

Contents

<i>Preface</i>	viii
Chapter 1 The wave function	1
1.1 Wave motion	2
1.2 Wave packet	8
1.3 Dispersion of a wave packet	15
1.4 Particles and waves	18
1.5 Heisenberg uncertainty principle	21
1.6 Young's double-slit experiment	23
1.7 Stern–Gerlach experiment	26
1.8 Physical interpretation of the wave function	29
Problems	34
Chapter 2 Schrödinger wave mechanics	36
2.1 The Schrödinger equation	36
2.2 The wave function	37
2.3 Expectation values of dynamical quantities	41
2.4 Time-independent Schrödinger equation	46
2.5 Particle in a one-dimensional box	48
2.6 Tunneling	53
2.7 Particles in three dimensions	57
2.8 Particle in a three-dimensional box	61
Problems	64
Chapter 3 General principles of quantum theory	65
3.1 Linear operators	65
3.2 Eigenfunctions and eigenvalues	67
3.3 Hermitian operators	69

3.4	Eigenfunction expansions	75
3.5	Simultaneous eigenfunctions	77
3.6	Hilbert space and Dirac notation	80
3.7	Postulates of quantum mechanics	85
3.8	Parity operator	94
3.9	Hellmann–Feynman theorem	96
3.10	Time dependence of the expectation value	97
3.11	Heisenberg uncertainty principle	99
	Problems	104
Chapter 4	Harmonic oscillator	106
4.1	Classical treatment	106
4.2	Quantum treatment	109
4.3	Eigenfunctions	114
4.4	Matrix elements	121
4.5	Heisenberg uncertainty relation	125
4.6	Three-dimensional harmonic oscillator	125
	Problems	128
Chapter 5	Angular momentum	130
5.1	Orbital angular momentum	130
5.2	Generalized angular momentum	132
5.3	Application to orbital angular momentum	138
5.4	The rigid rotor	148
5.5	Magnetic moment	151
	Problems	155
Chapter 6	The hydrogen atom	156
6.1	Two-particle problem	157
6.2	The hydrogen-like atom	160
6.3	The radial equation	161
6.4	Atomic orbitals	175
6.5	Spectra	187
	Problems	192
Chapter 7	Spin	194
7.1	Electron spin	194
7.2	Spin angular momentum	196
7.3	Spin one-half	198
7.4	Spin–orbit interaction	201
	Problems	206

Chapter 8	Systems of identical particles	208
8.1	Permutations of identical particles	208
8.2	Bosons and fermions	217
8.3	Completeness relation	218
8.4	Non-interacting particles	220
8.5	The free-electron gas	226
8.6	Bose–Einstein condensation	229
	Problems	230
Chapter 9	Approximation methods	232
9.1	Variation method	232
9.2	Linear variation functions	237
9.3	Non-degenerate perturbation theory	239
9.4	Perturbed harmonic oscillator	246
9.5	Degenerate perturbation theory	248
9.6	Ground state of the helium atom	256
	Problems	260
Chapter 10	Molecular structure	263
10.1	Nuclear structure and motion	263
10.2	Nuclear motion in diatomic molecules	269
	Problems	279
Appendix A	Mathematical formulas	281
Appendix B	Fourier series and Fourier integral	285
Appendix C	Dirac delta function	292
Appendix D	Hermite polynomials	296
Appendix E	Legendre and associated Legendre polynomials	301
Appendix F	Laguerre and associated Laguerre polynomials	310
Appendix G	Series solutions of differential equations	318
Appendix H	Recurrence relation for hydrogen-atom expectation values	329
Appendix I	Matrices	331
Appendix J	Evaluation of the two-electron interaction integral	341
	<i>Selected bibliography</i>	344
	<i>Index</i>	347
	Physical constants	