Table of Contents

Preface iii

PART I INTRODUCTIONS 1

1 Astrophysics Introduction 3

2 Theoretical Physics Introduction 15

3 Computational Physics Introduction 25

4 Mathematical Introduction 35

PART II THE CONTINUUM LIMIT: $N \to \infty$ 45

5 Paradoxical Thermodynamics 47

6 Statistical Mechanics 54

7 Motion in a Central Potential 63

8 Some Famous Models 74

9 Methods 84

PART III MEAN FIELD DYNAMICS: $N = 10^6$ 98

10 Violent Relaxation 99

11 Internal Mass Loss 111

12 External Influences 119

PART IV MICROPHYSICS: $N = 2$ 129

13 Exponential Orbit Instability 130

14 Two-Body Relaxation 138

15 From Kepler to Kustaanheimo 154

PART V GRAVOTHERMODYNAMICS: $N = 10^6$ 164
16 Escape and Mass Segregation 165
17 Gravothermal Instability 176
18 Core Collapse Rate for Star Clusters 185
PART VI GRAVITATIONAL SCATTERING: $N = 3$ 193
19 Thought Experiments 195
20 Mathematical Three-Body Scattering 203
21 Analytical Approximations 215
22 Laboratory Experiments 229
23 Gravitational Burning and Transmutation 239
PART VII PRIMORDIAL BINARIES: $N = 4$ 246
24 Binaries in Star Clusters 247
25 Triple Formation and Evolution 253
26 A Non-Renewable Energy Source 264
PART VIII POST-COLLAPSE EVOLUTION: $N = 10^6$ 272
27 Surviving Core Collapse 273
28 Gravothermal Oscillations 283
29 Dissolution 294
PART IX STAR CLUSTER ECOLOGY 300
30 Stellar and Dynamical Evolution 302
31 Collisions and Capture 307
32 Binary Star Evolution and Blue Stragglers 315
33 Star Cluster Evolution 323
A Appendix – A Simple N-Body Integrator 331
B Appendix – Hints to solution of problems 341
References 354
Index 376