

CONTENTS

Preface	v
Notations	vi
Part I GENERAL FIELD THEORY	
Chapter 1 MANY PARTICLE SYSTEMS AND FIELD THEORIES	3
1. An NR Quantum System with n Degrees of Freedom	3
2. Continuum Limit	4
3. A Free Field	6
4. Nonrelativistic Many-particle Systems	13
Chapter 2 RELATIVISTIC FREE FIELD THEORIES	16
1. Free Scalar Fields	16
2. Free Dirac Equations	20
3. Plane Wave Solutions to Dirac Equations	26
4. Free Dirac Fields	29
5. Negative Energy Sea	32
Chapter 3 INTERACTIONS AMONG FIELDS	36
1. An Example of Field Interactions	36
2. Interaction Picture and Dyson's Expansion	38
3. S -Matrix, In-states, and Out-states	42
4. Wick's Theorem	43
5. Second Order Processes	48
6. Explicit Amplitudes	53
Chapter 4 FEYNMAN DIAGRAMS AND CROSS SECTIONS	58
1. Position-space Feynman Rules	58
2. Momentum-space Feynman Rules	59
3. Cross Sections	64
4. Phase-space Factors	67
5. An Example	68

Chapter 5	QUANTUM ELECTRODYNAMICS	74
1.	The Classical Electromagnetic Field	74
2.	Quantization of the Electromagnetic Field	78
3.	The Photon Propagators	80
4.	The Minimal Coupling and the Feynman Rules	82
5.	Electron-electron Scattering	85
6.	Interactions with the Classical Sources	89
7.	Compton Scattering and the Low Energy Theorem	95
Chapter 6	HIGHER ORDER PROCESSES	98
1.	Degrees of Divergence	98
2.	The Vacuum Polarization Diagrams	99
3.	Electron Self-energy Diagrams	109
4.	Vertex Corrections	112
Chapter 7	ZERO TEMPERATURE FERMI SYSTEM	121
1.	Introduction	121
2.	The Feynman Rules	122
3.	Hartree-Fock Approximation	126
Chapter 8	THE ELECTRON GAS MODEL	130
1.	The Model	130
2.	Hartree-Fock Approximation	131
3.	Polarization and Screening	134
4.	Decay of Electrons and Holes	139
Chapter 9	BRUEKNER THEORY OF NUCLEAR MATTER	145
1.	Nuclear Matter	145
2.	Bruekner Theory	146
Chapter 10	ZERO TEMPERATURE BOSE SYSTEM	153
1.	Noninteracting Bose System	153
2.	Zero Temperature Interacting Bose System	156
3.	Self-energy Diagrams	160
Chapter 11	LIQUID HELIUM-4	165
1.	Review of Facts	165
2.	Superfluidity	168
Chapter 12	CLASSICAL SYSTEMS WITH NOISES	172
1.	Equivalent Systems	172
2.	Feynman Rules	177
3.	Fokker-Planck Equations and Boltzmann Distribution	180

Part II ADVANCED FIELD THEORY

Chapter 1	FIELD QUANTIZATIONS	187
1.	Action Principle	187
2.	Quantization of a Scalar Field	191
3.	Quantization of a Dirac Field	193
4.	Quantization of a Vector Field	196
Chapter 2	LORENTZ TRANSFORMATION PROPERTIES	202
1.	Lorentz Invariance	202
2.	Free Scalar and Dirac Fields	205
3.	Stress Tensor	211
4.	Schwinger Relation	215
Chapter 3	DISCRETE TRANSFORMATIONS	218
1.	Parity	218
2.	Charge Conjugation	220
3.	Time Reversal	223
4.	TCP Theorem	226
5.	Spin and Statistics	227
Chapter 4	PATH INTEGRAL FORMULATION	230
1.	Nonrelativistic Quantum Mechanics	230
2.	Classical Limit	232
3.	Hamiltonian Path Integrals	238
4.	Scalar Field Theories and Feynman Rules	240
5.	Dyson-Schwinger Equation	247
6.	Grassmann Algebra	250
7.	Fermion System	253
Chapter 5	GAUGE THEORIES	258
1.	Path Integral Formulation of Maxwell Fields	258
2.	Quantum Electrodynamics	265
3.	Yang-Mills Fields	268
4.	Path Integrals and Feynman Rules	272
5.	Examples	278
Chapter 6	RENORMALIZATION THEORY	281
1.	Renormalization of QED — One Loop Diagrams	289
2.	Dyson's Prescriptions	286
3.	Overlapping Divergences	290
4.	BPHZ Renormalization	292
5.	Classification of Renormalizable Theories	297

Chapter 7	RENORMALIZATION OF NON-ABELIAN GAUGE THEORIES	300
1.	Non-abelian Gauge Theories	300
2.	Gauge Field Self-energy Diagrams	303
3.	Other Renormalization Parts	310
4.	Slavnov-Taylor Identities	313
5.	Higgs Mechanism	318
Chapter 8	RENORMALIZATION GROUP	322
1.	Intermediate Renormalization and its Group Property	322
2.	Callan-Symanzik Equations	326
3.	Solutions to Callan-Symanzik Equations	330
4.	An Example	333
5.	Asymptotically Free Theories	338
Chapter 9	INSTANTON	343
1.	Solutions to a Classical Yang-Mills Theory	343
2.	Instanton as a Tunneling Solution	347
3.	Tunneling Potential and Vacuum	352
4.	Zero Modes	357
5.	Axial Anomaly	364
6.	Decay of a False Vacuum	368
	Subject Index	373