

Contents

Preface iv

- Why Study Physics? iv
- Goals of the Text iv
- Features v
- Acknowledgements vii
- About the Author ix

Introduction I

- Motion 1
- Matter 2
- Applications 3
- Mathematics 4
- Derivations 4
- Study Objectives 4

Measurement and Units 6

- Use of Units 6
- Significant Figures 11
- Order-of-Magnitude Estimates 12
- In Perspective: N-Rays, Polywater, and Cold Fusion 14

I Description of Motion 16

- I-1 Trajectory of a Particle 16
- I-2 Speed 18
- I-3 Displacement 22
- I-4 Vector Algebra 23
- I-5 Components of Vectors 27
- I-6 Velocity 31
 - Problem Solving Strategy 36

2 Motion in a Straight Line 41

- 2-1 Acceleration in One Dimension 41
- 2-2 Linear Motion at Constant Acceleration 45
- 2-3 Free Fall 49
 - A Closer Look: Free Fall in Air 53
- *2-4 Graphical Analysis of Linear Motion 54
 - In Perspective: Galileo Galilei 56

3 Motion in a Plane 64

- 3-1 Acceleration on a Curved Path 65
- 3-2 Projectile Motion 67
- 3-3 Circular Motion 72
- 3-4 Reference Frames and Relative Motion 76

4 Newton's Laws of Motion 87

- 4-1 Classical Mechanics 88
- 4-2 Force 88
- 4-3 Newton's First Law 90
- 4-4 Mass 91
- 4-5 Newton's Second and Third Laws 92
- 4-6 Force Laws 96
- 4-7 The Concept of Force 101
- 4-8 Applications of Newton's Laws of Motion 102

5 Friction and Other Applications of Newton's Laws 118

- 5-1 Friction 118
 - A Closer Look: Microscopic Description of Friction 124
- 5-2 Centripetal Force 125
- 5-3 Center of Mass 127

6 Gravitation 139

- 6-1 Universal Gravitation 139
- 6-2 Gravitational Attraction of the Earth 144
- *6-3 Noninertial Reference Frames 147
 - In Perspective: Origins of the Theory of Universal Gravitation 152
 - In Perspective: Isaac Newton 154

7 Energy 162

- 7-1 Work and Kinetic Energy 163
- 7-2 Gravitational Potential Energy; Constant Gravitational Force 169
- 7-3 Gravitational Potential Energy; Variable Gravitational Force 173
- 7-4 Spring Potential Energy; Conservation of Energy 177
- 7-5 Conservative and Nonconservative Forces 180
- 7-6 Power 182
 - A Closer Look: The Energy to Run 184
- *7-7 Energy of a System of Particles 187

8 Momentum 199

- 8-1 Impulse and Linear Momentum 199
- 8-2 Momentum of a System of Particles; Conservation of Linear Momentum 202
- 8-3 Collisions and Kinetic Energy 204

9 Rotation 214

- 9-1 Description of Rotational Motion 214
- 9-2 Torque 219
- 9-3 Dynamics of Rotation about a Fixed Axis 221
- 9-4 Rotational Kinetic Energy 224
- 9-5 Angular Momentum 226
- *9-6 Energy Analysis of Running 228

10 Static Equilibrium 237

- 10-1 Conditions for Static Equilibrium 237
- 10-2 Center of Gravity 242
- *10-3 Stress and Strain 244

11 Fluids 257

- 11-1 Properties of Fluids 257
- 11-2 Pressure in a Fluid at Rest 259
- 11-3 Archimedes' Principle 265
- *11-4 Surface Tension and Capillarity 270
- 11-5 Fluid Dynamics; Bernoulli's Equation 273
- *11-6 Viscosity 279
- *11-7 Poiseuille's Law 282

12 Temperature and Kinetic Theory 295

- 12-1 Temperature Measurement 295
- 12-2 Ideal Gas Law 298
- 12-3 Kinetic Theory; Model of an Ideal Gas 303
- *12-4 Derivation of the Ideal Gas Law 306
- *12-5 Vapor Pressure and Humidity 309
- 12-6 Thermal Expansion 311

13 Heat 320

- 13-1 Definition of Heat 320
- 13-2 Calorimetry 321
- 13-3 Radiation 326
- 13-4 Convection 329
- 13-5 Conduction 330

14 Thermodynamics 338

- 14-1 Thermodynamic Systems 339
- 14-2 First Law of Thermodynamics 341
- 14-3 Heat Engines and Refrigerators 346
- 14-4 Second Law of Thermodynamics 349
- *14-5 Human Metabolism 355

15 Harmonic Motion 366

- 15-1 Simple Harmonic Motion 366
- 15-2 Relationship between SHM and Circular Motion 369
- 15-3 Mass and Spring 371
- 15-4 The Pendulum 374
- 15-5 Damped and Forced Oscillations 378

16 Mechanical Waves; Sound 386

- 16-1 Description of Waves 387
- 16-2 Wave Speed 392
- 16-3 Moving Sources and Observers: The Doppler Effect 395
- 16-4 Power and Intensity; the Decibel Scale 399
- 16-5 Time Dependence of the Displacement of a Particle of the Medium 404
- 16-6 Superposition of Waves; Beats; Standing Waves 405
A Closer Look: The Ear 418

17 The Electric Field 427

- 17-1 Electric Charge 427
- 17-2 Coulomb's Law 431
- 17-3 The Electric Field 434
- 17-4 Fields Produced by Continuous Distributions of Charge 440
- 17-5 Field Lines 444

18 Electric Potential 457

- 18-1 Electrical Potential Energy and Electric Potential 458
- 18-2 Capacitance 468
- 18-3 Dielectrics 476
- *18-4 The Oscilloscope 479

19 Electric Current 493

- 19-1 Electric Current 493
- 19-2 Ohm's Law 495
- 19-3 Electric Power; Batteries and AC Sources 500
A Closer Look: Superconductivity 501
- *19-4 Electric Current and Ohm's Law on the Microscopic Level 509

20 Direct Current Circuits 518

- 20-1 Description of Circuits 519
- 20-2 Kirchhoff's Rules 520
- 20-3 Equivalent Resistance 523
- *20-4 Multiloop Circuits 526
- 20-5 Measurement of Current, Potential Difference, and Resistance 528
- 20-6 RC Circuits 529
A Closer Look: Electrical Effects in the Human Body 532
- 20-7 Electric Shock and Household Electricity 534

21 Magnetism 550

- 21-1 The Magnetic Field 550
- 21-2 Magnetic Forces on Current-Carrying Conductors 554
- 21-3 Motion of a Point Charge in a Magnetic Field 560
- 21-4 Magnetic Fields Produced by Electric Currents 563
- 21-5 Magnetic Fields Produced by Permanent Magnets 569
- *21-6 Magnetic Materials 572
A Closer Look: Biomagnetism 574

22 Electromagnetic Induction and AC Circuits 588

- 22-1 Faraday's Law 589
- 22-2 Inductance 597
- *22-3 Alternating Current Circuits 603
In Perspective: Michael Faraday 616

23 Light 628

- 23-1 Electromagnetic Waves 629
- 23-2 The Nature of Light 632
- 23-3 The Propagation of Light 638
- 23-4 Reflection and Refraction 644

24 Geometrical Optics 662

- 24-1 Plane Mirrors 663
- 24-2 Spherical Mirrors 665
- 24-3 Lenses 676

25 The Eye and Optical Instruments* 698

- 25-1 The Human Eye 699
- 25-2 The Magnifier 710
- 25-3 The Microscope 713
- 25-4 The Telescope 716
A Closer Look: Structure of the Retina and Color Sensitivity 719
- *25-5 Factors Limiting Visual Acuity 722

26 Wave Optics 731

- 26-1 Wave Properties of Light 732
- 26-2 Interference 736
- 26-3 Diffraction 741
- 26-4 Polarization 748
A Closer Look: Magic in the Sky 754

27 Relativity 765

- 27-1 Measurement of Time; Einstein's Postulates 766
- 27-2 Time Dilation 770
- 27-3 Length Contraction 776
- 27-4 Relative Velocity 779
- 27-5 Relativistic Mass and Energy 781
A Closer Look: General Relativity 784
In Perspective: Albert Einstein 788

28 Quantum Concepts 798

- 28-1 Photons 799
- 28-2 Wave-Particle Duality 804
- 28-3 The Uncertainty Principle 807
In Perspective: Richard Feynman 810
In Perspective: Stephen Hawking 813

29 The Atom 818

- 29-1 Atomic Spectra and the Bohr Model of the Atom 819
- 29-2 Wave Properties of Electrons; Quantum Mechanics 830
- 29-3 Quantum Theory of Atomic Structure and Spectra; X-Rays 835
A Closer Look: Lasers 841
A Closer Look: Semiconductors 845

30 Nuclear Physics and Elementary Particles 854

- 30-1 Nuclear Structure 854
- 30-2 Radioactive Decay 861
- 30-3 Nuclear Reactions; Fission and Fusion 871
- 30-4 Biological Effects of Radiation 877
- 30-5 Elementary Particles 880
In Perspective: Marie Curie 886

Appendix A Review of Mathematics 895

- A-1 Basic Operations 895
- A-2 Powers of Ten and Scientific Notation 896
- A-3 Logarithms 898
- A-4 Algebra 899
- A-5 Geometry 903
- A-6 Trigonometry 905

Appendix B Gauss's Law 906

- B-1 Electric Flux 906
- B-2 Gauss's Law and Applications 907
- B-3 Derivation of Gauss's Law 911

Appendix C Models of Electrical Conduction in Metals 913**Appendix D Selected Isotopes 916****Appendix E Answers to Odd-Numbered Problems 920****Index 931**