

CONTENTS

<i>Preface</i>	xi
<i>Acknowledgments</i>	xv

PART I ELEMENTARY QUANTUM THEORY

<i>Chapter 1</i> An Introduction to Quantum Mechanics	
1 Wave-Particle Duality	1
2 Classical Wave Motion	12
3 Periodic Boundary Conditions and Complex Fourier Components	18
4 Fourier Series and Fourier Integrals	22
5 Wave Nature of Particles	30
6 Development of the Time-Dependent and Time-Independent Schrödinger Wave Equations	45
7 Wave-Packet Solutions and the Uncertainty Relation	55
8 Expectation Values for Quantum-Mechanical Operators	70
9 Probability Current Density	85
10 Energy Levels and Density of States	87
11 Reflection and Transmission Coefficients for a Particle Beam at a Potential-Energy Step Discontinuity and at a Rectangular Barrier	94
12 Bound-State Problems	113
Problems	133
Answers to Multiple Choice Problems	145

**PART II QUANTUM STATISTICS OF MANY-PARTICLE
SYSTEMS; FORMULATION OF THE FREE-ELECTRON
MODEL FOR METALS**

Chapter 2 Many-Particle Systems and Quantum Statistics		
1	Wave Functions for a Many-Particle System	146
2	Statistics for a Many-Particle System	166
	Problems	185
Chapter 3 Free-Electron Model and the Boltzmann Equation		
1	Free-Electron Gas in Three Dimensions	188
2	Electronic Specific Heat	200
3	Electrical Conductivity and the Derivation of Ohm's Law	209
4	Thermal Electron Emission from Metals	213
5	General Method for Evaluating Statistical Quantities Involving Fermi-Dirac Statistics	217
6	The Temperature Dependence of the Fermi Energy and Other Applications of the General Approximation Technique	221
7	The Boltzmann Equation	225
	Problems	235

**PART III APPROXIMATION TECHNIQUES FOR THE
SCHRÖDINGER EQUATION**

Chapter 4 The WKB Approximation and Electron Tunneling		
1	Development of the WKB Approximation	237
2	Application of the WKB Technique to Barrier Penetration	241
3	Tunneling in Metal-Insulator-Metal Structures	246
4	Tunnel Current at 0°K between Two Metals Separated by a Rectangular Barrier	256
5	Tunnel Current at 0°K for Barriers of Arbitrary Shape	260
6	Temperature Dependence of the Electron Tunnel Current	265
7	Applications of Electron Tunneling	268

**Chapter 5 Perturbation Theory, Diffraction of Valence Electrons,
and the Nearly-Free-Electron Model**

1	Stationary-State Perturbation Theory	279
2	Elementary Treatment of Diagonalization	286
3	Higher-Order Perturbations and Applications	290
4	Degenerate Case for Second-Order Treatment	294
5	Removal of Degeneracy in Second Order	294
6	Time-Dependent Perturbation Theory	298
7	Example: Harmonic Perturbation	301
8	Example: Constant Perturbation in First Order	306
9	Example: Constant Perturbation in Second Order	307
10	Transition Probability and Fermi's Golden Rule	308
11	Differential Cross Section for Scattering	311
12	Diffraction of Electrons by the Periodic Potential of a Crystal	313
13	Diffraction of Conduction Electrons and the Nearly-Free-Electron Model	317
14	Differential Scattering Cross Section for Plane-Wave States and a Coulomb Potential	327
	Problems	332

PART IV ENERGY BANDS IN CRYSTALS

Chapter 6 The Periodicity of Crystalline Solids

1	Generalities	334
2	Unit Cells and Bravais Lattices	336
3	Miller Indices and Crystal Directions	341
4	Some Specific Crystal Structures	343
5	Crystal Bonding	343
6	The Reciprocal Lattice: Fourier Space for Arbitrary Functions That Have the Lattice Periodicity	344
7	Wigner-Seitz Cell	352
8	First Brillouin Zone	353
9	Higher Brillouin Zones	354
	Problems	354

Chapter 7 Bloch's Theorem and Energy Bands for a Periodic Potential

1	Fourier Series Expansions for Arbitrary Functions of Position within the Crystal	357
---	---	-----

x CONTENTS

2	The Periodic Potential Characteristic of the Perfect Monocrystal	369
3	The Hamiltonian for an Electron in a Periodic Potential	372
4	Fourier Series Derivation of Bloch's Theorem	373
5	Properties of Bloch Functions	382
6	Correspondence with the Free-Electron Model	390
7	Additional Properties of Bloch Functions	405
8	Energy Bands from the Viewpoint of the One-Electron Atomic Levels	408
9	Energy Gaps and Energy Bands: Insulators, Semiconductors, and Metals	409
	Problems	411
 <i>Appendix</i> Physical Constants: Symbols, Units, and Values		413
 References		414
 <i>Index</i>		417