Contents

Foreword by Victor F. Weisskopf ix

Preface by the Editor xi

Preface by the Students xiii

Introduction xv

1. Wave Functions of Force-Free Particles 1

1. Association of waves with particles 1
2. The wave function and wave equation 3
3. The uncertainty principle 5
4. Wave packets and the mechanics of point particle:. Probability density 10
5. Measuring arrangements. Discussion of examples 12
6. Classical statistics and quantum statistics 19

2. Description of a Particle in a Box and in Free Space 23

7. One particle in a box. The equation of continuity 23
8. Normalization in the continuum. The Dirac &function 27
9. The completeness relation. Expansion theorem 31
10. Initial-value problem and the fundamental solution 33

3. Particle in a Field of Force 38

11. The Hamiltonian operator 38
12. Hermitian operators 40

13. Expectation values and the classical equation of motion. Commutation relations (commutators) 43

4. More than One Particle 51

14. More than one particle 51

5. Eigenvalue Problems. Functions of Mathematical Physics 55

15. The linear harmonic oscillator. Hermite polynomials 55
16. Matrix calculus illustrated with the linear harmonic oscillator 63
17. The harmonic oscillator in a plane. Degeneracy 72
18. The hydrogen atom 88

6. Collision Processes 107

19. Asymptotic solution of the scattering problem 108
20. The scattering cross section. The Rutherford scattering formula 110
21. Solution of the force-free wave equation 112
22. Expansion of a plane wave in Legendre polynomials 115
23. Solution of the Schrödinger equation with an arbitrary central potential 116
24. The Born approximation 120
25. Scattering of low-energy particles 123

7. Approximate Methods for Solving the Wave Equation 126

26. Eigenvalue problem of a particle in a uniform field 126
27. The WKB method 132

8. Matrices and Operators. Perturbation Theory 138

28. General relationship between matrices and operators. Transformation theory 138
29. General formalism of perturbation theory in the matrix representation 143
30. Time-dependent perturbation 147

9. Angular Momentum and Spin 152

31. General commutation relations 152
32. Matrix elements of the angular momentum 154
33. Spin 156
34. Spinors and space rotations 159

IO. Identical Particle:. with Spin 165

35. Symmetry classes 165
36. The exclusion principle 167
37. The helium atom 169
38. Collision of two identical particles: Mott's theory 173
39. The statistics of nuclear spins 175

Exercises 177

40. Fundamental solution for interval 177
41. Bound states and tunnel effect 179
42. Kronig-Penney potential 180
43. Spherical harmonics 180
44. Fundamental solution for harmonic oscillator 182
45. Angular momentum 184
46. Partial waves 185
47. The symmetrical top 186

Bibliography 191

Appendix. Comments by the Editor 193

Index 199