
Table

VOLUME I

Directions for Use	v
Introduction.	3
Foreword	6

Chapter I	Waves and particles. Introduction to the fundamental ideas of quantum mechanics	7
	<i>A. Electromagnetic waves and photons.</i>	<i>10</i>
	<i>B. Material particles and matter waves.</i>	<i>18</i>
	<i>C. Quantum description of a particle ; wave packets.</i>	<i>21</i>
	<i>D. Particle in a time-independent scalar potential.</i>	<i>31</i>

Complements of chapter I

READER'S GUIDE.	41
<i>A₁: Order of magnitude of the wavelengths associated with material particles</i>	<i>42</i>
<i>B₁: Constraints imposed by the uncertainty relations.</i>	<i>45</i>
<i>C₁: The uncertainty relations and atomic parameters.</i>	<i>47</i>
<i>D₁: An experiment illustrating the uncertainty relation</i>	<i>50</i>
<i>E₁: A simple treatment of a two-dimensional wave packet</i>	<i>53</i>
<i>F₁: The relation between one- and three-dimensional problems.</i>	<i>57</i>
<i>G₁: One-dimensional Gaussian wave packet: spreading of the wave packet</i>	<i>61</i>
<i>H₁: Stationary states of a particle in one-dimensional square potentials</i>	<i>67</i>
<i>J₁: Behavior of a wave packet at a potential step.</i>	<i>79</i>
<i>K₁: Exercises</i>	<i>86</i>

Chapter II	The mathematical tools of quantum mechanics	91
	A. <i>One-particle wave function space.</i>	94
	B. <i>State space. Dirac notation.</i>	108
	C. <i>Representations in the state space.</i>	121
	D. <i>Eigenvalue equations. Observables.</i>	132
	E. <i>Two important examples of representations and observables. . . .</i>	144
	F. <i>Tensor product of state spaces.</i>	153
 Complements of chapter II		
	READER'S GUIDE.	164
	A _{II} : <i>The Schwarz inequality.</i>	165
	B _{II} : <i>Review of some useful properties of linear operators.</i>	166
	C _{II} : <i>Unitary operators</i>	176
	D _{II} : <i>A more detailed study of the $\{ \mathbf{r} \rangle \}$ and $\{ \mathbf{p} \rangle \}$ representations</i>	182
	E _{II} : <i>Some general properties of two observables, Q and P, whose commutator is equal to $i\hbar$.</i>	187
	F _{II} : <i>The parity operator.</i>	192
	G _{II} : <i>An application of the properties of the tensor product : the two-dimensional infinite well.</i>	199
	H _{II} : <i>Exercises</i>	203
 Chapter III		
Chapter III	The postulates of quantum mechanics	211
	A. <i>Introduction</i>	213
	B. <i>Statement of the postulates.</i>	214
	C. <i>The physical interpretation of the postulates concerning observables and their measurement.</i>	225
	D. <i>The physical implications of the Schrödinger equation.</i>	236
	E. <i>The superposition principle and physical predictions.</i>	252
 Complements of chapter III		
	READER'S GUIDE.	267
	A _{III} : <i>Particle in an infinite potential well</i>	269
	B _{III} : <i>Study of the probability current in some special cases.</i>	280
	C _{III} : <i>Root-mean-square deviations of two conjugate observables. . .</i>	286
	D _{III} : <i>Measurements bearing on only one part of a physical system. .</i>	290
	E _{III} : <i>The density operator.</i>	295
	F _{III} : <i>The evolution operator.</i>	308
	G _{III} : <i>The Schrödinger and Heisenberg pictures.</i>	312
	H _{III} : <i>Gauge invariance</i>	315
	J _{III} : <i>Propagator for the Schrödinger equation.</i>	329
	K _{III} : <i>Unstable states. Lifetime.</i>	337
	L _{III} : <i>Exercises</i>	341

M_{III} : Bound states of a particle in a "potential well" of arbitrary shape	351
N_{III} : Unbound states of a particle in the presence of a potential well or barrier of arbitrary shape.	359
O_{III} : Quantum properties of a particle in a one-dimensional periodic structure.	367
Chapter IV Application of postulates to simple cases: spin 1/2 and two-level systems	385
A. Spin 1/2 particle: quantization of the angular momentum.	387
B. Illustration of the postulates in the case of a spin 1/2	395
C. General study of two-level systems.	405
Complements of chapter IV	
READER'S GUIDE.	416
A_{IV} : The Pauli matrices.	417
B_{IV} : Diagonalization of a 2×2 Hermitian matrix	420
C_{IV} : Fictitious spin 1/2 associated with a two-level system.	424
D_{IV} : System of two spin 1/2 particles.	430
E_{IV} : Spin 1/2 density matrix.	437
F_{IV} : Spin 1/2 particle in a static magnetic field and a rotating field: magnetic resonance	443
G_{IV} : A simple model of the ammonia molecule.	455
H_{IV} : Coupling between a stable state and an unstable state.	470
J_{IV} : Exercises.	476
Chapter V The one-dimensional harmonic oscillator	481
A. Introduction	483
B. Eigenvalues of the Hamiltonian.	488
C. Eigenstates of the Hamiltonian.	496
D. Discussion	503
Complements of chapter V	
READER'S GUIDE.	509
A_V : Some examples of harmonic oscillators.	511
B_V : Study of the stationary states in the $\{ x\rangle\}$ representation. Hermite polynomials	529
C_V : Solving the eigenvalue equation of the harmonic oscillator by the polynomial method.	535
D_V : Study of the stationary states in the $\{ p\rangle\}$ representation.	542
E_V : The isotropic three-dimensional harmonic oscillator.	547

	F_V : <i>A charged harmonic oscillator placed in a uniform electric field.</i> . . .	552
	G_V : <i>Coherent "quasi-classical" states of the harmonic oscillator.</i> . . .	559
	H_V : <i>Normal vibrational modes of two coupled harmonic oscillators.</i> . .	575
	J_V : <i>Vibrational modes of an infinite linear chain of coupled harmonic oscillators; phonons</i>	586
	K_V : <i>Vibrational modes of a continuous physical system. Application to radiation; photons.</i>	605
	L_V : <i>The one-dimensional harmonic oscillator in thermodynamic equilibrium at a temperature T.</i>	620
	M_V : <i>Exercises.</i>	634
Chapter VI	General properties of angular momentum in quantum mechanics	641
	A. <i>Introduction: the importance of angular momentum.</i>	643
	B. <i>Commutation relations characteristic of angular momentum.</i>	644
	C. <i>General theory of angular momentum.</i>	647
	D. <i>Application to orbital angular momentum.</i>	660
	Complements of chapter VI	
	READER'S GUIDE.	677
	A_{VI} : <i>Spherical harmonics</i>	678
	B_{VI} : <i>Angular momentum and rotations.</i>	690
	C_{VI} : <i>Rotation of diatomic molecules.</i>	712
	D_{VI} : <i>Angular momentum of stationary states of a two-dimensional harmonic oscillator</i>	727
	E_{VI} : <i>A charged particle in a magnetic field; Landau levels.</i>	742
	F_{VI} : <i>Exercises.</i>	765
Chapter VII	Particle in a central potential. The hydrogen atom.	773
	A. <i>Stationary states of a particle in a central potential.</i>	776
	B. <i>Motion of the center of mass and relative motion for a system of two interacting particles</i>	784
	C. <i>The hydrogen atom</i>	790

Complements of chapter VII

READER'S GUIDE.	804
A _{VII} : <i>Hydrogen-like systems</i>	805
B _{VII} : <i>A soluble example of a central potential: the isotropic three-dimensional harmonic oscillator.</i>	814
C _{VII} : <i>Probability currents associated with the stationary states of the hydrogen atom</i>	824
D _{VII} : <i>The hydrogen atom placed in a uniform magnetic field. Paramagnetism and diamagnetism. The Zeeman effect.</i>	828
E _{VII} : <i>Some atomic orbitals. Hybrid orbitals</i>	841
F _{VII} : <i>Vibrational-rotational levels of diatomic molecules.</i>	856
G _{VII} : <i>Exercises</i>	870
BIBLIOGRAPHY	873
INDEX.	891

VOLUME II

Chapter VIII	An elementary approach to the quantum theory of scattering by a potential	901
	A. <i>Introduction</i>	903
	B. <i>Stationary scattering states. Calculation of the cross section.</i> . . .	907
	C. <i>Scattering by a central potential. Method of partial waves.</i>	921

Complements of chapter VIII

READER'S GUIDE.	937
A _{VIII} : <i>The free particle: stationary states with well-defined angular momentum</i>	938
B _{VIII} : <i>Phenomenological description of collisions with absorption.</i> . .	951
C _{VIII} : <i>Some simple applications of scattering theory.</i>	957

Chapter IX	Electron spin	965
	A. <i>Introduction of electron spin.</i>	968
	B. <i>Special properties of angular momentum 1/2.</i>	972
	C. <i>Non-relativistic description of a spin 1/2 particle.</i>	974
 Complements of chapter IX		
	READER'S GUIDE.	982
	A _{IX} : <i>Rotation operators for a spin 1/2 particle.</i>	983
	B _{IX} : <i>Exercises.</i>	990
Chapter X	Addition of angular momenta	997
	A. <i>Introduction</i>	999
	B. <i>Addition of two spin 1/2's. Elementary method.</i>	1003
	C. <i>Addition of two arbitrary angular momenta. General method.</i>	1009
 Complements of chapter X		
	READER'S GUIDE.	1025
	A _X : <i>Examples of addition of angular momenta.</i>	1027
	B _X : <i>Clebsch-Gordan coefficients</i>	1035
	C _X : <i>Addition of spherical harmonics.</i>	1043
	D _X : <i>Vector operators: the Wigner-Eckart theorem.</i>	1048
	E _X : <i>Electric multipole moments.</i>	1059
	F _X : <i>Evolution of two angular momenta \mathbf{J}_1 and \mathbf{J}_2 coupled by an interaction $a\mathbf{J}_1 \cdot \mathbf{J}_2$.</i>	1072
	G _X : <i>Exercises</i>	1086
Chapter XI	Stationary perturbation theory	1093
	A. <i>Description of the method.</i>	1096
	B. <i>Perturbation of a non-degenerate level</i>	1100
	C. <i>Perturbation of a degenerate level</i>	1104

Complements of chapter XI

READER'S GUIDE.	1109
A_{XI} : <i>A one-dimensional harmonic oscillator subjected to a perturbing potential in x, x^2, x^3.</i>	1110
B_{XI} : <i>Interaction between the magnetic dipoles of two spin 1/2 particles</i>	1120
C_{XI} : <i>Van der Waals forces.</i>	1130
D_{XI} : <i>The volume effect: the influence of the spatial extension of the nucleus on the atomic levels.</i>	1141
E_{XI} : <i>The variational method.</i>	1148
F_{XI} : <i>Energy bands of electrons in solids: a simple model.</i>	1156
G_{XI} : <i>A simple example of the chemical bond: the H_2^+ ion.</i>	1169
H_{XI} : <i>Exercises.</i>	1200

Chapter XII	An application of perturbation theory : the fine and hyperfine structure of the hydrogen atom . . .	1209
	A. <i>Introduction</i>	1212
	B. <i>Additional terms in the Hamiltonian.</i>	1213
	C. <i>The fine structure of the $n = 2$ level.</i>	1219
	D. <i>The hyperfine structure of the $n = 1$ level.</i>	1227
	E. <i>The Zeeman effect of the hyperfine structure of the 1s ground state</i>	1232

Complements of chapter XII

READER'S GUIDE.	1246
A_{XII} : <i>The magnetic hyperfine Hamiltonian.</i>	1247
B_{XII} : <i>Calculation of the mean values of the fine-structure Hamiltonian in the 1s, 2s and 2p states.</i>	1257
C_{XII} : <i>The hyperfine structure and the Zeeman effect for muonium and positronium</i>	1262
D_{XII} : <i>The influence of the electron spin on the Zeeman effect of the hydrogen resonance line.</i>	1270
E_{XII} : <i>The Stark effect for the hydrogen atom.</i>	1279

Chapter XIII Approximation methods for time-dependent problems.	1283
A. <i>Statement of the problem.</i>	1285
B. <i>Approximate solution of the Schrödinger equation.</i>	1286
C. <i>An important special case: sinusoidal or constant perturbation.</i>	1291
Complements of chapter XIII	
READER'S GUIDE.	1303
A _{XIII} : <i>Interaction of an atom with an electromagnetic wave.</i>	1304
B _{XIII} : <i>Linear and non-linear responses of a two-level system subject to a sinusoidal perturbation.</i>	1322
C _{XIII} : <i>Oscillations of a system between two discrete states under the effect of a resonant perturbation.</i>	1339
D _{XIII} : <i>Decay of a discrete state resonantly coupled to a continuum of final states</i>	1343
E _{XIII} : <i>Exercises</i>	1356
Chapter XIV Systems of identical particles	1369
A. <i>Statement of the problem.</i>	1371
B. <i>Permutation operators</i>	1377
C. <i>The symmetrization postulate</i>	1386
D. <i>Discussion</i>	1396

Complements of chapter XIV

READER'S GUIDE	1409
<i>A_{XIV}: Many-electron atoms. Electronic configurations</i>	1410
<i>B_{XIV}: Energy levels of the helium atom : configurations, terms, multiplets</i>	1418
<i>C_{XIV}: Physical properties of an electron gas. Application to solids. .</i>	1432
<i>D_{XIV}: Exercises</i>	1447
Appendix I Fourier series and Fourier transforms	1457
Appendix II The Dirac δ -"function"	1467
Appendix III Lagrangian and Hamiltonian in classical mechanics	1481
BIBLIOGRAPHY	1499
INDEX.	1517