

Contents

<i>Preface</i>	<i>page</i> ix
1 From particles to fields	1
1.1 Classical harmonic chain: phonons	3
1.2 Functional analysis and variational principles	11
1.3 Maxwell's equations as a variational principle	15
1.4 Quantum chain	19
1.5 Quantum electrodynamics	24
1.6 Noether's theorem	30
1.7 Summary and outlook	34
1.8 Problems	35
2 Second quantization	39
2.1 Introduction to second quantization	40
2.2 Applications of second quantization	50
2.3 Summary and outlook	83
2.4 Problems	83
3 Feynman path integral	95
3.1 The path integral: general formalism	95
3.2 Construction of the path integral	97
3.3 Applications of the Feynman path integral	112
3.4 Problems	146
3.5 Problems	146
4 Functional field integral	156
4.1 Construction of the many-body path integral	158
4.2 Field integral for the quantum partition function	165
4.3 Field theoretical bosonization: a case study	173
4.4 Summary and outlook	181
4.5 Problems	181
5 Perturbation theory	193

5.1	General structures and low-order expansions	194
5.2	Ground state energy of the interacting electron gas	208
5.3	Infinite-order expansions	223
5.4	Summary and outlook	232
5.5	Problems	233
6	Broken symmetry and collective phenomena	242
6.1	Mean-field theory	243
6.2	Plasma theory of the interacting electron gas	243
6.3	Bose–Einstein condensation and superfluidity	251
6.4	Superconductivity	265
6.5	Field theory of the disordered electron gas	301
6.6	Summary and outlook	329
6.7	Problems	331
7	Response functions	360
7.1	Crash course in modern experimental techniques	360
7.2	Linear response theory	368
7.3	Analytic structure of correlation functions	372
7.4	Electromagnetic linear response	389
7.5	Summary and outlook	399
7.6	Problems	400
8	The renormalization group	409
8.1	The one-dimensional Ising model	412
8.2	Dissipative quantum tunneling	422
8.3	Renormalization group: general theory	429
8.4	RG analysis of the ferromagnetic transition	444
8.5	RG analysis of the nonlinear σ -model	456
8.6	Berezinskii–Kosterlitz–Thouless transition	463
8.7	Summary and outlook	474
8.8	Problems	475
9	Topology	496
9.1	Example: particle on a ring	497
9.2	Homotopy	502
9.3	θ -terms	505
9.4	Wess–Zumino terms	536
9.5	Chern–Simons terms	569
9.6	Summary and outlook	588
9.7	Problems	588
10	Nonequilibrium (classical)	602
10.1	Fundamental questions of (nonequilibrium) statistical mechanics	607
10.2	Langevin theory	609

10.3 Boltzmann kinetic theory	623
10.4 Stochastic processes	632
10.5 Field theory I: zero dimensional theories	643
10.6 Field theory II: higher dimensions	654
10.7 Field theory III: applications	665
10.8 Summary and Outlook	684
10.9 Problems	684
11 Nonequilibrium (quantum)	693
11.1 Prelude: Quantum master equation	695
11.2 Keldysh formalism: basics	700
11.3 Particle coupled to an environment	716
11.4 Fermion Keldysh theory (a list of changes)	720
11.5 Kinetic equation	723
11.6 A mesoscopic application	729
11.7 Full counting statistics	745
11.8 Summary and outlook	753
11.9 Problems	753
<i>Index</i>	766