

# Contents

<i>Preface</i>	<i>page vii</i>
<b>1 From particles to fields</b>	<b>1</b>
1.1 Classical harmonic chain: phonons	3
1.2 Functional analysis and variational principles	12
1.3 Maxwell's equations as a variational principle	16
1.4 Quantum chain	19
1.5 Quantum electrodynamics	25
1.6 Noether's theorem	31
1.7 Summary and outlook	34
1.8 Problems	35
<b>2 Second quantization</b>	<b>39</b>
2.1 Introduction to second quantization	40
2.2 Applications of second quantization	50
2.3 Summary and outlook	82
2.4 Problems	83
<b>3 Feynman path integral</b>	<b>94</b>
3.1 The path integral: general formalism	94
3.2 Construction of the path integral	96
3.3 Applications of the Feynman path integral	112
3.4 Summary and outlook	147
3.5 Problems	147
<b>4 Functional field integral</b>	<b>157</b>
4.1 Construction of the many-body path integral	159
4.2 Field integral for the quantum partition function	166
4.3 Field theoretical bosonization: a case study	175
4.4 Summary and outlook	183
4.5 Problems	183

<b>5</b>	<b>Perturbation theory</b>	<b>195</b>
5.1	General structures and low-order expansions	196
5.2	Ground state energy of the interacting electron gas	211
5.3	Infinite-order expansions	225
5.4	Summary and outlook	235
5.5	Problems	236
<b>6</b>	<b>Broken symmetry and collective phenomena</b>	<b>246</b>
6.1	Mean-field theory	247
6.2	Plasma theory of the interacting electron gas	247
6.3	Bose–Einstein condensation and superfluidity	256
6.4	Superconductivity	270
6.5	Field theory of the disordered electron gas	310
6.6	Summary and outlook	338
6.7	Problems	340
<b>7</b>	<b>Response functions</b>	<b>370</b>
7.1	Crash course in modern experimental techniques	370
7.2	Linear response theory	378
7.3	Analytic structure of correlation functions	382
7.4	Electromagnetic linear response	400
7.5	Summary and outlook	410
7.6	Problems	410
<b>8</b>	<b>The renormalization group</b>	<b>419</b>
8.1	The one-dimensional Ising model	422
8.2	Dissipative quantum tunneling	433
8.3	Renormalization group: general theory	441
8.4	RG analysis of the ferromagnetic transition	456
8.5	RG analysis of the nonlinear $\sigma$ -model	469
8.6	Berezinskii–Kosterlitz–Thouless transition	476
8.7	Summary and outlook	487
8.8	Problems	489
<b>9</b>	<b>Topology</b>	<b>511</b>
9.1	Example: particle on a ring	512
9.2	Homotopy	517
9.3	$\theta$ -Terms	521
9.4	Wess–Zumino terms	553
9.5	Chern–Simons terms	588
9.6	Summary and outlook	607
9.7	Problems	608
	<i>Index</i>	621