preface

The satisfaction of understanding how rainbows are formed, how ice skaters spin, or why ocean tides roll in and out—phenomena that we have all seen or experienced—is one of the best motivators available for building scientific literacy. This book attempts to make that sense of satisfaction accessible to non-science majors. Intended for use in a one-semester or two-quarter course in conceptual physics, this book is written in a narrative style, frequently using questions designed to draw the reader into a dialogue about the ideas of physics. This inclusive style allows the book to be used by anyone interested in exploring the nature of physics and explanations of everyday physical phenomena.

> *"Griffith has done a very respectable job in presenting his conceptual physics course in a clear, useable fashion. It is a fine work that is evidently quickly evolving into a top-notch textbook."*
>
> —Michael Bretz,
> University of Michigan

How This Book Is Organized

With the exception of the reorganization of chapters 15, 16, and 17 introduced in the fourth edition, we have retained the same order of topics as in the previous editions. It is traditional with some minor variations. The chapter on energy (chapter 6) appears prior to that on momentum (chapter 7) so that energy ideas can be used in the discussion of collisions. Wave motion is found in chapter 15, following electricity and magnetism and prior to chapters 16 and 17 on optics. The chapter on fluids (chapter 9) follows mechanics and leads into the chapters on thermodynamics. The first 17 chapters are designed to introduce students to the major ideas of classical physics and can be covered in a one-semester course with some judicious paring.

The complete 21 chapters could easily support a two-quarter course, and even a two-semester course in which the ideas are treated thoroughly and carefully. Chapters 18 and 19 on atomic and nuclear phenomena, are considered essential by many instructors, even in a one-semester course. If included in such a course, we recommend curtailing coverage in other areas to avoid student overload. Sample syllabi for these different types of courses can be found on the Instructor Center of the Online Learning Center.

Some instructors would prefer to put chapter 20 on relativity at the end of the mechanics section or just prior to the modern physics material. Relativity has little to do with everyday phenomena, of course, but is included because of the high interest that it generally holds for students. The final chapter (21) introduces a variety of topics in modern physics—including particle physics, cosmology, semiconductors, computers, and superconductivity—that could be used to stimulate interest at various points in a course.

One plea to instructors, as well as to students using this book: Don't try to cram too much material into too short a time! We have worked diligently to keep this book to a reasonable length while still covering the core concepts usually found in an introduction to physics. These ideas are most enjoyable when enough time is spent in lively discussion and in consideration of questions so that a real understanding develops. Trying to cover material too quickly defeats the conceptual learning and leaves students in a dense haze of words and definitions. Less can be more if a good understanding results.

Mathematics in a Conceptual Physics Course

The use of mathematics in a physics course is a formidable block for many students, particularly non-science majors. Although there have been attempts to teach conceptual physics without any mathematics, these attempts miss an opportunity to help students gain confidence in using and manipulating simple quantitative relationships.

Clearly mathematics is a powerful tool for expressing the quantitative relationships of physics. The use of mathematics can be carefully limited, however, and subordinated to the physical concepts being addressed. Many users of the first edition of this text felt that mathematical expressions appeared too frequently for the comfort of some students. In response, we substantially reduced the use of mathematics in the body of the text in the second edition. Most users have indicated that the current level is about right, so we have not changed the mathematics level in this edition.

> *"The level of presentation is pitch-perfect for a college physics course. I happen to have a need for a book at just this level, compromising between a math-free conceptual book and one that goes for the full college-level (but not university-level) treatment. The brevity of presentation also lends itself well to a one-semester survey course format."*
>
> —Brent Royuk,
> Concordia University

Logical coherence is a strong feature of this book. Formulas are introduced carefully after conceptual arguments are provided, and statements in words of these relationships generally accompany their introduction. We have continued to fine tune the example boxes that present sample exercises and questions. Most of these provide simple numerical illustrations of the ideas discussed. No mathematics prerequisite beyond high school algebra should be necessary. A discussion of the basic ideas of very simple algebra is found in appendix A, together with some practice exercises, for students who need help with these ideas.

New to This Edition

We have made some significant additions and changes to the fifth edition. As this book has evolved, however, we have tried to remain faithful to the principles that have guided the writing of the book from the outset. One of these has been to keep the book to a manageable length, both in the number of chapters and in the overall content. Many books become bloated as users and reviewers request more and more pet topics. We have strived to maintain a carefully organized framework for building an understanding of basic physics. The changes include:

1. **Answers to Selected Questions.** At the request of users and reviewers, we have added answers to selected questions in appendix D in the text. Written answers are provided to every sixth question starting with question 3 in appendix D in a format involving one or two complete sentences. In addition, students can find answers to questions 6, 12, 18, etc., on the Online Learning Center (OLC) via the Internet. These answers provide feedback on an appropriate style for responding to the conceptual questions that students and instructors can expand upon.
2. **New Everyday Phenomenon Boxes.** Three new everyday phenomenon boxes have been added. Two of these involve biological applications of physics ideas and the third involves some chemistry. Most chapters now have two everyday phenomenon boxes. The new titles are:
   everyday phenomenon box 9.1 Measuring Blood Pressure
   everyday phenomenon box 13.1 Electrical Impulses in Nerve Cells
   everyday phenomenon box 18.1 Fuel Cells and the Hydrogen Economy
3. **Secrets to Success.** A brief section—Secrets to Success in Studying Physics—has been added prior to chapter 1. This provides pointers to students on ways in which studying physics may differ from study modes they may have used in other disciplines.
4. **Updated Artwork.** The photographs and artwork in the text have been updated in several places to achieve both better relevance and clarity. Some new photographs have been added. In many cases, the changes are minor but are aimed at helping the user see the critical features. Many of these changes have been suggested by sharp-eyed users and reviewers.
5. **New Sample Exercises.** At the request of reviewers, a few new sample exercises have been added. These are intended to fill gaps in helping students understand simple quantitative aspects of the concepts being addressed.
6. **Continued Refinements in Textual Clarity.** Although the clarity of writing, which has been extensively praised by reviewers, is one of the strongest features of this text, it can always be improved. The changes are often subtle, but they always have the objective of making explanations both technically correct and clear.

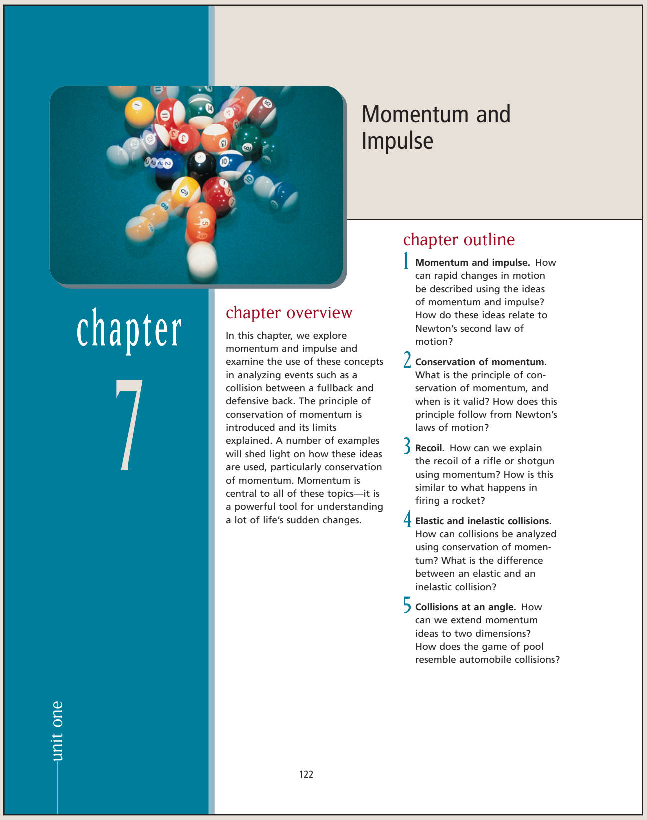
Learning Aids

The overriding theme of this book is to introduce physical concepts by appealing to everyday phenomena whenever possible. To achieve this goal, this text includes a variety of features to make the study of *The Physics of Everyday Phenomena* more effective and enjoyable. A few key concepts form the basis for understanding physics, and the textual features described here reinforce this structure so that the reader will not be lost in a flurry of definitions and formulas.

> *"The presentation is outstanding: Clear, concise, not too complicated, not trivial either. The style is refreshing. Students are invited to think; they are not overwhelmed by complicated explanations. . . ."*
>
> —Klaus Rossberg,
> Oklahoma City University

Chapter Openers

Each chapter begins with an illustration from everyday experience and then proceeds to use it as a theme for introducing relevant physical concepts. Physics can seem abstract to many students, but using everyday phenomena and concrete examples reduces that abstractness. The chapter **overview** previews the chapter's contents and what students can expect to learn from reading the chapter. The overview introduces the concepts to be covered, facilitating the integration of topics, and helping students to stay focused and organized while reading the chapter for the first time. The chapter **outline** includes all the major topic headings within the body of the chapter. It also contains questions that provide students with a guide of what they will be expected to know in order to comprehend the major concepts of the chapter. (These questions are then correlated to the end-of-chapter summaries.)



"Very good chapter overview and chapter outline for each chapter and for each unit. Very clear introduction and illustration of physics phenomena, concepts, and principles, and excellent exercises, problems, and home experiments/observations at the end of each chapter."

—Hai-Sheng Wu,
Minnesota State University, Mankato

The chapter outlines, questions, and summaries provide a clear framework for the ideas discussed in each chapter. One of the difficulties that students have in learning physics (or any subject) is that they fail to construct the big picture of how things fit together. A consistent chapter framework can be a powerful tool in helping students see how ideas mesh.

Other Text Features

Running summary paragraphs are found at the end of each chapter section to supplement the more general summary at the end of the chapter.

> Rotational displacement, rotational velocity, and rotational acceleration are the quantities that we need to fully describe the motion of a rotating object. They describe how far the object has rotated (rotational displacement), how fast it is rotating (rotational velocity), and the rate at which the rotation may be changing (rotational acceleration). These definitions are analogous to similar quantities used to describe linear motion. They tell us how the object is rotating, but not why. Causes of rotation are considered next.

"I found the liberal use of questions such as "Do you believe in atoms? And, if so, why?" to motivate the discussion to be outstanding. I also found the interwoven history used to guide the discussion to be excellent. I often use that approach myself. It usually leads to a natural flow of concepts and also informs the student how we know what we know, as well as giving them training in scientific thinking and showing them how science is done in real life. . . . Only someone who actively resisted understanding could fail to understand Griffith's text. He writes clearly, logically, and interestingly."

—Charles W. Rogers,
Southwestern Oklahoma
State University

Subsection headings are often cast in the form of questions to motivate the reader and pique curiosity.

> **What is the difference between speed and velocity?**
>
> Imagine that you are driving a car around a curve (as illustrated in figure 2.5) and that you maintain a constant speed of 60 km/h. Is your velocity also constant in this case? The answer is no, because **velocity** involves the direction of motion as well as how fast the object is going. The direction of motion is changing as the car goes around the curve.
>
> To ... this distinction ... as ... de-

Study hints and **study suggestions** provide students with pointers on their use of the textbook, tips on applying the principles of physical concepts, and suggestions for home experiments.

study hint

Except for the examples involving impulse, most of the situations described in this chapter highlight the principle of conservation of momentum. The basic ideas used in applying conservation of momentum are:

1. External forces are assumed to be much smaller than the very strong forces of interaction in a collision or other brief event. If external forces acting on the system can be ignored, momentum is conserved.
2. The total momentum of the system before the collision or other brief interaction $\mathbf{p}_{\text{initial}}$ is equal to the momentum after the event $\mathbf{p}_{\text{final}}$. Momentum is conserved and does not change.
3. Equality of momentum before and after the event can be used to obtain other information about the motion of the objects.

For review, look back at how these three points are used in each of the examples in this chapter. The total momentum of the system before and after the event is always found by adding the momentum values of the individual objects as *vectors*. You should be able to describe the magnitude and direction of this total momentum for each of the examples.

Example boxes are included within the chapter and contain 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 physics.

example box 2.4

Sample Exercise: Uniform Acceleration

A car traveling due east with an initial velocity of 10 m/s accelerates for 6 seconds at a constant rate of 4 m/s².
a. What is its velocity at the end of this time?
b. How far does it travel during this time?

a.
$v_0 = 10 \text{ m/s} \qquad v = v_0 + at$
$a = 4 \text{ m/s}^2 \qquad = 10 \text{ m/s} + (4 \text{ m/s}^2)(6 \text{ s})$
$t = 6 \text{ s} \qquad = 10 \text{ m/s} + 24 \text{ m/s}$
$v = ? \qquad = \mathbf{34 \text{ m/s}}$

$$\mathbf{v} = \mathbf{34 \text{ m/s due east}}$$

b.
$$d = v_0 t + \tfrac{1}{2}at^2$$
$$= (10 \text{ m/s})(6 \text{ s}) + \tfrac{1}{2}(4 \text{ m/s}^2)(6 \text{ s})^2$$
$$= 60 \text{ m} + (2 \text{ m/s}^2)(36 \text{ s}^2)$$
$$= 60 \text{ m} + 72 \text{ m} = \mathbf{132 \text{ m}}$$

Everyday phenomenon boxes relate physical concepts discussed in the text to real-world topics, societal issues, and modern technology, underscoring the relevance of physics and how it relates to our day-to-day lives. The list of topics includes:

The Case of the Malfunctioning Coffee Pot (chapter 1)
Transitions in Traffic Flow (chapter 2)
The 100-m Dash (chapter 2)
Shooting a Basketball (chapter 3)
The Tablecloth Trick (chapter 4)
Riding an Elevator (chapter 4)
Seat Belts, Air Bags, and Accident Dynamics (chapter 5)

everyday phenomenon box 9.1

Measuring Blood Pressure

The Situation. When you visit your doctor's office, the nurse will almost always take your blood pressure before the doctor spends time with you. A cuff is placed around your upper arm (as shown in the photograph) and air is pumped into the cuff, producing a feeling of tightness in your arm. Then the air is slowly released while the nurse listens to something with a stethoscope and records some numbers, such as 125 over 80.

Having your blood pressure measured is a standard procedure for most visits to a doctor's office. How does this process work?

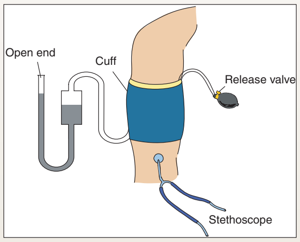
What is the significance of these two numbers? What is blood pressure and how is it measured? Why are these readings an important factor, along with your weight, temperature, and medical history, in assessing your health?

The Analysis. Your blood flows through an elaborate system of arteries and veins in your body. As we all know, this flow is driven by your heart, which is basically a pump. More accurately, the heart is a double pump. One-half pumps blood through your lungs, where the blood cells pick up oxygen and discard carbon dioxide. The other half of the heart pumps blood through the rest of your body to deliver oxygen and nutrients. Arteries carry blood away from the heart into small capillaries that interface with other cells in muscles and organs. The veins collect blood from the capillaries and carry it back to the heart.

We measure the blood pressure in a major artery in your upper arm at about the same height as your heart. When air is pumped into the cuff around your upper arm, it compresses this artery so that the blood flow stops. The nurse places the stethoscope, a listening device, near this same artery at a lower point in the arm and listens for the blood flow to restart as the air in the cuff is released.

The heart is a pulsating pump that pumps blood most strongly when the heart muscle is most fully compressed. The pressure therefore fluctuates between high and low values. The higher reading in the blood pressure measurement, the *systolic* pressure, is taken when the blood just begins to spurt through the compressed artery at the peak of the heart's cycle. The lower reading, the *diastolic* pressure, is taken when blood flow occurs even at the low point in the cycle. There are distinctive sounds picked up by the stethoscope at these two points.

The pressure recorded is actually the pressure in the air cuff for these two conditions. It is a *gauge* pressure, meaning that it is the pressure difference between the pressure being measured and atmospheric pressure. It is recorded in the units mm of mercury, which is the common way of recording atmospheric pressure. Thus a reading of 125 means that the pressure in the cuff is 125 mm of mercury *above* atmospheric pressure. A mercury manometer that is open to the air on one side (see the drawing) will measure gauge pressure directly.



An open-ended manometer can be used to measure the gauge pressure of the cuff. The stethoscope is used to listen for sounds indicating the restart of blood flow.

High blood pressure can be a symptom of many health problems, but most specifically, it is a warning sign for heart attacks and strokes. When arteries become constricted from the buildup of plaque deposits inside, the heart must work harder to pump blood through the body. Over time this can weaken the heart muscle. The other danger is that blood vessels might burst in the brain, causing a stroke, or blood clots might break loose and block smaller arteries in the heart or brain. In any case, high blood pressure is an important indicator of a potential problem.

Low blood pressure can also be a sign of problems. It can cause dizziness when not enough blood is reaching the brain. When you stand up quickly, you sometimes experience a feeling of "light-headedness" because it takes a brief time for the heart to adjust to the new condition where your head is higher. Giraffes have a blood pressure about three times higher than humans (in gauge pressure terms). Why do you suppose this is so?

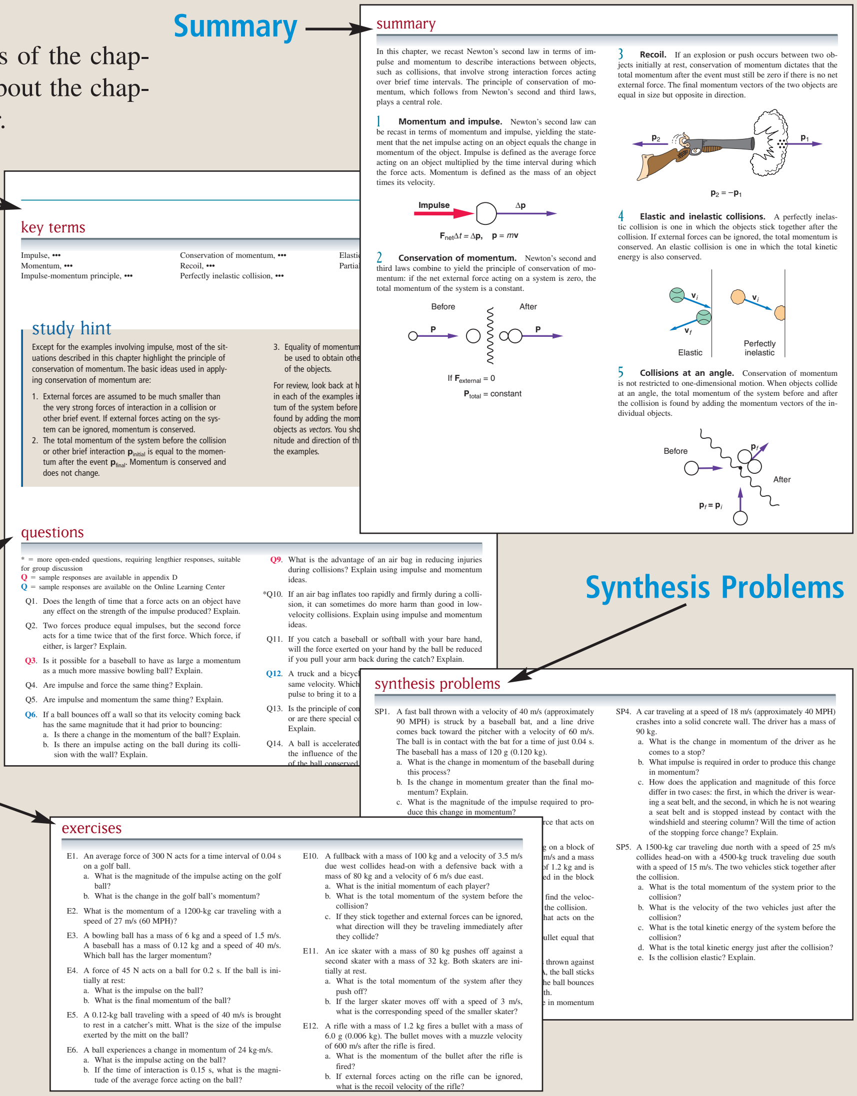
"This book compared to others is simply interesting. Topics like physics of music and color perception really engaged me, even as I read most of the chapters in one sitting. It indeed does a good job at getting at everyday phenomena."

—Tim Bolton,
Kansas State University

Explaining the Tides (chapter 5)
Energy and the Pole Vault (chapter 6)
An Automobile Collision (chapter 7)
Achieving the State of Yo (chapter 8)
Bicycle Gears (chapter 8)
Measuring Blood Pressure (chapter 9)
Throwing a Curveball (chapter 9)
Solar Collectors and the Greenhouse Effect (chapter 10)
Hybrid Automobile Engines (chapter 11)
A Productive Pond (chapter 11)
Lightning (chapter 12)
Electrical Impulses in Nerve Cells (chapter 13)
The Hidden Switch in Your Toaster (chapter 13)
Direct-Current Motors (chapter 14)
Vehicle Sensors at Traffic Lights (chapter 14)
A Moving Car Horn and the Doppler Effect (chapter 15)
Why Is the Sky Blue? (chapter 16)
Antireflection Coatings on Eyeglasses (chapter 16)
Rainbows (chapter 17)
Laser Refractive Surgery (chapter 17)
Fuel Cells and the Hydrogen Economy (chapter 18)
Electrons and Television (chapter 18)
Radiation Exposure (chapter 19)
What Happened at Chernobyl? (chapter 19)
The Twin Paradox (chapter 20)
Holograms (chapter 21)

End-of-Chapter Features

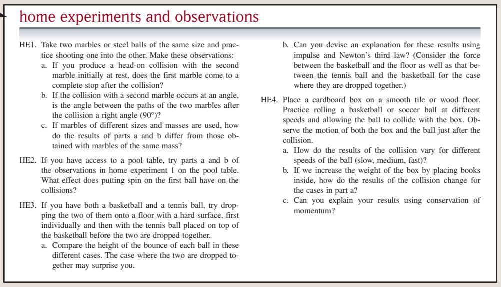
- The **summary** highlights the key elements of the chapter and correlates to the questions asked about the chapter's major concepts on the chapter opener.



- **Key terms** are page-referenced to where students can find the terms defined in context.
- **Questions** are designed to challenge students to demonstrate their understanding of the key concepts. Selected answers are provided in appendix D to assist students with their study of more difficult concepts.
- **Exercises** and **synthesis problems** are intended to help students test their grasp of problem-solving. The odd-numbered exercises have answers in appendix D. By working through the odd-numbered exercises and checking the answer in appendix D, students can gain confidence in tackling the even-numbered exercises, and thus reinforce their problem-solving skills.

- Because many courses for non-science majors do not have a laboratory component, **home experiments and observations** are found at the end of each chapter. The spirit of these home experiments is to enable students to explore the behavior of physical phenomena using easily available rulers, string, paper clips, balls, toy cars, flashlight batteries, and so on. Many instructors have found them useful for putting students into the exploratory and observational frame of mind that is important to scientific thinking. This is certainly one of our objectives in developing scientific literacy.

Home Experiments and Observations



home experiments and observations

HE1. Take two marbles or steel balls of the same size and practice shooting one into the other. Make these observations:
a. If you produce a head-on collision with the second marble initially at rest, does the first marble come to a complete stop after the collision?
b. If the collision with a second marble occurs at an angle, is the angle between the paths of the two marbles after the collision a right angle (90°)?
c. If marbles of different sizes and masses are used, how do the results of parts a and b differ from those obtained with marbles of the same mass?

HE2. If you have access to a pool table, try parts a and b of the observations in home experiment 1 on the pool table. What effect does putting spin on the first ball have on the collisions?

HE3. If you have both a basketball and a tennis ball, try dropping the two of them onto a floor with a hard surface, first individually and then with the tennis ball placed on top of the basketball before the two are dropped together.
a. Compare the height of the bounce of each ball in these different cases. The case where the two are dropped together may surprise you.
b. Can you devise an explanation for these results using impulse and Newton's third law? (Consider the force between the basketball and the floor as well as that between the tennis ball and the basketball for the case where they are dropped together.)

HE4. Place a cardboard box on a smooth tile or wood floor. Practice rolling a basketball or soccer ball at different speeds and allowing the ball to collide with the box. Observe the motion of both the box and the ball just after the collision.
a. How do the results of the collision vary for different speeds of the ball (slow, medium, fast)?
b. If we increase the weight of the box by placing books inside, how do the results of the collision change for the cases in part a?
c. Can you explain your results using conservation of momentum?

> *"The selection of problems and questions at the end of each chapter is excellent. They provide students with a comprehensive review of the chapters and at the same time present challenges to reinforce the concepts. . . . Many students taking an introductory physics course do not have a chance to take a lab component with the course. The home experiments can go a long way toward addressing this deficiency."*
>
> —Farhang Amiri, Weber State University

Supplements

Instructor's Testing and Resource CD-ROM

The cross-platform CD-ROM contains the Test Bank and the Instructor's Manual (with answers to the end-of-chapter questions and exercises) in both Word and PDF formats. The Test Bank questions are also found in a computerized Test Bank. McGraw-Hill's EZ Test is a flexible and easy-to-use electronic testing program. The program allows instructors to create tests from book-specific items. It accommodates a wide range of question types, and instructors may add their own questions. Multiple versions of the test can be created, and any test can be exported for use with course management systems such as WebCT, BlackBoard, or PageOut. EZ Test Online is a new service that provides a place to easily administer EZ Test–created exams and quizzes online. The program is available for Windows and Macintosh environments.

Also located on the Instructor's Testing and Resources CD-ROM are personal response system questions in a CPS eInstruction database and as PowerPoint files.

Classroom Performance System

The Classroom Performance System (CPS) by eInstruction brings interactivity into the classroom or lecture hall. It is a wireless response system that gives 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. CPS allows 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 Physics of Everyday Phenomena* text and formatted for CPS eInstruction and PowerPoint are available on the Online Learning Center and the Instructor's Testing and Resource CD-ROM.

Digital Content Manager CD

Electronic art at your fingertips! This cross-platform DVD/CD-ROM provides instructors with visuals from the text in multiple formats. Instructors can easily create customized classroom presentations, visually-based tests and quizzes, dynamic content for a course website, or attractive printed support materials. Available on the DVD or CD are the following resources in digital formats. These items have also been placed into PowerPoint files for ease of use:

- **Art and Photo Library:** Full-color digital files of all of the illustrations and many of the photos in the text can be readily incorporated into lecture presentations, exams, or custom-made classroom materials.
- **Animations Library:** Files of animations and videos covering the many topics in *The Physics of Everyday Phenomena* are included so that they may be easily used in a lecture or classroom setting.
- **Lecture Outlines:** Lecture notes, incorporating illustrations and animated images, have been written for the fifth edition text. They are provided in PowerPoint format so that instructors may use these lectures as written or customize them to fit their lecture.

Online Learning Center (OLC)

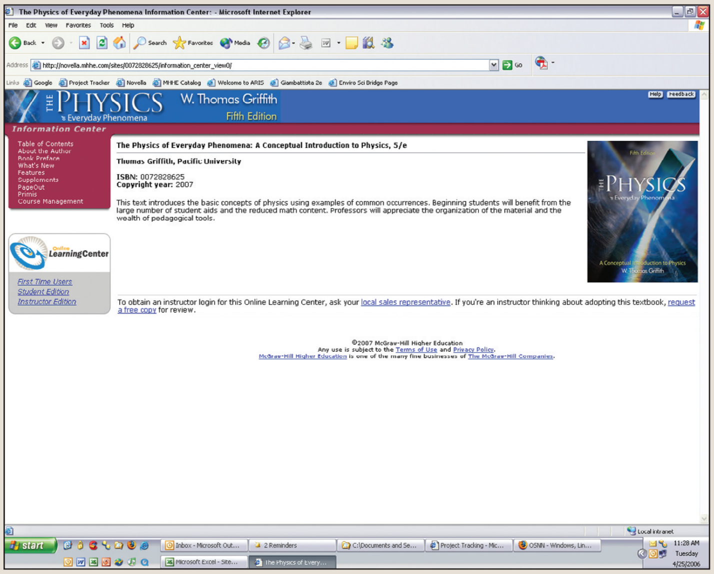
The OLC is a text-specific website that provides students with useful study tools designed to help improve their understanding of the material presented in the text and class. For the instructor, the OLC is designed to help ease the time burdens of the course by providing valuable presentation and preparation tools.

For Students

- Student Study Guide Integration
  - Mastery Quiz
  - Know
  - Understand
  - Study Hints
  - Practice Problems
  - Answers to Questions
- Animations
- Crossword Puzzles
- Links Library
- Chapter Summary
- Chapter Objectives

For Instructors

- All Student Content
- PowerPoint Lectures
- Instructor's Manual
- Sample Syllabus
- CPS eInstruction Questions
- Image Library



Acknowledgments

A large number of people have contributed to this fifth edition, either directly or indirectly. I extend particular thanks to those who participated in reviews of the fourth edition. Their thoughtful suggestions have had direct impact upon the clarity and accuracy of this edition, even when it was not possible to fully incorporate all of their ideas due to space limitations or other constraints. I also thank the contributors to the website, Joseph Schaeffer; the Instructor's Manual and Test Bank, Lyle Ford; and the PowerPoint Lectures, Daniel Bubb, Art Braundmeier, Virgil Stubblefield, and Mikolaj Sawicki.

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