using the Wigner Function- $V(x) = |x|$ - CC BY 4.0
- 10.40: Variation Method Using the Wigner Function-The Harmonic Oscillator - CC BY 4.0
- 10.41: Variation Method Using the Wigner Function - The Quartic Oscillator - CC BY 4.0
- 10.42: Variation Method Using the Wigner Function - The Feshbach Potential - CC BY 4.0
- 11: Miscellaneous - CC BY 4.0
 - 11.1: The Art of Science - CC BY 4.0
 - 11.2: Mass-Energy Equivalence - CC BY 4.0
 - 11.3: Commentary on "Probing the Orbital Energy of an Electron in an Atom" - CC BY 4.0
 - 11.4: The Use of Models in Introductory Chemistry - CC BY 4.0
 - 11.5: Reaction to Gillespie's Six Great Ideas in Chemistry - Another Great Idea - CC BY 4.0
 - 11.6: An Alternative Derivation of Gas Pressure Using the Kinetic Theory - CC BY 4.0
 - 11.7: Examining Fourier Synthesis with Dirac Notation - CC BY 4.0
 - 11.8: Finding Roots of Transcendental Equations - CC BY 4.0
 - 11.9: Calculation of the Composition of a Weak Polyprotic Acid Using Mathcad - CC BY 4.0
 - 11.10: Solving Linear Equations Using Mathcad - CC BY 4.0
 - 11.11: Let's Teach High School Students Computer Algebra Methods - CC BY 4.0
 - 11.12: Thermodynamics and Kinetics - CC BY 4.0
 - 11.13: Simple Kinetic Derivations of Thermodynamic Relations - CC BY 4.0
 - 11.14: The Global Approach to Thermodynamics - CC BY 4.0
 - 11.15: Global Thermodynamic Analyses of Heat Engines - CC BY 4.0
 - 11.16: Using Charles' Law to Determine Absolute Zero - CC BY 4.0
 - 11.17: The Origin of $KE = \frac{3}{2} RT$ - CC BY 4.0
 - 11.18: Cosmic Background Radiation - CC BY 4.0
 - 11.19: Age of the Elements - CC BY 4.0
- Back Matter - Undeclared
 - Index - Undeclared
 - Glossary - Undeclared
 - Detailed Licensing - Undeclared