

Physics: Power Tools for Problem Solving

1 Math for Physics

- 1.1 Geometry for Physics , 1
- 1.2 Trig for Physics (and Splitting Vectors), 2
- 1.3 Two Interpretations of Metric Prefixes , 5
- 1.4 Conversion Factors , 6

Chapter 1 Flash-Cards Review , 7

Chapter 1 Summary , 8

- 1.91 Problems , x51
- 1.92 Solutions for Problems , x52

2 Motion (Kinematics)

- 2.1 Power Tools for Problem Solving, 9
Learning from Mistakes (how I didn't learn to ski)
- 2.2 Basics of Motion: Velocity and Acceleration, 11
The " tvvax " Problem-Solving Strategy
- 2.3 How to Choose a Useful Equation , 12
- 2.4 Free Flight: the motion of falling bodies , 14
- 2.6 Problems with more than one Time Interval , 15
- 2.7 Problems with more than one Object , 18
- 2.8 Problems with more than one Direction, 20
- 2.8 More Strategies for 2-Dimensional Motion , 22
- 2.9 Ratio Logic (combining intuition and math), 24
- 2.10 Relative Motion (trains, boats, and planes) , 28
- 2.10 Graphs of Motion (point slope shape area) , 31
Chapter 2 Flash-Card Review , 36
Chapter 2 Summary , 38
- 2.91 Problems , x53
- 2.92 Solutions for Problems , x56
(yes, the numbering in Chapter 2 is mixed up)

3 Force and Motion (Dynamics)

- 3.1 Common Sense Cause-and-Effect with $F = ma$, 40
- 3.2 Problem-Solving Strategies using $F=ma$, 41
- 3.3 A Summary of $F=ma$ Strategies , 46
- 3.4 Playing with Problems, Modes of Thinking ,
(verbal, visual, math), Principles and Practice , 47
- 3.5 Newton's Third Law of Motion , 49
- 3.6 Inclined Planes , 50
- 3.7 Friction-Force , 52
- 3.8 Spring-Force , 56
Chapter 3 Flash-Card Review , 56
Chapter 3 Summary , 58
- 3.91 Problems , x61
- 3.92 Solutions for Problems , x63

4 Work and Kinetic Energy Impulse and Momentum

- 4.1 Deriving the Work-Energy and
Impulse-Momentum Equations , 61

Chapter 4A: Work and Kinetic Energy

- 4.2 For Straight-Line Motion, $Work = F d \cos \phi$. 62
- 4.3 How to Derive and Use the Total Work Equation , 63
- 4.4 Transformations of Potential and Kinetic Energy , 67
- 4.5 Power , 69
- 4.6 The Meaning of Graph-Areas , 70
- 4.7 A Many-Sided Equation , 71

Chapter 4B: Impulse and Momentum

- 4.8 Internal and External Forces , 72
- 4.9 2-Dimensional Collisions , 75
- 4.10 Elastic Collisions , 76
- 4.11 Center-of-Mass Calculations , 77
- 4.12 How to Choose a Useful Equation , 79
Chapter 4 Flash-Card Review , 81
Chapter 4 Summary , 83
- 4.91 Problems
- 4.92 Solutions for Problems

5 Rotational Motion

Introduction (how to use the chapter) , 85

5A The Basics of Circular Motion: Centripetal & Tangential Directions , 86

5B Centripetal Acceleration , 87

5C Gravity, GMm/r^2 , Orbiting Planets , 90

Part 1:Gravity-Force = $G M m / r^2$, 90
Part 2:The Orbiting of Planets & Satellites , 91

5D Rotational Motion (analogies to tvvax-system) , 92

Part 1:Rotational Distance, Velocity, Acceleration , 92
Part 2:Radians and Connecting-Equations , 93
Part 3:Comparing 2 kinds of Velocity,
and 4 kinds of Acceleration , 94
Part 4:a " tvvax system " for Rotational Motion , 97

5E Torque , 99

5F Torque Dynamics (rotational analogies to $F=ma$) , 100

Part 1:Rotational Inertia (Moment of Inertia) , 100
Part 2:How to Cope With "Equation Overload" , 102
Part 3:Angular $F = ma$ ($\tau = I a$) , 103
Part 4:Angular Work-Energy , 104
Part 5:Angular Impulse-Momentum , 107

5G Torque Statics (non-dynamic equilibrium) , 109

Chapter 5 Flash-Card Review , 111

Chapter 5 Summary , 113

- 5.91 Problems
- 5.92 Solutions for Problems
- 5.93 Derivations of Rotational Motion Formulas

6 Solids and Fluids

- 6.1 Solid, Liquid, and Gas , 117
- 6.2 Density and Pressure (for solids) , 118
- 6.3 Solids and Elasticity , 119
- 6.4 Fluids at Rest: Basics, Pascal, Archimedes , 122
- 6.5 Fluids in Motion: Flow Rate, Viscosity , 126

Chapter 6 Flash-Card Review , 129

Chapter 6 Summary

- 6.91 Problems
- 6.92 Solutions for Problems

7 Kinetic Theory & Thermodynamics

- 7.1 Temperature, Kinetic Energy, and Heat
- 7.2 Moles, Atomic Mass, and Molecular Mass
- 7.3 The Ideal Gas Law
- 7.4 Kinetic Theory
- 7.5 Heat Capacity and Phase Changes
- 7.6 Heat Transfer by Conduction, Convection, Radiation
- 7.7 The First Law of Thermodynamics
- 7.8 The Second Law of Thermodynamics

Chapter 7 Flash-Card Review

Chapter 7 Summary

- 7.91 Problems
- 7.92 Solutions for Problems

8 Simple Harmonic Motion

- 8.1 Exploring a Cycle of Simple Harmonic Motion , 130
- 8.2 Simple Harmonic Motion and Circular Motion , 132
- 8.3 Equations for Simple Harmonic Motion , 134
- 8.4 Vertical Spring-Oscillations and Pendulums , 138

Chapter 8 Flash-Card Review , 139

Chapter 8 Summary , 141

- 8.91 Optional Problems
- 8.92 Solutions for Optional Problems

9 Waves and Sound

- 9.1 Basic Principles of Wave Motion
- 9.2 Standing Waves and Music
- 9.3 Relative Velocity for Bullets, Sound, and Light
- 9.4 The Doppler Effect
- 9.5 Amplitude, Power and Intensity, The Decibel Scale for Sound Intensity

Chapter 9 Flash-Card Review

Chapter 9 Summary

- 9.91 Problems
- 9.92 Solutions for Problems
- 9.93 Music
- 9.94 Equations for Traveling Waves

10 Electrostatics

- 10.1 Electric Force and Electric Field , 142
- 10.2 Principle of Superposition (for F and E) , 144
- 10.3 Electric Field Patterns for Large Objects , 146
- 10.4 Work done by Electrostatic Force , 149
- 10.5 Electric Potential (also called Voltage) , 150
- 10.6 Principle of Superposition (for W and V) , 152
- 10.7 The Relationship of F, E and V:
Equipotential Surfaces & Parallel Plates , 154
- 10.8 Summary of Electrostatic Relationships , 156
- 10.93 Gauss's Law (production & properties of flux) , 158
- 10.94 Geometry, Charge Density, Ratio Logic , 159
- 10.95 Gauss's Law Problem-Solving Strategy , 160

Chapter 10 Flash-Card Review

Chapter 10 Summary (is in 10.8, pg 156)

- 10.91 Problems
- 10.92 Solutions for Problems

11 Direct-Current Circuits: Resistors and Capacitors

Introduction to the Dual (R-and-C) Chapter , 162

- 11.1 Batteries cause Charge Movement and Buildup , Resistors and $V = IR$, Capacitors and $Q = VC$, 163
- 11.2 Voltage Logic for Circuits , 165
- 11.3 Series and Parallel Circuit Connections , 166
- 11.4 A Strategy for Analyzing Circuits , 168
- 11.5 Other Circuit-Analysis Tools , 169
- 11.6 Power and Energy Storage , 171
- 11.7 Ratio Logic for Resistors and Capacitors , 172
- 11.8 A Summary of Capacitor Formulas , 173
- 11.9 Kirchhoff's Junction & Loop Rules
- 11.10 RC Circuits , 175

Chapter 11 Flash-Card Review

Chapter 11 Summary (brief & rough) , 178

- 11.91 Problems
- 11.92 Solutions for Problems
- ~~11.93 Current Density & Drift Velocity~~

12 Magnetism

- 12.1 Moving Charge Produces Magnetism
- 12.2 Moving Charge is Affected by Magnetism
- 12.3 Combining Right-Hand Rules (curled, straight)
- 12.4 Induced Voltage & Current (Faraday & Lenz)
making and using electricity (generators & motors)
- 12.6 Inductors and LR Circuits

Chapter 12 Flash-Card Review

Chapter 12 Summary

- ~~12.91 Problems~~
- ~~12.92 Solutions for Problems~~

13 Alternating Current Circuits

- 13.1 Alternating Current
- 13.2 Equations for Alternating Current Circuits
- 13.3 Time-Dependence of Voltage Maximums
- 13.4 Phasor Diagrams, Phase Angles, and
Time-Dependent Equations

Chapter 13 Flash-Card Review

Chapter 13 Summary

- ~~13.91 Problems~~
- ~~13.92 Solutions for Problems~~
- 13.93 time-dependance of V; phasor diagrams

14 Light & Optics

- 14.1 Electromagnetic Waves and Light , 179
- 14.2 Speed of Light, Index of Refraction , 180
- 14.3 Reflection and Refraction , 181
- 14.4 The Principles of Optics: understanding
how a lens or mirror forms images , 184
- 14.5 The Lens (and Mirror) Maker's Equation
Cameras, Microscopes and Telescopes , 190

Chapter 14 Flash-Card Review , 193

~~Chapter 14 Summary~~

- 14.91 Problems
- 14.92 Solutions for Problems

15 Interference & Diffraction

- 15.1 Wave Diffraction and Interference,
Double-Slit and Multiple-Slit Gratings
- 15.2 Single-Slit Diffraction
- 15.3 Thin-Film Interference
- 15.4 Polarization of Light

Chapter 15 Flash-Card Review

Chapter 15 Summary

- 15.91 Problems
- 15.92 Solutions for Problems

16 Relativity

- 16.1 The Special Theory of Relativity , 195
- 16.2 Time Dilation and Simultaneity , 196
- 16.3 Length Contraction and Mass Increase , 200
- 16.4 Momentum and Energy, $E = mc^2$, 202
- 16.5 Relativistic Addition of Velocities , 203
- 16.6 Relativistic Doppler Effect for Light Waves , 205
- 16.7 The General Theory of Relativity , 205

Chapter 16 Flash-Card Review , 207

~~Chapter 16 Summary~~

- 16.91 Problems
- 16.92 Solutions for Problems
- 16.93 Lorentz Transformations

17 Quantum Mechanics

- 17.1 Wave-Particle Duality: Photons , 208
- 17.2 Wave-Particle Duality: Electrons , 210
- 17.3 Quantum Mechanics , 212
- 17.4 Uncertainty Principle,
Critical Thinking in Quantum Mechanics , 215
- ~~17.5 nuclear forces & radioactive decay (maybe)~~

Chapter 17 Flash-Card Review , 218

~~Chapter 17 Summary~~

- 17.91 Problems
- 17.92 Solutions for Problems

18 Algebra for Physics

- 18.1 How to Make Equations , 220
- 18.2 Basic Algebra , 222
- 18.3 Fractions and Percentages , 226
- 18.4 Overall Equation-Solving Strategy , 228
- 18.5 Math Bloopers (ignoring if-then,...) , 229
- 18.6 Exponents, Scientific Notation, Logarithms , 232

- 18.7 Quadratic Equations : a detour,
some tricks, and The Formula , 236
- 18.8 Solving for two (or more) unknowns
by using Simultaneous Equations , 238
- 18.9 Ratio Logic , 239
- 18.10 How to Find a Maximum or Minimum , 242
(strategies for Coping with Conflicting Factors)
- 18.11 Using a Calculator for Physics , 243
- 18.93 (not necessarily in order) Significant Figures,
Trig for non-90° Triangles, Trig Formulas for
Angle Addition & Multiplication, SI Summary

Chapter 18 Flash-Card Review

Chapter 18 Summary

~~18.91 Problems~~

~~18.92 Solutions for Problems~~

19 Calculus for Physics

- 2.10 Motion Graphs (is in Chapter 2)
- 19.1 Functions, Derivatives and Integrals
(Point, Slope, Shape, Area) , 245
- 19.2 How To Do Physics-Calculus Problems
{ to accompany Section 2.10 } , 248
- 19.3 { to accompany Chapter 4 } , 251
- 19.4 { to accompany Chapter 5C } , 253
- 19.5 { to accompany Chapter 5F } , 255
- ~~19.6 Exponential Increase and Decrease~~
~~{ for Sections 11.#, 12.#, 17.# } (maybe)~~
- 19.7 { to accompany Sections 10.1 & 10.2 } , 256
- 19.8 { to accompany Sections 10.4 to 10.7 } , 257
- 19.9 { to accompany Section 10.93-10.95 } , 258
- ~~19.10 { to accompany Chapter 12 }~~
- 19.11 Dot-Product Vector Multiplication , 259
Cross-Product Vector Multiplication , 259
Unit-Vector Notation , 260

Chapter 19 Flash-Card Review

Chapter 19 Summary , 262

~~19.91 Problems~~

~~19.92 Solutions for Problems~~

~~19.93 How to Find Derivatives & Integrals~~

~~19.94 Partial Derivatives~~

20 Strategies for Problem Solving

- 20.1 Essential Strategies for Solving Problems
- 20.2 Improving Your Problem-Solving Skill
- 20.3 Concentration, Confidence and Fun
- 20.4 Active Study: Reading and Listening
- 20.5 Visual Thinking (this is now in 20.1)
- 20.6 Exam Preparation and Performance
- 20.7 Using Your Time Effectively
- 20.8 Creative and Critical Thinking,
and Scientific Method

Chapter 20 Flash-Card Review

Chapter 20 Summary

- 20.91 Memory Systems & Flashcards
- 20.92 More Problem-Solving Tips
- 20.93 Overcoming Math-Science Anxiety
- 20.94 Skillful Writing
- 20.95 More Exam-Performance Tips
- 20.96 Life Planning & Whole-Person Living
- 20.97 Becoming More Creative