

Contents

<i>Preface</i>	<i>page ix</i>
I Part I	1
1 From Particles to Fields	3
1.1 Classical Harmonic Chain: Phonons	5
1.2 Functional Analysis and Variational Principles	13
1.3 Maxwell's Equations as a Variational Principle	17
1.4 Quantum Chain	21
1.5 Quantum Electrodynamics	26
1.6 Noether's Theorem	30
1.7 Summary and Outlook	35
1.8 Problems	35
2 Second Quantization	40
2.1 Introduction to Second Quantization	41
2.2 Applications of Second Quantization	51
2.3 Summary and Outlook	79
2.4 Problems	80
3 Path Integral	91
3.1 The Path Integral: General Formalism	91
3.2 Construction of the Path Integral	93
3.3 Advanced Applications of the Feynman Path Integral	109
3.4 Construction of the Many-Body Field Integral	127
3.5 Field Integral for the Quantum Partition Function	136
3.6 Field-Theoretical Bosonization: A Case Study	144
3.7 Summary and Outlook	153
3.8 Problems	153
4 Perturbation Theory	171
4.1 General Concept and Low-Order Expansions	172
4.2 Ground State Energy of the Interacting Electron Gas	187
4.3 Infinite-Order Expansions	199
4.4 Perturbation Theory of the Disordered Electron Gas	208
4.5 Summary and Outlook	224
4.6 Problems	225

5	Broken Symmetry and Collective Phenomena	233
5.1	Case Study: Plasma Theory of the Electron Gas	234
5.2	Bose–Einstein Condensation and Superfluidity	242
5.3	Superconductivity	257
5.4	Field Theory of the Disordered Electron Gas	286
5.5	Summary and Outlook	293
5.6	Problems	294
6	Renormalization Group	312
6.1	Renormalization: Two Examples	314
6.2	Renormalization Group: General Theory	329
6.3	RG Analysis of the Ferromagnetic Transition	342
6.4	RG Analysis of the Nonlinear σ -Model	353
6.5	Berezinskii–Kosterlitz–Thouless Transition	360
6.6	Summary and Outlook	372
6.7	Problems	372
7	Response Functions	384
7.1	Experimental Approaches to Condensed Matter	384
7.2	Linear Response Theory	390
7.3	Analytic Structure of Correlation Functions	393
7.4	Electromagnetic Linear Response	407
7.5	Summary and Outlook	413
7.6	Problems	414
II	Part II	419
8	Topological Field Theory	421
8.1	Topological Quantum Matter	422
8.2	Example: Particle on a Ring	431
8.3	Homotopy	434
8.4	θ -terms	437
8.5	Wess–Zumino Terms	472
8.6	Chern–Simons Terms	491
8.7	Summary and Outlook	508
8.8	Problems	509
9	Relativistic Field Theory	522
9.1	Dirac Theory	523
9.2	Anomalies	543
9.3	Summary and Outlook	558
9.4	Problems	559

10	Gauge Theory	572
10.1	Geometric Approach to Gauge Theory	573
10.2	Connections	584
10.3	Lattice Gauge Theory	595
10.4	Quantum Lattice Gauge Theory	603
10.5	Topological Gauge Theory	612
10.6	Summary and Outlook	623
10.7	Problems	624
11	Nonequilibrium (Classical)	632
11.1	Fundamental Concepts of Nonequilibrium Statistical Mechanics	633
11.2	Langevin Theory	636
11.3	Boltzmann Kinetic Theory	646
11.4	Stochastic Processes	652
11.5	Field Theory I: Zero-dimensional Theories	662
11.6	Field Theory II: Higher Dimensions	670
11.7	Field Theory III: Applications	679
11.8	Summary and Outlook	686
11.9	Problems	687
12	Nonequilibrium (Quantum)	697
12.1	Prelude: Quantum Master Equation	698
12.2	Keldysh Field Theory: Basics	705
12.3	Particle Coupled to an Environment	720
12.4	Fermion Keldysh Theory	724
12.5	Kinetic Equation	728
12.6	Non-equilibrium Quantum Transport	733
12.7	Full Counting Statistics	747
12.8	Summary and Outlook	753
12.9	Problems	754
	Appendix	766
A.1	Differential Geometry and Differential Forms	766
A.2	Elements of Probability Theory	780
A.3	Conformal Field Theory Essentials	785
A.4	Fourier and Wigner Transforms	799
	<i>Index</i>	803