

**4 ■ Oscillatory Systems**

86

- 4.1 Simple Harmonic Motion 86
- 4.2 The Motion of a Pendulum 89
- 4.3 Damped Harmonic Oscillator 93
- 4.4 Response to External Forces 94
- 4.5 Electrical Circuit Oscillations 98
- 4.6 Accuracy and Stability 102
- 4.7 Projects 104

**5 ■ Few-Body Problems: The Motion of the Planets**

108

- 5.1 Planetary Motion 108
- 5.2 The Equations of Motion 108
- 5.3 Circular and Elliptical Orbits 110
- 5.4 Astronomical Units 112
- 5.5 Log-Log and Semilog Plots 112
- 5.6 Simulation of the Orbit 115
- 5.7 Impulsive Forces 119
- 5.8 Velocity Space 122
- 5.9 A Mini-Solar System 123
- 5.10 Two-Body Scattering 126
- 5.11 Three-Body Problems 133
- 5.12 Projects 137

**6 ■ The Chaotic Motion of Dynamical Systems**

141

- 6.1 Introduction 141
- 6.2 A Simple One-Dimensional Map 141
- 6.3 Period Doubling 147
- 6.4 Universal Properties and Self-Similarity 153
- 6.5 Measuring Chaos 157
- \*6.6 Controlling Chaos 162
- 6.7 Higher-Dimensional Models 166
- 6.8 Forced Damped Pendulum 169
- \*6.9 Hamiltonian Chaos 173
- 6.10 Perspective 181
- 6.11 Projects 181
- Appendix 6A: Stability of the Fixed Points of the Logistic Map 189
- Appendix 6B: Finding the Roots of a Function 190

**7 ■ Random Processes**

197

- 7.1 Order to Disorder 197
- 7.2 Random Walks 203

- 7.3 Modified Random Walks 210
- 7.4 The Poisson Distribution and Nuclear Decay 217
- 7.5 Problems in Probability 219
- 7.6 Method of Least Squares 221
- 7.7 Applications to Polymers 225
- 7.8 Diffusion-Controlled Chemical Reactions 233
- 7.9 Random Number Sequences 236
- 7.10 Variational Methods 240
- 7.11 Projects 245
- Appendix 7A: Random Walks and the Diffusion Equation 249

**8 ■ The Dynamics of Many-Particle Systems**

255

- 8.1 Introduction 255
- 8.2 The Intermolecular Potential 255
- 8.3 Units 256
- 8.4 The Numerical Algorithm 258
- 8.5 Periodic Boundary Conditions 258
- 8.6 A Molecular Dynamics Program 261
- 8.7 Thermodynamic Quantities 273
- 8.8 Radial Distribution Function 280
- 8.9 Hard Disks 282
- 8.10 Dynamical Properties 293
- 8.11 Extensions 297
- 8.12 Projects 300
- Appendix 8A: Reading and Saving Configurations 307

**9 ■ Normal Modes and Waves**

313

- 9.1 Coupled Oscillators and Normal Modes 313
- 9.2 Numerical Solutions 319
- 9.3 Fourier Series 322
- 9.4 Two-Dimensional Fourier Series 333
- 9.5 Fourier Integrals 335
- 9.6 Power Spectrum 336
- 9.7 Wave Motion 340
- 9.8 Interference 345
- 9.9 Fraunhofer Diffraction 352
- 9.10 Fresnel Diffraction 355
- Appendix 9A: Complex Fourier Series 358
- Appendix 9B: Fast Fourier Transform 359
- Appendix 9C: Plotting Scalar Fields 362