

Teacher Edition

FOURTH EDITION
physics



CONTENTS

PART 1

| | |
|-----------------------------------|------|
| <i>Biblical Worldview Shaping</i> | viii |
| <i>Building Academic Rigor</i> | x |
| <i>Technology Solutions</i> | xii |
| <i>Everything Is Physics</i> | xiv |
| <i>Features of This Textbook</i> | xvi |
| <i>Using Your Teacher Edition</i> | xx |

Unit 1 Kinematics

xxx

Chapter 1 Lesson Plan Overview L-2a

| | |
|--|----|
| 1 Foundations of Physics | 2 |
| 1.1 Solving Problems with Physics | 3 |
| <i>Serving as a Systems Engineer: It's Complex</i> | 7 |
| <i>Ethics: Christian Ethics and Physics</i> | 8 |
| <i>Case Study: GPS and Scientific Inquiry</i> | 9 |
| 1.2 Dimensions of Physics | 10 |
| 1.3 Principles of Measurement | 16 |
| <i>Case Study: Measurement and Uncertainty</i> | 19 |
| 1.4 Integrity in Data | 21 |
| <i>Mini Lab: Just Eyeball It!</i> | 28 |

Chapter 2 Lesson Plan Overview L-32a

| | |
|--|----|
| 2 Motion in One Dimension | 32 |
| 2.1 Describing Motion | 33 |
| 2.2 The Equations of Motion | 44 |
| <i>Worldview Investigation: Crash Course</i> | 50 |
| <i>Case Study: Using Kinematics to Model Stopping Distance</i> | 52 |
| <i>Mini Lab: Tossup</i> | 53 |
| <i>Ethics: Car Seat Regulations</i> | 58 |

Chapter 3 Lesson Plan Overview L-60a

| | |
|--|----|
| 3 Vectors and Scalars | 60 |
| 3.1 Vector and Scalar Properties | 61 |
| <i>Case Study: Mapping Currents</i> | 65 |
| 3.2 Graphical Vector Operations | 66 |
| 3.3 Algebraic Vector Operations | 70 |
| <i>Mini Lab: Using Vectors to Predict Hurricane Movement</i> | 82 |
| <i>Ethics: Should I Stay or Should I Go?</i> | 85 |

Chapter 4 Lesson Plan Overview L-86a

| | |
|--|-----|
| 4 Motion in Two Dimensions | 86 |
| 4.1 Kinematics of Two-Dimensional Motion | 87 |
| <i>Serving as a Humanitarian Engineer: Helping Where It Is Most Needed</i> | 91 |
| 4.2 Projections | 92 |
| <i>Mini Lab: Catapulting to Fame</i> | 101 |
| <i>Case Study: Shot Put Release Angles</i> | 102 |
| <i>Ethics: Humanitarian Airdrops</i> | 105 |



CONTENTS

Unit 2 Dynamics

106

Chapter 5 Lesson Plan Overview L-108a

5 Newton's Laws 108

| | | |
|-----|--|-----|
| 5.1 | Forces | 109 |
| | <i>Mini Lab: Forcing the Issue</i> | 117 |
| 5.2 | Newton's Laws of Motion | 120 |
| | <i>Serving as a Naval Architect: Whatever Floats Your Boat</i> | 126 |
| | <i>STEM Connection: Getting Airborne with Newton's Third Law</i> | 129 |
| | <i>Case Study: On a Carrier Flight Deck</i> | 130 |

Chapter 6 Lesson Plan Overview L-134a

6 Applying Newton's Laws 134

| | | |
|-----|---|-----|
| 6.1 | Simplifying Problems | 135 |
| | <i>Mini Lab: Stand Tall</i> | 138 |
| | <i>Serving as a Civil Engineer: Building Islands</i> | 140 |
| 6.2 | Transmitting Mechanical Forces | 141 |
| 6.3 | Friction | 150 |
| 6.4 | More Applications | 154 |
| | <i>STEM Connection: Using Forces to Prevent Accidents</i> | 161 |
| | <i>Ethics: Building Codes</i> | 165 |

Chapter 7 Lesson Plan Overview L-166a

7 Rotational and Circular Motion 166

| | | |
|-----|--|-----|
| 7.1 | Rotational Motion | 167 |
| 7.2 | Circular Motion | 177 |
| | <i>Worldview Investigation: Artificial Gravity</i> | 182 |
| 7.3 | Universal Gravitation | 183 |
| | <i>STEM Connection: Gravity Assist</i> | 186 |
| | <i>Mini Lab: Designing a Loop Coaster</i> | 189 |
| | <i>Case Study: Geology and Newton's Law</i> | 190 |

Chapter 8 Lesson Plan Overview L-194a

8 Work and Energy 194

| | | |
|-----|--|-----|
| 8.1 | Work and Power | 195 |
| 8.2 | Energy | 201 |
| | <i>Serving as a Hydroelectric Engineer: Powering Up with Water</i> | 206 |
| 8.3 | Conservation of Energy | 209 |
| | <i>Case Study: A Study in Energy Transformations</i> | 210 |
| | <i>Mini Lab: Water Falls</i> | 214 |
| | <i>Ethics: The Human Race and the Environment</i> | 219 |

Chapter 9 Lesson Plan Overview L-220a

9 Momentum 220

| | | |
|-----|--|-----|
| 9.1 | Principles of Momentum | 221 |
| | <i>Case Study: Creating SAFER Space</i> | 227 |
| 9.2 | Collisions | 228 |
| | <i>Worldview Investigation: Crack versus Clank</i> | 235 |
| | <i>Serving as a Sports Engineer: Having a Ball</i> | 237 |
| 9.3 | Center of Mass and Angular Momentum | 238 |
| | <i>Mini Lab: A Massive Task</i> | 241 |

Chapter 10 Lesson Plan Overview L-248a

10 Periodic Motion 248

| | | |
|------|---|-----|
| 10.1 | Simple Harmonic Motion | 249 |
| 10.2 | Periodic Motion and the Pendulum | 258 |
| 10.3 | Waves | 262 |
| | <i>Mini Lab: Changing the Harmonics of a Bottle</i> | 268 |
| 10.4 | Sound | 270 |
| | <i>Worldview Investigation: Oh the Noise</i> | 274 |
| | <i>Case Study: Foucault Pendulum</i> | 277 |



Unit 3 Thermodynamics and Matter

282

Chapter 11 Lesson Plan Overview L-284a

| | |
|---|-----|
| 11 Expansion and Temperature | 284 |
| 11.1 Thermal Expansion | 285 |
| <i>STEM Connection:</i> Expansion Joints | 289 |
| 11.2 Measuring Temperature | 292 |
| 11.3 Gas Laws | 297 |
| <i>Worldview Investigation:</i> The Need to Breathe | 304 |
| <i>Mini Lab:</i> Ball and Ring | 305 |

Chapter 12 Lesson Plan Overview L-310a

| | |
|---|-----|
| 12 Thermal Energy and Heat | 310 |
| 12.1 Theories of Heat | 311 |
| 12.2 Thermal Energy and Matter | 316 |
| <i>Mini Lab:</i> Finding the Heat Capacity | 327 |
| 12.3 Mechanisms for Thermal Energy Transfer | 328 |
| <i>Worldview Investigation:</i> Lake Turnover | 331 |
| <i>STEM Connection:</i> Car Cooling System | 332 |

PART 2

| | |
|------------------------------|-----|
| 13 Thermodynamic Laws | 338 |
| 14 Fluid Mechanics | 366 |

Unit 4 Electromagnetics

| | |
|-------------------------------|-----|
| 15 Static Electricity | 394 |
| 16 Electric Fields | 412 |
| 17 Current Electricity | 432 |
| 18 Magnetism | 462 |
| 19 Electromagnetism | 492 |

Unit 5 Geometric Optics and Light

| | |
|--------------------------------|-----|
| 20 Light and Reflection | 520 |
| 21 Refraction | 554 |
| 22 Wave Optics | 582 |

Unit 6 Modern Physics

| | |
|---------------------------|-----|
| 23 Relativity | 610 |
| 24 Quantum Physics | 644 |
| 25 Nuclear Physics | 670 |



CONTENTS

PART 1

| | |
|-----------------------------------|------|
| <i>Biblical Worldview Shaping</i> | viii |
| <i>Building Academic Rigor</i> | x |
| <i>Technology Solutions</i> | xii |
| <i>Everything Is Physics</i> | xiv |
| <i>Features of This Textbook</i> | xvi |
| <i>Using Your Teacher Edition</i> | xx |

| | | | |
|-----------------------------------|-----|---|-----|
| Unit 1 Kinematics | xxx | 7 Rotational and Circular Motion | 166 |
| 1 Foundations of Physics | 2 | 8 Work and Energy | 194 |
| 2 Motion in One Dimension | 32 | 9 Momentum | 220 |
| 3 Vectors and Scalars | 60 | 10 Periodic Motion | 248 |
| 4 Motion in Two Dimensions | 86 | | |
| | | Unit 3 Thermodynamics and Matter | 282 |
| Unit 2 Dynamics | 106 | 11 Expansion and Temperature | 284 |
| 5 Newton's Laws | 108 | 12 Thermal Energy and Heat | 310 |
| 6 Applying Newton's Laws | 134 | | |

PART 2

Unit 3 Thermodynamics and Matter (continued)

| | | | |
|--|--------|--|--------|
| <i>Chapter 13 Lesson Plan Overview</i> | L-338a | <i>Chapter 14 Lesson Plan Overview</i> | L-366a |
| 13 Thermodynamic Laws | 338 | 14 Fluid Mechanics | 366 |
| 13.1 The Zeroth and First Laws | 339 | 14.1 Hydrostatics: Fluids at Rest | 367 |
| 13.2 The Second and Third Laws | 349 | <i>Mini Lab: Determining Draft</i> | 373 |
| <i>Case Study: Giving Yellow Fever the Cold Shoulder</i> | 355 | 14.2 Hydrodynamics: Fluids in Motion | 380 |
| <i>Mini Lab: Cooling Air</i> | 356 | <i>Serving as an Aerospace Engineer: Ideas That Take Off</i> | 386 |
| 13.3 Entropy and Its Consequences | 357 | <i>Worldview Investigation: Wind Power</i> | 389 |
| <i>Ethics: Technology Help for All</i> | 365 | | |

CONTENTS

Unit 4 Electromagnetics

392

Chapter 15 Lesson Plan Overview L-394a

| | |
|--|-----|
| 15 Static Electricity | 394 |
| 15.1 Electric Charge | 395 |
| <i>STEM Connection:</i> The Faraday Cage | 396 |
| <i>Mini Lab:</i> Investigating Static Electricity | 398 |
| 15.2 Detecting Electric Charge | 400 |
| <i>Serving as a High-Voltage Power Line Inspector:</i> Keeping the Lights On | 403 |

Chapter 16 Lesson Plan Overview L-412a

| | |
|---------------------------------------|-----|
| 16 Electric Fields | 412 |
| 16.1 Modeling Electric Fields | 413 |
| <i>Case Study:</i> N95 Mask | 421 |
| 16.2 Capacitors | 422 |
| <i>STEM Connection:</i> Defibrillator | 425 |
| <i>Mini Lab:</i> Making a Capacitor | 427 |

Chapter 17 Lesson Plan Overview L-432a

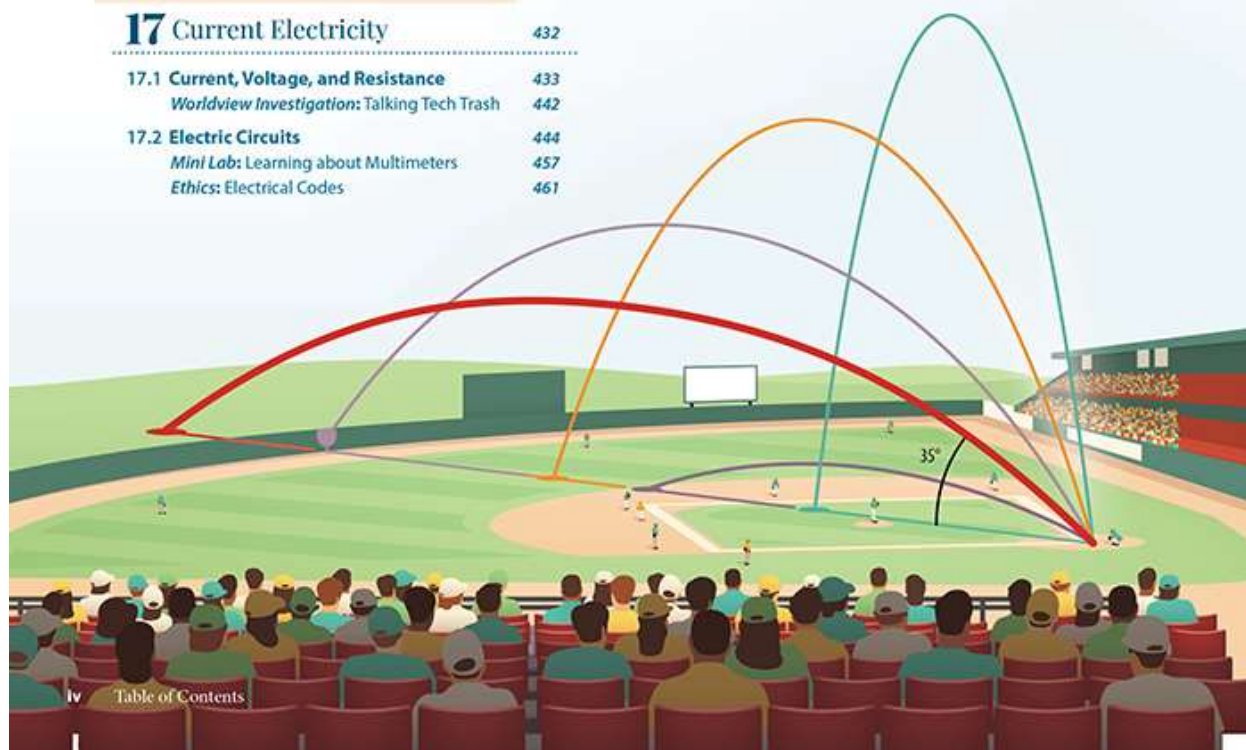
| | |
|--|-----|
| 17 Current Electricity | 432 |
| 17.1 Current, Voltage, and Resistance | 433 |
| <i>Worldview Investigation:</i> Talking Tech Trash | 442 |
| 17.2 Electric Circuits | 444 |
| <i>Mini Lab:</i> Learning about Multimeters | 457 |
| <i>Ethics:</i> Electrical Codes | 461 |

Chapter 18 Lesson Plan Overview L-462a

| | |
|---|-----|
| 18 Magnetism | 462 |
| 18.1 Describing Magnetism | 463 |
| <i>Case Study:</i> Paleomagnetism and Earth's Age | 470 |
| 18.2 Magnetism and Charges | 471 |
| 18.3 Magnetism and Conductors | 481 |
| <i>Mini Lab:</i> Mapping a Magnetic Field | 483 |
| <i>STEM Connection:</i> DC Motors | 487 |

Chapter 19 Lesson Plan Overview L-492a

| | |
|---|-----|
| 19 Electromagnetism | 492 |
| 19.1 Currents and Magnetic Fields | 493 |
| <i>Mini Lab:</i> Magnets and Current | 500 |
| 19.2 Generating Current | 503 |
| <i>Serving as an Electrical Engineer:</i> Instant Messaging | 513 |
| <i>Worldview Investigation:</i> Smart Grids | 514 |



Unit 5 Geometric Optics and Light

518

Chapter 20 Lesson Plan Overview L-520a**20** Light and Reflection 520

20.1 Forms and Sources of Light 521

20.2 Intensity and Color 530

20.3 Reflection and Mirrors 538

Mini Lab: Pinhole Camera 539*Case Study:* Astronomical Albedo 540*Ethics:* Could Mirrors Stop Global Warming? 553**Chapter 21 Lesson Plan Overview L-554a****21** Refraction 554

21.1 Theory of Refraction 555

Mini Lab: Magnifying Glass 565

21.2 Application of Refraction 566

Serving as an Optometrist: Restoring Sight 574*STEM Connection:* Eyeglasses 575**Chapter 22 Lesson Plan Overview L-582a****22** Wave Optics 582

22.1 Wave Interference 583

22.2 Diffraction 591

Serving as an Optical Tester:

Looking Into Safety 595

Mini Lab: Optical Resolving Power of the

Human Eye 599

22.3 Polarization of Light 600

Worldview Investigation: Busting

Counterfeiters 604

Unit 6 Modern Physics

608

Chapter 23 Lesson Plan Overview L-610a**23** Relativity 610

23.1 Galilean Relativity 611

Mini Lab: Accounting for Relativity 619

23.2 Special Relativity 620

STEM Connection: Warp Drive 636

23.3 General Relativity 637

Case Study: Gravitational Red Shift 640**Chapter 24 Lesson Plan Overview L-644a****24** Quantum Physics 644

24.1 Quantum Theory 645

Mini Lab: Approximating a Blackbody 649

24.2 Quantum Mechanics and the Atom 652

Worldview Investigation: Quantum

Cryptography 661

24.3 Modern Atomic Models 662

Case Study: Lasers 666*Ethics:* Information Security and
Identity Theft 669**Chapter 25 Lesson Plan Overview L-670a****25** Nuclear Physics 670

25.1 The Nucleus 671

25.2 Radiation and Radioactivity 676

Mini Lab: Predicting the Flip of a Coin 685*Case Study:* Geochronology 688

25.3 Nuclear Reactions 689

Worldview Investigation: Good Radiation 695

25.4 Subatomic Particles 697

Serving as a Particle Physicist: Smashing

Good Work! 701

CONTENTS

Case Studies

| | |
|--|-----|
| <i>GPS and Scientific Inquiry</i> | 9 |
| <i>Measurement and Uncertainty</i> | 19 |
| <i>Using Kinematics to Model Stopping Distance</i> | 52 |
| <i>Mapping Currents</i> | 65 |
| <i>Shot Put Release Angles</i> | 102 |
| <i>On a Carrier Flight Deck</i> | 130 |
| <i>Geology and Newton's Law</i> | 190 |
| <i>A Study in Energy Transformations</i> | 210 |
| <i>Creating SAFER Space</i> | 227 |
| <i>Foucault Pendulum</i> | 277 |
| <i>Giving Yellow Fever the Cold Shoulder</i> | 355 |
| <i>N95 Mask</i> | 421 |
| <i>Paleomagnetism and Earth's Age</i> | 470 |
| <i>Astronomical Albedo</i> | 540 |
| <i>Gravitational Red Shift</i> | 640 |
| <i>Lasers</i> | 666 |
| <i>Geochronology</i> | 688 |

Ethics

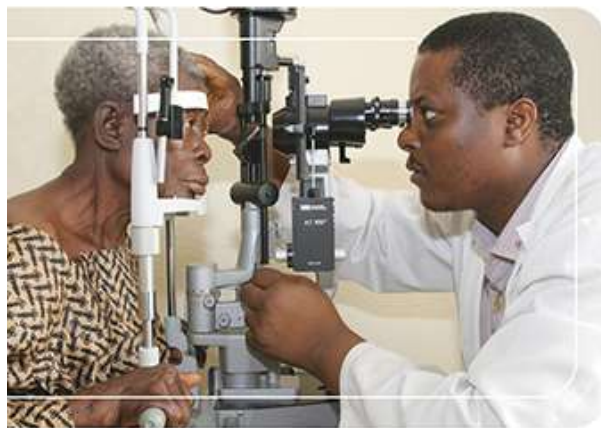
| | |
|--|-----|
| <i>Christian Ethics and Physics</i> | 8 |
| <i>Car Seat Regulations</i> | 58 |
| <i>Should I Stay or Should I Go?</i> | 85 |
| <i>Humanitarian Airdrops</i> | 105 |
| <i>Building Codes</i> | 165 |
| <i>The Human Race and the Environment</i> | 219 |
| <i>Technology Help for All</i> | 365 |
| <i>Electrical Codes</i> | 461 |
| <i>Could Mirrors Stop Global Warming?</i> | 553 |
| <i>Information Security and Identity Theft</i> | 669 |

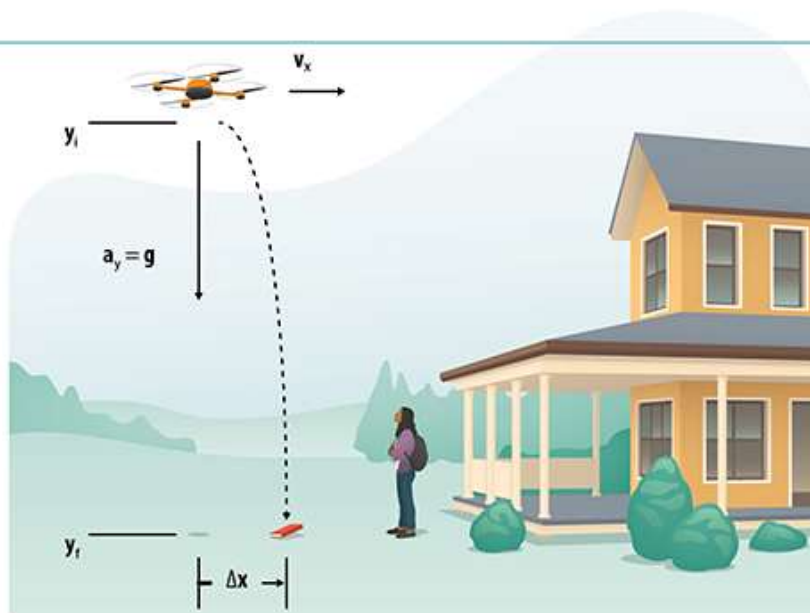
Mini Lab Activities

| | |
|--|-----|
| <i>Just Eyeball It!</i> | 28 |
| <i>Tossup</i> | 53 |
| <i>Using Vectors to Predict Hurricane Movement</i> | 82 |
| <i>Catapulting to Fame</i> | 101 |
| <i>Forcing the Issue</i> | 117 |
| <i>Stand Tall</i> | 138 |
| <i>Designing a Loop Coaster</i> | 189 |
| <i>Water Falls</i> | 214 |
| <i>A Massive Task</i> | 241 |
| <i>Changing the Harmonics of a Bottle</i> | 268 |
| <i>Ball and Ring</i> | 305 |
| <i>Finding the Heat Capacity</i> | 327 |
| <i>Cooling Air</i> | 356 |
| <i>Determining Draft</i> | 373 |
| <i>Investigating Static Electricity</i> | 398 |
| <i>Making a Capacitor</i> | 427 |
| <i>Learning about Multimeters</i> | 457 |
| <i>Mapping a Magnetic Field</i> | 483 |
| <i>Magnets and Current</i> | 500 |
| <i>Pinhole Camera</i> | 539 |
| <i>Magnifying Glass</i> | 565 |
| <i>Optical Resolving Power of the Human Eye</i> | 599 |
| <i>Accounting for Relativity</i> | 619 |
| <i>Approximating a Blackbody</i> | 649 |
| <i>Predicting the Flip of a Coin</i> | 685 |

Serving as a(n) . . .

| | |
|---|-----|
| <i>Systems Engineer: It's Complex</i> | 7 |
| <i>Humanitarian Engineer: Helping Where It Is Most Needed</i> | 91 |
| <i>Naval Architect: Whatever Floats Your Boat</i> | 126 |
| <i>Civil Engineer: Building Islands</i> | 140 |
| <i>Hydroelectric Engineer: Powering Up with Water</i> | 206 |
| <i>Sports Engineer: Having a Ball</i> | 237 |
| <i>Aerospace Engineer: Ideas That Take Off</i> | 386 |
| <i>High-Voltage Power Line Inspector: Keeping the Lights On</i> | 403 |
| <i>Electrical Engineer: Instant Messaging</i> | 513 |
| <i>Optometrist: Restoring Sight</i> | 574 |
| <i>Optical Tester: Looking Into Safety</i> | 595 |
| <i>Particle Physicist: Smashing Good Work!</i> | 701 |





STEM Connections

| | |
|---|-----|
| <i>Getting Airborne with Newton's Third Law</i> | 129 |
| <i>Using Forces to Prevent Accidents</i> | 161 |
| <i>Gravity Assist</i> | 186 |
| <i>Expansion Joints</i> | 289 |
| <i>Car Cooling System</i> | 332 |
| <i>The Faraday Cage</i> | 396 |
| <i>Defibrillator</i> | 425 |
| <i>DC Motors</i> | 487 |
| <i>Eyeglasses</i> | 575 |
| <i>Warp Drive</i> | 636 |

Worldview Investigations

| | |
|-------------------------------|-----|
| <i>Crash Course</i> | 50 |
| <i>Artificial Gravity</i> | 182 |
| <i>Crack versus Clank</i> | 235 |
| <i>Oh the Noise</i> | 274 |
| <i>The Need to Breathe</i> | 304 |
| <i>Lake Turnover</i> | 331 |
| <i>Wind Power</i> | 389 |
| <i>Talking Tech Trash</i> | 442 |
| <i>Smart Grids</i> | 514 |
| <i>Busting Counterfeiters</i> | 604 |
| <i>Quantum Cryptography</i> | 661 |
| <i>Good Radiation</i> | 695 |

APPENDICES

| | |
|---|-----|
| A Understanding Scientific Terms | 706 |
| B Mathematical Reference | 708 |
| C Greek Alphabet | 715 |
| D Physical Constants | 716 |
| E SI Units | 717 |
| F Metric Prefixes | 718 |
| G Planetary and Astronomical Data | 718 |
| H Moments of Inertia for Selected Objects | 719 |
| I Worldview Investigation Rubrics | 720 |
| J Ethics Essay Rubric | 722 |
| K Mini Lab Materials List | 724 |
| L Optical Test Sheet (Chapter 22 Mini Lab) | 729 |

GLOSSARY

STUDENT EDITION INDEX

TEACHER EDITION INDEX

EXPLAINING THE GOSPEL

PERIODIC TABLE OF THE ELEMENTS