PHYSICAL SCIENCE

EIGHTH EDITION

PHYSICAL SCIENCE

BILL W. TILLERY

ARIZONA STATE UNIVERSITY

Higher Education

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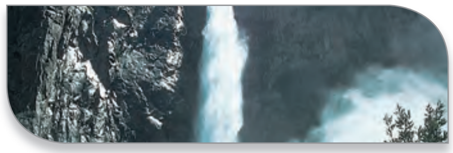

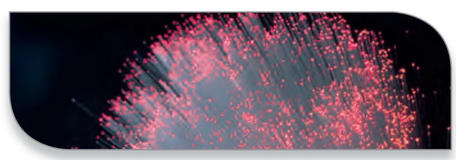

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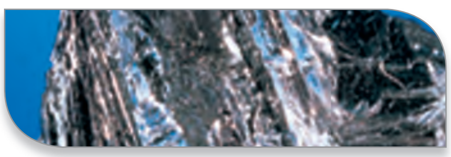

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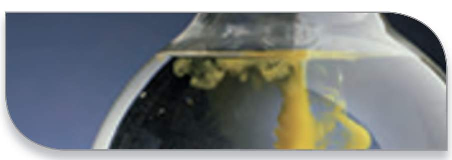

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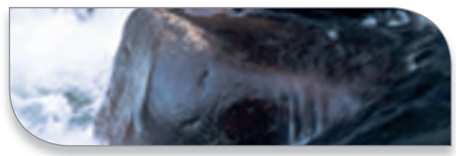

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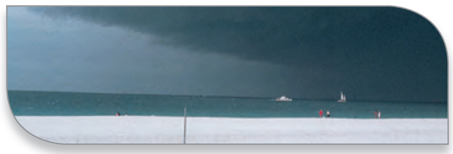

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PREFACE

Physical Science is a straightforward, easy-to-read but substantial introduction to the fundamental behavior of matter and energy. It is intended to serve the needs of nonscience majors who are required to complete one or more physical science courses. It introduces basic concepts and key ideas while providing opportunities for students to learn reasoning skills and a new way of thinking about their environment. No prior work in science is assumed. The language, as well as the mathematics, is as simple as can be practical for a college-level science course.

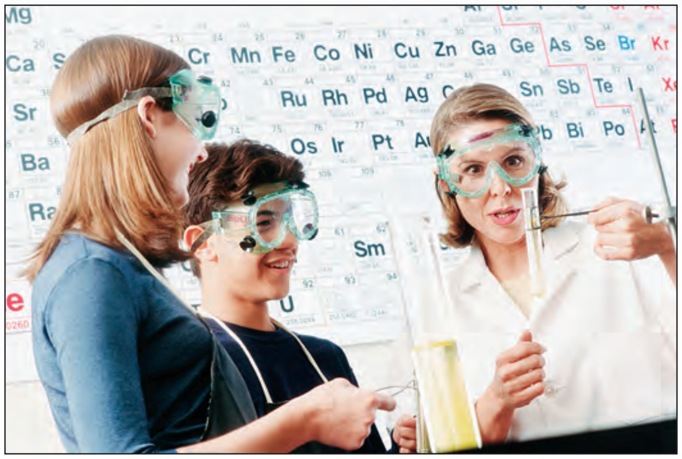
ORGANIZATION

The *Physical Science* sequence of chapters is flexible, and the instructor can determine topic sequence and depth of coverage as needed. The materials are also designed to support a conceptual approach or a combined conceptual and problem-solving approach. With laboratory studies, the text contains enough material for the instructor to select a sequence for a two-semester course. It can also serve as a text in a one-semester astronomy and earth science course or in other combinations.

> **"The text is excellent. I do not think I could have taught the course using any other textbook. I think one reason I really enjoy teaching this course is because of the text. I could say for sure that this is one of the best textbooks I have seen in my career. . . . I love this textbook for the following reasons: (1) it is comprehensive, (2) it is very well written, (3) it is easily readable and comprehendible, (4) it has good graphics."**
> **—Ezat Heydari, Jackson State University**

MEETING STUDENT NEEDS

Physical Science is based on two fundamental assumptions arrived at as the result of years of experience and observation from teaching the course: (a) that students taking the course often have very limited background and/or aptitude in the natural sciences; and (b) that this type of student will better grasp the ideas and principles of physical science if they are discussed with minimal use of technical terminology and detail. In addition, it is critical for the student to see relevant applications of the material



to everyday life. Most of these everyday-life applications, such as environmental concerns, are not isolated in an arbitrary chapter; they are discussed where they occur naturally throughout the text.

Each chapter presents historical background where appropriate, uses everyday examples in developing concepts, and follows a logical flow of presentation. The historical chronology, of special interest to the humanistically inclined nonscience major, serves to humanize the science being presented. The use of everyday examples appeals to the nonscience major, typically accustomed to reading narration, not scientific technical writing, and also tends to bring relevancy to the material being presented. The logical flow of presentation is helpful to students not accustomed to thinking about relationships between what is being read and previous knowledge learned, a useful skill in understanding the physical sciences. Worked examples help students to integrate concepts and understand the use of relationships called equations. They also serve as a model for problem solving; consequently, special attention is given to *complete* unit work and to the clear, fully expressed use of mathematics. Where appropriate, chapters contain one or more activities, called Concepts Applied, that use everyday materials rather than specialized laboratory equipment. These activities are intended to bring the science concepts closer to the world of the student. The activities are supplemental and can be done as optional student activities or as demonstrations.

"It is more readable than any text I've encountered. This has been my first experience teaching university physical science; I picked up the book and found it very user-friendly. The level of detail is one of this text's greatest strengths. It is well suited for a university course."
—Richard M. Woolheater, Southeastern Oklahoma State University

"The author's goals and practical approach to the subject matter are exactly what we are looking for in a textbook. . . . The practical approach to problem solving is very appropriate for this level of student."
—Martha K. Newchurch, Nicholls State University

". . . the book engages minimal use of technical language and scientific detail in presenting ideas. It also uses everyday examples to illustrate a point. This approach bonds with the mindset of the nonscience major who is used to reading prose in relation to daily living."
—Ignatius Okafor, Jarvis Christian College

"I was pleasantly surprised to see that the author has written a textbook that seems well suited to introductory physical science at this level. . . . *Physical Science* seems to strike a nice balance between the two—avoiding unnecessary complications while still maintaining a rigorous viewpoint. I prefer a textbook that goes beyond what I am able to cover in class, but not too much. Tillery seems to have done a good job here."
—T. G. Heil, University of Georgia

NEW TO THIS EDITION

Numerous revisions have been made to the text to add new topic areas, update the content on current events and the most recent research topics, and make the text even more user-friendly and relevant for students:

Two new elements have been added to this edition to further enhance the text's focus on developing concepts:

- Core and Supporting Concepts have been added to the chapter openers to help integrate the chapter concepts and the chapter outline. The Core and Supporting Concepts outline and emphasize the concepts at a chapter level. The concepts list is designed to help students focus their studies by identifying the most important topics in the outline.
- A new Appendix D: Solutions for Follow-Up Example Exercises has been added to provide solutions to the unanswered, second example problems within chapters to further assist students in grasping the concepts as well as the quantitative work conveyed in the in-chapter examples.

The end-of-chapter Applying the Concepts multiple-choice self-tests have been revised to better focus on the concepts covered within each chapter.

The list below provides chapter-specific updates:

Chapter 1: Text information on pseudoscience has been updated and expanded.
Chapter 2: Five new beginning "one-step problems" have been added to the Parallel Exercises Set A and B sections. Also, information on GPS has been added.
Chapter 3: There is a new section on Conserving Energy.
Chapter 5: A Closer Look on hearing problems has been added.
Chapter 7: A new section on special relativity and general relativity (with cross references to astronomy) has been added.
Chapter 11: A Closer Look on decompression sickness is now included.
Chapter 14: A Myth, Mistakes, and Misunderstanding box on seeing stars during day from bottom of a well has been added.
Chapter 15: The information on Pluto and the definition of planets have been updated, along with the most recent data on space exploration, space probes, and new probes. Sections with more detail on Kepler's Laws, the geocentric model, and the heliocentric model have been included. A Myth, Mistakes, and Misunderstanding box on blue moons has also been added.
Chapter 16: The material on global warming has been updated and revised.
Chapter 17: A new Science and Society box on using mineral resources now appears.
Chapter 19: A new photo of a cinder cone volcano has been added.
Chapter 21: Photos of actual fossils have been added. Also, the sections on Geologic Periods and Typical Fossils, Mass Extinctions, and Interpreting Geologic History—A Summary have been expanded.
Chapter 23: Sections on Climate Change, Causes of Global Climate Change, and Global Warming along with a discussion of hurricane Katrina have been added.
Chapter 24: A Closer Look on rogue waves is now included.

THE LEARNING SYSTEM

Physical Science has an effective combination of innovative learning aids intended to make the student's study of science more effective and enjoyable. This variety of aids is included to help students clearly understand the concepts and principles that serve as the foundation of the physical sciences.

OVERVIEW

Chapter 1 provides an *overview* or orientation to what the study of physical science in general and this text in particular are all about. It discusses the fundamental methods and techniques used by scientists to study and understand the world around us. It also explains the problem-solving approach used throughout the text so that students can more effectively apply what they have learned.

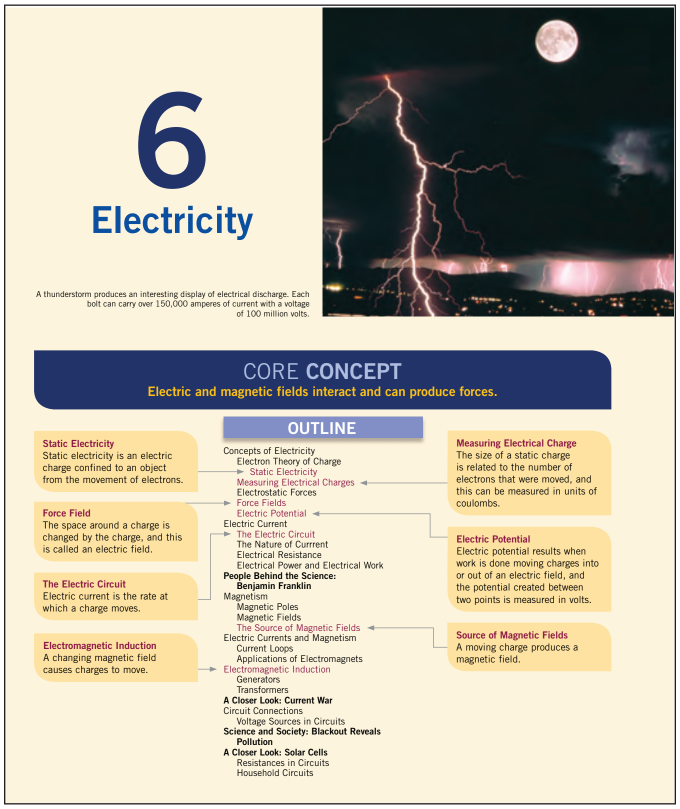
CHAPTER OPENING TOOLS

Core Concept and Supporting Concepts

New! Core and Supporting Concepts integrate the chapter concepts and the chapter outline. The Core and Supporting Concepts outline and emphasize the concepts at a chapter level. The concepts list is designed to help students focus their studies by identifying the most important topics in the chapter outline.

Chapter Outline

The chapter outline includes all the major topic headings and subheadings within the body of the chapter. It gives you a quick glimpse of the chapter's contents and helps you locate sections dealing with particular topics.



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Electricity

A thunderstorm produces an interesting display of electrical discharge. Each bolt can carry over 150,000 amperes of current with a voltage of 100 million volts.

CORE CONCEPT

Electric and magnetic fields interact and can produce forces.

OUTLINE

Concepts of Electricity
Electron Theory of Charge
Static Electricity
Measuring Electrical Charges
Electrostatic Forces
Force Fields
Electric Potential
Electric Current
The Electric Circuit
The Nature of Currrent
Electrical Resistance
Electrical Power and Electrical Work
People Behind the Science: Benjamin Franklin
Magnetism
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The Source of Magnetic Fields
Electric Currents and Magnetism
Current Loops
Applications of Electromagnets
Electromagnetic Induction
Generators
Transformers
A Closer Look: Current War
Circuit Connections
Voltage Sources in Circuits
Science and Society: Blackout Reveals Pollution
A Closer Look: Solar Cells
Resistances in Circuits
Household Circuits

Static Electricity Static electricity is an electric charge confined to an object from the movement of electrons.

Force Field The space around a charge is changed by the charge, and this is called an electric field.

The Electric Circuit Electric current is the rate at which a charge moves.

Electromagnetic Induction A changing magnetic field causes charges to move.

Measuring Electrical Charge The size of a static charge is related to the number of electrons that were moved, and this can be measured in units of coulombs.

Electric Potential Electric potential results when work is done moving charges into or out of an electric field, and the potential created between two points is measured in volts.

Source of Magnetic Fields A moving charge produces a magnetic field.

Chapter Overview

Each chapter begins with an introductory overview. The overview previews the chapter's contents and what you can expect to learn from reading the chapter. It adds to the general outline of the chapter by introducing you to the concepts to be covered, facilitating in the integration of topics, and helping you to stay focused and organized while reading the chapter for the first time. After reading the introduction, browse through the chapter, paying particular attention to the topic headings and illustrations so that you get a feel for the kinds of ideas included within the chapter.

"Tillery does a much better job explaining concepts and reinforcing them. I believe his style of presentation is better and more comfortable for the student. His use of the overviews and examples is excellent!"
—George T. Davis, Jr., Mississippi Delta Community College

OVERVIEW

Chapters 2–5 have been concerned with *mechanical* concepts, explanations of the motion of objects that exert forces on one another. These concepts were used to explain straight-line motion, the motion of free fall, and the circular motion of objects on the earth as well as the circular motion of planets and satellites. The mechanical concepts were based on Newton's laws of motion and are sometimes referred to as Newtonian physics. The mechanical explanations were then extended into the submicroscopic world of matter through the kinetic molecular theory. The objects of motion were now particles, molecules that exert force on one another, and concepts associated with heat were interpreted as the motion of these particles. In a further extension of Newtonian concepts, mechanical explanations were given for concepts associated with sound, a mechanical disturbance that follows the laws of motion as it moves through the molecules of matter.

You might wonder, as did the scientists of the 1800s, if mechanical interpretations would also explain other natural phenomena such as electricity, chemical reactions, and light. A mechanical model would be very attractive because it already explained so many other facts of nature, and scientists have always looked for basic, unifying theories. Mechanical interpretations were tried, as electricity was considered a moving fluid, and light was considered a mechanical wave moving through a material fluid. There were many unsolved puzzles with such a model, and gradually it was recognized that electricity, light, and chemical reactions could not be explained by mechanical interpretations. Gradually, the point of view changed from a study of particles to a study of the properties of the space around the particles. In this chapter, you will learn about electric charge in terms of the space around particles. This model of electric charge, called the *field model*, will be used to develop concepts about electric current, the electric circuit, and electrical work and power. A relationship between electricity and the fascinating topic of magnetism is discussed next, including what magnetism is and how it is produced. The relationship is then used to explain the mechanical production of electricity (Figure 6.1), how electricity is measured, and how electricity is used in everyday technological applications.

CONCEPTS OF ELECTRICITY

You are familiar with the use of electricity in many electrical devices such as lights, toasters, radios, and calculators. You are also aware that electricity is used for transportation and for heating and cooling places where you work and live. Many people accept electrical devices as part of their surroundings, with only a hazy notion of how they work. To many people, electricity seems to be magical. Electricity is not magical, and it can be understood, just as we understand any other natural phenomenon. There are theories that explain observations, quantities that can be measured, and relationships between these quantities, or laws, that lead to understanding. All of the observations, measurements, and laws begin with an understanding of *electric charge*.

ELECTRON THEORY OF CHARGE

It was a big mystery for thousands of years. No one could figure out why a rubbed piece of amber, which is fossilized tree resin, would attract small pieces of paper (papyrus), thread, and hair. This unexplained attraction was called the "amber effect." Then about one hundred years ago, J. J. Thomson (1856–1940) found the answer while experimenting with electric currents. From these experiments, Thomson was able to conclude that negatively charged particles were present in all matter and in fact might be the stuff of which matter is made. The amber effect was traced to the movement of these particles, so they were called *electrons* after the Greek word for amber. The word *electricity* is also based on the Greek word for amber.

Today, we understand that the basic unit of matter is the *atom*, which is made up of electrons and other particles such as *protons* and *neutrons*. The atom is considered to have a dense center part called a *nucleus* that contains the closely situated protons and neutrons. The electrons move around the nucleus at some relatively greater distance (Figure 6.2). Details on the nature of protons, neutrons, electrons, and models of how the atom is constructed will be considered in chapter 8. For understanding electricity, you need only consider the protons in the nucleus, the electrons that move around the nucleus, and the fact that electrons can be moved from an atom and caused to move to or from one object to another. Basically, the electrical, light, and chemical phenomena involve the *electrons* and not the more massive nucleus. The massive nuclei remain in a relatively fixed position in a solid, but some of the electrons can move about from atom to atom.

Electric Charge

Electrons and protons have a property called electric charge. Electrons have a *negative electric charge* and protons have a *positive electric charge*. The negative or positive description simply means that these two properties are opposite; it does not mean that one is better than the other. Charge is as fundamental to these subatomic particles as gravity is to masses. This means that you cannot separate gravity from a mass, and you cannot separate charge from an electron or a proton.

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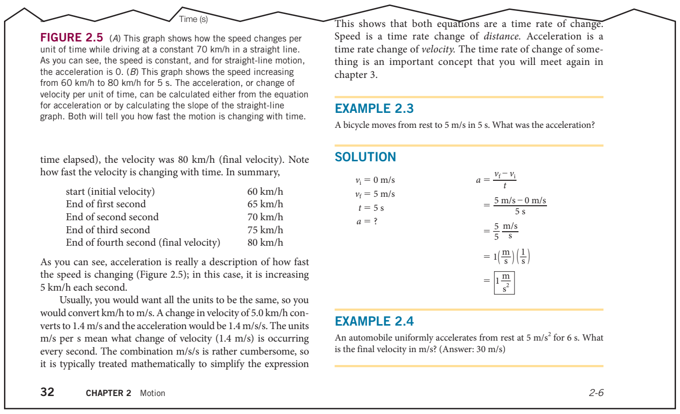
EXAMPLES

Each topic discussed within the chapter contains one or more concrete, worked *Examples* of a problem and its solution as it applies to the topic at hand. Through careful study of these examples, students can better appreciate the many uses of problem solving in the physical sciences.

"I feel this book is written well for our average student. The images correlate well with the text, and the math problems make excellent use of the dimensional analysis method. While it was a toss-up between this book and another one, now that we've taught from the book for the last year, we are extremely happy with it."
—Alan Earhart, Three Rivers Community College



APPLYING SCIENCE TO THE REAL WORLD

Concepts Applied

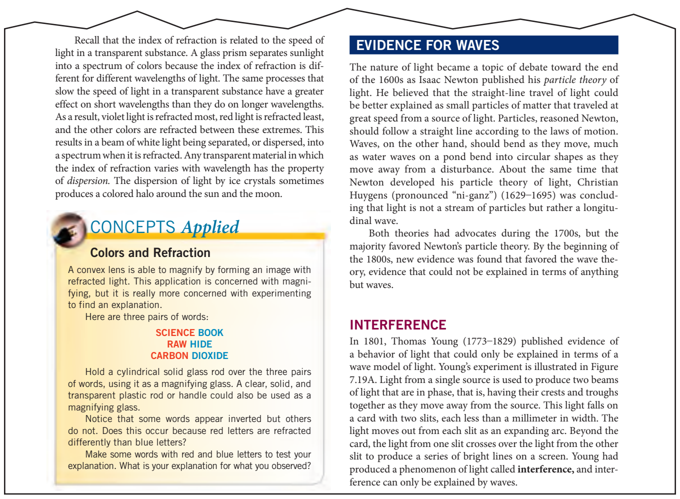
Each chapter also includes one or more *Concepts Applied* boxes. These activities are simple investigative exercises that students can perform at home or in the classroom to demonstrate important concepts and reinforce understanding of them. This feature also describes the application of those concepts to everyday life.

Science and Society

These readings relate the chapter's content to current societal issues. Many of these boxes also include Questions to Discuss that provide an opportunity to discuss issues with your peers.

Myths, Mistakes, and Misunderstandings

These brief boxes provide short, scientific explanations to dispel a societal myth or a home experiment or project that enables you to dispel the myth on your own.



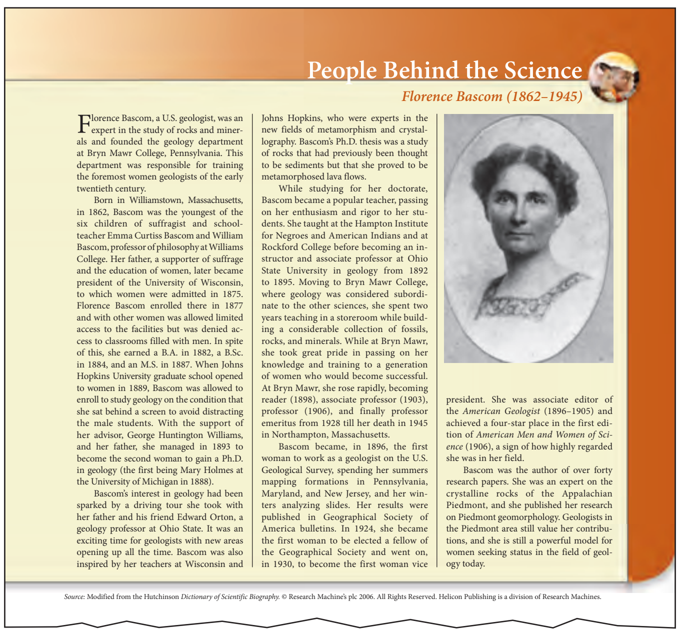
Closer Look

One or more boxed *Closer Look* features can be found in each chapter of *Physical Science*. These readings present topics of special human or environmental concern (the use of seat belts, acid rain, and air pollution, for example). In addition to environmental concerns, topics are presented on interesting technological applications (passive solar homes, solar cells, catalytic converters, etc.) or on the cutting edge of scientific research (for example, El Niño and dark energy). All boxed features are informative materials that are supplementary in nature. The *Closer Look* readings serve to underscore the relevance of physical science in confronting the many issues we face daily.

People Behind the Science

Many chapters also have fascinating biographies that spotlight well-known scientists, past or present. From these *People Behind the Science* biographies, students learn about the human side of the science: physical science is indeed relevant, and real people do the research and make the discoveries. These readings present physical science in real-life terms that students can identify with and understand.

> **"The People Behind the Science features help relate the history of science and the contributions of the various individuals."**
> **—Richard M. Woolheater, Southeastern Oklahoma State University**



People Behind the Science

Florence Bascom (1862–1945)

Florence Bascom, a U.S. geologist, was an expert in the study of rocks and minerals and founded the geology department at Bryn Mawr College, Pennsylvania. This department was responsible for training the foremost women geologists of the early twentieth century.

Born in Williamstown, Massachusetts, in 1862, Bascom was the youngest of the six children of suffragist and schoolteacher Emma Curtiss Bascom and William Bascom, professor of philosophy at Williams College. Her father, a supporter of suffrage and the education of women, later became president of the University of Wisconsin, to which women were admitted in 1875. Florence Bascom enrolled there in 1877 and with other women was allowed limited access to the facilities but was denied access to classrooms filled with men. In spite of this, she earned a B.A. in 1882, a B.Sc. in 1884, and an M.S. in 1887. When Johns Hopkins University graduate school opened to women in 1889, Bascom was allowed to enroll to study geology on the condition that she sat behind a screen to avoid distracting the male students. With the support of her advisor, George Huntington Williams, and her father, she managed in 1893 to become the second woman to gain a Ph.D. in geology (the first being Mary Holmes at the University of Michigan in 1888).

Bascom's interest in geology had been sparked by a driving tour she took with her father and his friend Edward Orton, a geology professor at Ohio State. It was an exciting time for geologists with new areas opening up all the time. Bascom was also inspired by her teachers at Wisconsin and Johns Hopkins, who were experts in the new fields of metamorphism and crystallography. Bascom's Ph.D. thesis was a study of rocks that had previously been thought to be sediments but that she proved to be metamorphosed lava flows.

While studying for her doctorate, Bascom became a popular teacher, passing on her enthusiasm and rigor to her students. She taught at the Hampton Institute for Negroes and American Indians and at Rockford College before becoming an instructor and associate professor at Ohio State University in geology from 1892 to 1895. Moving to Bryn Mawr College, where geology was considered subordinate to the other sciences, she spent two years teaching in a storeroom while building a considerable collection of fossils, rocks, and minerals. While at Bryn Mawr, she took great pride in passing on her knowledge and training to a generation of women who would become successful. At Bryn Mawr, she rose rapidly, becoming reader (1898), associate professor (1903), professor (1906), and finally professor emeritus from 1928 till her death in 1945 in Northampton, Massachusetts.

Bascom became, in 1896, the first woman to work as a geologist on the U.S. Geological Survey, spending her summers mapping formations in Pennsylvania, Maryland, and New Jersey, and her winters analyzing slides. Her results were published in Geographical Society of America bulletins. In 1924, she became the first woman to be elected a fellow of the Geographical Society and went on, in 1930, to become the first woman vice president. She was associate editor of the *American Geologist* (1896–1905) and achieved a four-star place in the first edition of *American Men and Women of Science* (1906), a sign of how highly regarded she was in her field.

Bascom was the author of over forty research papers. She was an expert on the crystalline rocks of the Appalachian Piedmont, and she published her research on Piedmont geomorphology. Geologists in the Piedmont area still value her contributions, and she is still a powerful model for women seeking status in the field of geology today.

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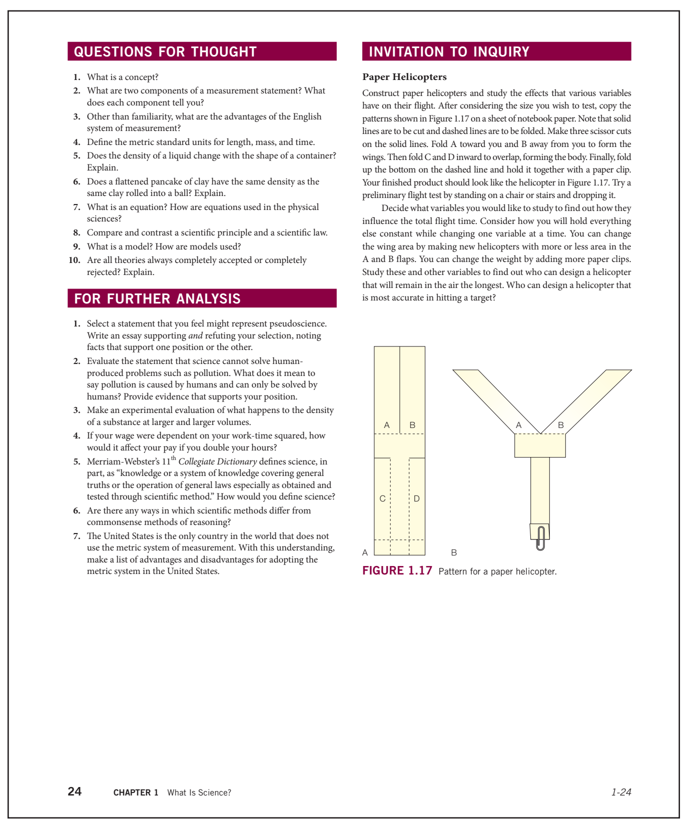
END-OF-CHAPTER FEATURES

At the end of each chapter, students will find the following materials:

- *Summary:* highlights the key elements of the chapter.
- *Summary of Equations* (chapters 1–13): reinforces retention of the equations presented.
- *Key Terms:* gives page references for finding the terms defined within the context of the chapter reading.
- *Applying the Concepts:* tests comprehension of the material covered with a multiple-choice quiz.
- *Questions for Thought:* challenges students to demonstrate their understanding of the topics.
- *Parallel Exercises* (chapters 1–13): reinforces problem-solving skills. There are two groups of parallel exercises, Group A and Group B. The Group A parallel exercises have complete solutions worked out, along with useful comments, in appendix E. The Group B parallel exercises are similar to those in Group A but do not contain answers in the text. By working through the Group A parallel exercises and checking the solutions in appendix E, students will gain confidence in tackling the parallel exercises in Group B and thus reinforce their problem-solving skills.
- *For Further Analysis:* exercises include analysis or discussion questions, independent investigations, and activities intended to emphasize critical thinking skills and societal issues, and develop a deeper understanding of the chapter content.
- *Invitation to Inquiry:* exercises that consist of short, open-ended activities that allow you to apply investigative skills to the material in the chapter.

> **"The most outstanding feature of Tillery's *Physical Science* is the use of the Group A Parallel Exercises. Prior to this text, I cannot count the number of times I have heard students state that they understood the material when presented in class, but when they tried the homework on their own, they were unable to remember what to do. The Group A problems with the complete solution were the perfect reminder for most of the students. I also believe that Tillery's presentation of the material addresses the topics with a rigor necessary for a college-level course but is easily understandable for my students without being too simplistic. The material is challenging but not too overwhelming."**
> **—J. Dennis Hawk, Navarro College**



QUESTIONS FOR THOUGHT

1. What is a concept?
2. What are two components of a measurement statement? What does each component tell you?
3. Other than familiarity, what are the advantages of the English system of measurement?
4. Define the metric standard units for length, mass, and time.
5. Does the density of a liquid change with the shape of a container? Explain.
6. Does a flattened pancake of clay have the same density as the same clay rolled into a ball? Explain.
7. What is an equation? How are equations used in the physical sciences?
8. Compare and contrast a scientific principle and a scientific law.
9. What is a model? How are models used?
10. Are all theories always completely accepted or completely rejected? Explain.

FOR FURTHER ANALYSIS

1. Select a statement that you feel might represent pseudoscience. Write an essay supporting *and* refuting your selection, noting facts that support one position or the other.
2. Evaluate the statement that science cannot solve human-produced problems such as pollution. What does it mean to say pollution is caused by humans and can only be solved by humans? Provide evidence that supports your position.
3. Make an experimental evaluation of what happens to the density of a substance at larger and larger volumes.
4. If your wage were dependent on your work-time squared, how would it affect your pay if you double your hours?
5. Merriam-Webster's 11th *Collegiate Dictionary* defines science, in part, as "knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method." How would you define science?
6. Are there any ways in which scientific methods differ from commonsense methods of reasoning?
7. The United States is the only country in the world that does not use the metric system of measurement. With this understanding, make a list of advantages and disadvantages for adopting the metric system in the United States.

INVITATION TO INQUIRY

Paper Helicopters

Construct paper helicopters and study the effects that various variables have on their flight. After considering the size you wish to test, copy the patterns shown in Figure 1.17 on a sheet of notebook paper. Note that solid lines are to be cut and dashed lines are to be folded. Make three scissor cuts on the solid lines. Fold A toward you and B away from you to form the wings. Then fold C and D inward to overlap, forming the body. Finally, fold up the bottom on the dashed line and hold it together with a paper clip. Your finished product should look like the helicopter in Figure 1.17. Try a preliminary flight test by standing on a chair or stairs and dropping it.

Decide what variables you would like to study to find out how they influence the total flight time. Consider how you will hold everything else constant while changing one variable at a time. You can change the wing area by making new helicopters with more or less area in the A and B flaps. You can change the weight by adding more paper clips. Study these and other variables to find out who can design a helicopter that will remain in the air the longest. Who can design a helicopter that is most accurate in hitting a target?

FIGURE 1.17 Pattern for a paper helicopter.

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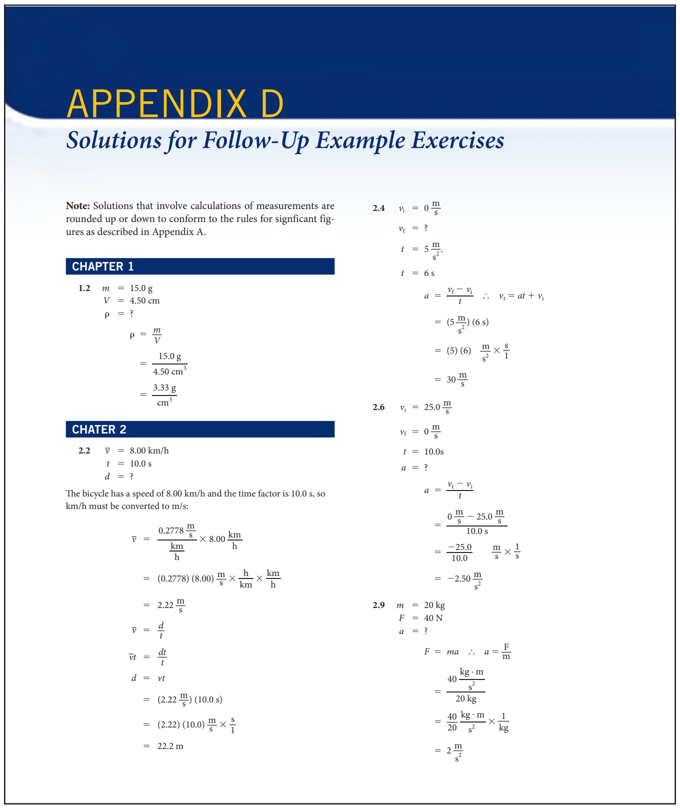
END-OF-TEXT MATERIALS

Appendices providing math review, additional background detail, solubility and humidity charts, solutions for the in-chapter follow-up examples, and solutions for the Group A Parallel Exercises can be found at the back of the text. There is also a glossary of all key terms, an index, and special tables printed on the inside covers for reference use.



APPENDIX D

Solutions for Follow-Up Example Exercises

Note: Solutions that involve calculations of measurements are rounded up or down to conform to the rules for signficant figures as described in Appendix A.

CHAPTER 1

1.2 $m = 15.0\text{ g}$
$V = 4.50\text{ cm}$
$\rho = ?$

$$\rho = \frac{m}{V} = \frac{15.0\text{ g}}{4.50\text{ cm}^3} = \frac{3.33\text{ g}}{\text{cm}^3}$$

CHATER 2

2.2 $\bar{v} = 8.00\text{ km/h}$
$t = 10.0\text{ s}$
$d = ?$

The bicycle has a speed of 8.00 km/h and the time factor is 10.0 s, so km/h must be converted to m/s:

$$\bar{v} = \frac{0.2778\,\frac{\text{m}}{\text{s}}}{\frac{\text{km}}{\text{h}}} \times 8.00\,\frac{\text{km}}{\text{h}} = (0.2778)(8.00)\,\frac{\text{m}}{\text{s}} \times \frac{\text{h}}{\text{km}} \times \frac{\text{km}}{\text{h}} = 2.22\,\frac{\text{m}}{\text{s}}$$

$$\bar{v} = \frac{d}{t} \qquad \bar{v}t = \frac{dt}{t}$$

$$d = vt = \left(2.22\,\frac{\text{m}}{\text{s}}\right)(10.0\text{ s}) = (2.22)(10.0)\,\frac{\text{m}}{\text{s}} \times \frac{\text{s}}{1} = 22.2\text{ m}$$

2.4 $v_i = 0\,\frac{\text{m}}{\text{s}}$
$v_f = ?$
$t = 5\,\frac{\text{m}}{\text{s}^2}.$
$t = 6\text{ s}$

$$a = \frac{v_f - v_i}{t} \quad \therefore \quad v_t = at + v_i$$

$$= \left(5\,\frac{\text{m}}{\text{s}^2}\right)(6\text{ s}) = (5)(6)\,\frac{\text{m}}{\text{s}^2} \times \frac{\text{s}}{1} = 30\,\frac{\text{m}}{\text{s}}$$

2.6 $v_i = 25.0\,\frac{\text{m}}{\text{s}}$
$v_f = 0\,\frac{\text{m}}{\text{s}}$
$t = 10.0\text{s}$
$a = ?$

$$a = \frac{v_t - v_i}{t} = \frac{0\,\frac{\text{m}}{\text{s}} - 25.0\,\frac{\text{m}}{\text{s}}}{10.0\text{ s}} = \frac{-25.0}{10.0}\,\frac{\text{m}}{\text{s}} \times \frac{1}{\text{s}} = -2.50\,\frac{\text{m}}{\text{s}^2}$$

2.9 $m = 20\text{ kg}$
$F = 40\text{ N}$
$a = ?$

$$F = ma \quad \therefore \quad a = \frac{F}{m}$$

$$= \frac{40\,\frac{\text{kg}\cdot\text{m}}{\text{s}^2}}{20\text{ kg}} = \frac{40}{20}\,\frac{\text{kg}\cdot\text{m}}{\text{s}^2} \times \frac{1}{\text{kg}} = 2\,\frac{\text{m}}{\text{s}^2}$$

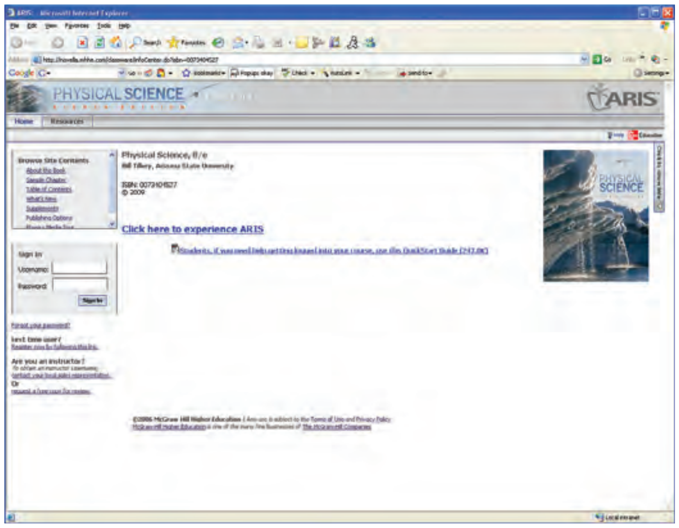
SUPPLEMENTS

Physical Science is accompanied by a variety of multimedia supplementary materials, including an interactive ARIS site with testing software containing multiple-choice test items and other teacher resources. The supplement package also includes a laboratory manual, both student and instructor's editions, by the author of the text.

MULTIMEDIA SUPPLEMENTARY MATERIALS

McGraw-Hill's ARIS—Assessment, Review, and Instruction System

McGraw-Hill's ARIS for *Physical Science* is a complete, online electronic homework and course management system designed for greater ease of use than any other system available. Available with the *Physical Science* eighth edition text, instructors can create and share course materials and assignments with colleagues with a few clicks of the mouse. All PowerPoint lectures, assignments, quizzes, an instructor's lab manual, text images, an instructor's manual, test bank questions, clicker questions, animations, and more are directly tied to text-specific materials in *Physical Science,* but instructors can also edit questions, import their own content, and create announcements and due dates for assignments. ARIS has automatic grading and reporting of easy-to-assign homework, quizzing, and testing. All student activity within McGraw-Hill's ARIS is automatically recorded and available to the instructor through a fully integrated grade book that can be downloaded to Excel.



Personal Response Systems

Personal Response Systems ("clickers') can bring interactivity into the classroom or lecture hall. Wireless response systems give the instructor and students immediate feedback from the entire class. The wireless response pads are essentially remotes that are easy to use and engage students. Clickers allow instructors to motivate student preparation, interactivity, and active learning. Instructors receive immediate feedback to gauge which concepts students understand. Questions covering the content of the *Physical Science* text and formatted in PowerPoint are available on ARIS for *Physical Science.*

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- **Animations Library:** Files of animations and videos covering the many topics in *Physical Science* are included so that you can easily make use these animations in a lecture or classroom setting.

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- **Lecture Outlines:** Lecture notes, incorporating illustrations and animated images, have been written to the eighth edition text. They are provided in PowerPoint format so that you may use these lectures as written or customize them to fit your lecture.

"I find Physical Science to be superior to either of the texts that I have used to date. . . . The animations and illustrations are better than those of other textbooks that I have seen, more realistic and less trivial."
—T. G. Heil, University of Georgia

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PRINTED SUPPLEMENTARY MATERIAL

Laboratory Manual

The *laboratory manual,* written and classroom tested by the author, presents a selection of laboratory exercises specifically written for the interests and abilities of nonscience majors. There are laboratory exercises that require measurement, data analysis, and thinking in a more structured learning environment. Alternative exercises that are open-ended "Invitations to Inquiry" are provided for instructors who would like a less structured approach. When the laboratory manual is used with *Physical Science,* students will have an opportunity to master basic scientific principles and concepts, learn new problem-solving and thinking skills, and understand the nature of scientific inquiry from the perspective of hands-on experiences. The *instructor's edition of the laboratory manual* can be found on the *Physical Science* ARIS site.

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During his time at Arizona State, Bill taught a variety of courses, including general education courses in science and society, physical science, and introduction to physics. He received more than forty grants from the National Science Foundation, the U.S. Office of Education, from private industry (Arizona Public Service), and private foundations (The Flinn Foundation) for science curriculum development and science teacher inservice training. In addition to teaching and grant work, Bill authored or coauthored more than sixty textbooks and many monographs, and served as editor of three separate newsletters and journals between 1977 and 1996.

Bill has attempted to present an interesting, helpful program that will be useful to both students and instructors. Comments and suggestions about how to do a better job of reaching this goal are welcome. Any comments about the text or other parts of the program should be addressed to:

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