Brief Contents

AP* EDITION

COLLEGE PHYSICS

A STRATEGIC APPROACH

SECOND EDITION

RANDALL D. KNIGHT

California Polytechnic State University, San Luis Obispo

BRIAN JONES

Colorado State University

STUART FIELD

Colorado State University

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About the Authors

Randy Knight has taught introductory physics for 28 years at Ohio State University and California Polytechnic University, where he is currently Professor of Physics and Director of the Minor in Environmental Studies. Randy received a Ph.D. in physics from the University of California, Berkeley and was a post-doctoral fellow at the Harvard-Smithsonian Center for Astrophysics before joining the faculty at Ohio State University. It was at Ohio that he began to learn about the research in physics education that, many years later, led to *Five Easy Lessons: Strategies for Successful Physics Teaching, Physics for Scientists and Engineers: A Strategic Approach,* and now to this book. Randy's research interests are in the field of lasers and spectroscopy. He also directs the environmental studies program at Cal Poly. When he's not in the classroom or in front of a computer, you can find Randy hiking, sea kayaking, playing the piano, or spending time with his wife Sally and their six cats.

Brian Jones has won several teaching awards at Colorado State University during his 20 years teaching in the Department of Physics. His teaching focus in recent years has been the College Physics class, including writing problems for the MCAT exam and helping students review for this test. Brian is also Director of the *Little Shop of Physics,* the Department's engaging and effective hands-on outreach program, which has merited coverage in publications ranging from the *APS News* to *People* magazine. Brian has been invited to give workshops on techniques of science instruction throughout the United States and internationally, including Belize, Chile, Ethiopia, Azerbaijan, Mexico and Slovenia. Previously, he taught at Waterford Kamhlaba United World College in Mbabane, Swaziland, and Kenyon College in Gambier, Ohio. Brian and his wife Carol have dozens of fruit trees and bushes in their yard, including an apple tree that was propagated from a tree in Isaac Newton's garden, and they have traveled and camped in most of the United States.

Stuart Field has been interested in science and technology his whole life. While in school he built telescopes, electronic circuits, and computers. After attending Stanford University, he earned a Ph.D. at the University of Chicago, where he studied the properties of materials at ultralow temperatures. After completing a postdoctoral position at the Massachusetts Institute of Technology, he held a faculty position at the University of Michigan. Currently at Colorado State University, Stuart teaches a variety of physics courses, including algebra-based introductory physics, and was an early and enthusiastic adopter of Knight's *Physics for Scientists and Engineers.* Stuart maintains an active research program in the area of superconductivity. His hobbies include woodworking; enjoying Colorado's great outdoors; and ice hockey, where he plays goalie for a local team.

BUILDS PROBLEM-SOLVING SKILLS AND CONFIDENCE

Clear, consistent instruction

Build confidence and success through a consistent three-step approach: **Prepare** the problem, try to **Solve** it, and **Assess** the answer.

PROBLEM-SOLVING STRATEGY 24.1 Magnetic field problems MP™

PREPARE Because current-carrying wires do not lie in the same plane as the fields they produce, you'll need to prepare an especially careful drawing. Generally, you should choose the plane of your drawing so that the magnetic field vectors lie either in the plane of the paper or perpendicular to it.

- Straight wires are usually easiest to draw as seen from their ends. Then the field vectors will lie in the plane of the paper.
- Us...
- Sol...
- If t... tha... can...

SOLVE ... noid) ... field ... noid. ...

ASSES...

Topic-specific ***Problem-Solving Strategies*** follow the same three-step framework and provide more detailed guidance.

1. **PREPARE** reinforces the value of gathering information, drawing figures, making assumptions, and planning—key steps that research shows are often skipped.
2. **SOLVE** carefully works through the mathematical steps of the solution, explaining algebraic manipulations and use of key information.
3. **ASSESS** verifies whether the answer makes sense—numerically and in context.

PROBLEM-SOLVING STRATEGY 9.1 Conservation of momentum problems MP™

1 → **PREPARE** Clearly define *the system.*

- If possible, choose a system that is isolated ($\vec{F}_{net} = \vec{0}$) or within which the interactions are sufficiently short and intense that you can ignore external forces for the duration of the interaction (the impulse approximation). Momentum is then conserved.
- If it's not possible to choose an isolated system, try to divide the problem into parts such that momentum is conserved during one segment of the motion. Other segments of the motion can be analyzed using Newton's laws or, as you'll learn in Chapter 10, conservation of energy.

Following Tactics Box 9.1, draw a before-and-after visual overview. Define symbols that will be used in the problem, list known values, and identify what you're trying to find.

2 → **SOLVE** The mathematical representation is based on the law of conservation of momentum: $\vec{P}_f = \vec{P}_i$. In component form, this is

$$(p_{1x})_f + (p_{2x})_f + (p_{3x})_f + \cdots = (p_{1x})_i + (p_{2x})_i + (p_{3x})_i + \cdots$$
$$(p_{1y})_f + (p_{2y})_f + (p_{3y})_f + \cdots = (p_{1y})_i + (p_{2y})_i + (p_{3y})_i + \cdots$$

3 → **ASSESS** Check that your result has the correct units, is reasonable, and answers the question.

Exercise 20

TACTICS BOX 4.3 Drawing a free-body diagram MP™

1. **Identify all forces acting on the object.** This step was described in Tactics Box 4.2.
2. **Draw a coordinate system.** Use the axes defined in your pictorial representation (Tactics Box 2.2). If those axes are tilted, for motion along an incline, then the axes of the free-body diagram should be similarly tilted.
3. **Represent the object as a dot at the origin of the coordinate axes.** This is the particle model.
4. **Draw v**... describe...
5. **Draw a**... gram, n... $\vec{F}_{net}$ poin... diagram...

TACTICS BOX 24.1 Right-hand rule for fields MP™

1. Point your *right* thumb in the direction of the current.
2. Curl your fingers around the wire to indicate a circle.
3. Your fingers point in the direction of the magnetic field lines around the wire.

Exercises 5–10

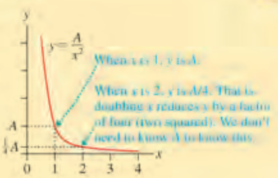
Tactics Boxes provide step-by-step procedures that build key skills that will be used over and over—such as drawing free-body diagrams and using ray tracing.

Inverse-square relationships MP™

Two quantities have an **inverse-square relationship** if y is inversely proportional to the *square* of x. We write the mathematical relationship as:

$$y = \frac{A}{x^2}$$

y is inversely proportional to x^2.



SCALING Inverse-square scaling means, for example:

- If you double x, you decrease y by a factor of 4, as you can see in the graph.
- If you increase x by a factor of 3, you decrease y by a factor of 9.
- If you decrease x by a factor of 3, you increase y by a factor of 9.

Generally: **An *increase* in x by a factor C results in a *decrease* of y by a factor C^2.**

LIMITS As x becomes large, y becomes very small; as x becomes small, y becomes very large.

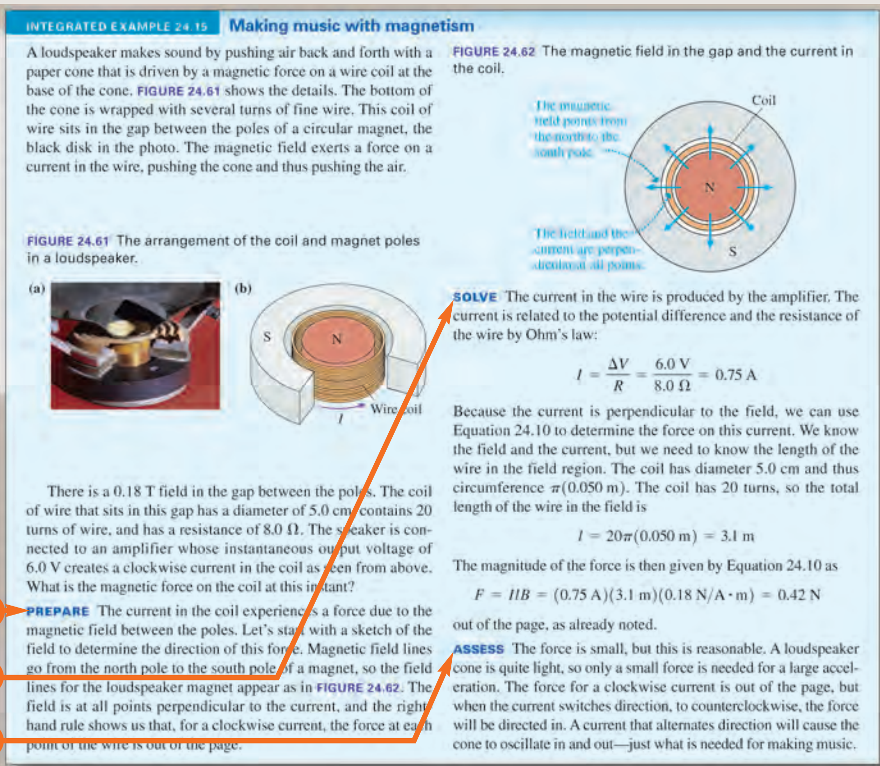
Exercise 23

Math Relationship Boxes ensure confidence with the key mathematical relationships most common in this course. Each relationship is consolidated in words, math, and graphics, along with tips on reasoning with limiting cases and scaling. Icons in the text refer back to these boxes to reinforce connections.

Explicit, guided practice

Worked Examples implement the Strategies and follow the same **PREPARE/SOLVE/ASSESS** framework as part of developing good problem-solving habits. They carefully walk through the underlying reasoning and pitfalls to avoid.

Integrated Examples at the end of each chapter demonstrate problem-solving in the context of a capstone, multi-concept real-world scenario.



INTEGRATED EXAMPLE 24.15 Making music with magnetism

A loudspeaker makes sound by pushing air back and forth with a paper cone that is driven by a magnetic force on a wire coil at the base of the cone. **FIGURE 24.61** shows the details. The bottom of the cone is wrapped with several turns of fine wire. This coil of wire sits in the gap between the poles of a circular magnet, the black disk in the photo. The magnetic field exerts a force on a current in the wire, pushing the cone and thus pushing the air.

FIGURE 24.61 The arrangement of the coil and magnet poles in a loudspeaker.

There is a 0.18 T field in the gap between the poles. The coil of wire that sits in this gap has a diameter of 5.0 cm, contains 20 turns of wire, and has a resistance of 8.0 Ω. The speaker is connected to an amplifier whose instantaneous output voltage of 6.0 V creates a clockwise current in the coil as seen from above. What is the magnetic force on the coil at this instant?

PREPARE The current in the coil experiences a force due to the magnetic field between the poles. Let's start with a sketch of the field to determine the direction of this force. Magnetic field lines go from the north pole to the south pole of a magnet, so the field lines for the loudspeaker magnet appear as in **FIGURE 24.62**. The field is at all points perpendicular to the current, and the right-hand rule shows us that, for a clockwise current, the force at each point of the wire is out of the page.

FIGURE 24.62 The magnetic field in the gap and the current in the coil.

SOLVE The current in the wire is produced by the amplifier. The current is related to the potential difference and the resistance of the wire by Ohm's law:

$$I = \frac{\Delta V}{R} = \frac{6.0\ \text{V}}{8.0\ \Omega} = 0.75\ \text{A}$$

Because the current is perpendicular to the field, we can use Equation 24.10 to determine the force on this current. We know the field and the current, but we need to know the length of the wire in the field region. The coil has diameter 5.0 cm and thus circumference $\pi(0.050\ \text{m})$. The coil has 20 turns, so the total length of the wire in the field is

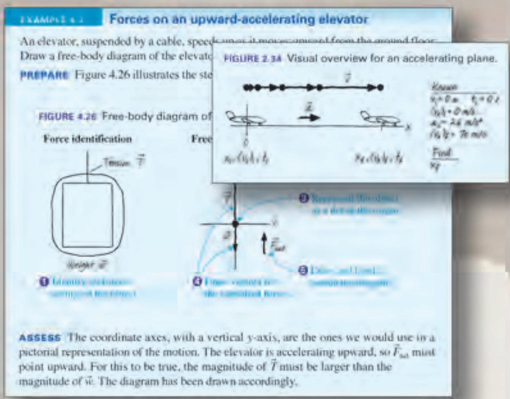
$$L = 20\pi(0.050\ \text{m}) = 3.1\ \text{m}$$

The magnitude of the force is then given by Equation 24.10 as

$$F = ILB = (0.75\ \text{A})(3.1\ \text{m})(0.18\ \text{N/A}\cdot\text{m}) = 0.42\ \text{N}$$

out of the page, as already noted.

ASSESS The force is small, but this is reasonable. A loudspeaker cone is quite light, so only a small force is needed for a large acceleration. The force for a clockwise current is out of the page, but when the current switches direction, to counterclockwise, the force will be directed in. A current that alternates direction will cause the cone to oscillate in and out—just what is needed for making music.



EXAMPLE 4.3 Forces on an upward-accelerating elevator

An elevator, suspended by a cable, speeds up as it moves upward from the ground floor. Draw a free-body diagram of the elevator.

PREPARE Figure 4.26 illustrates the steps.

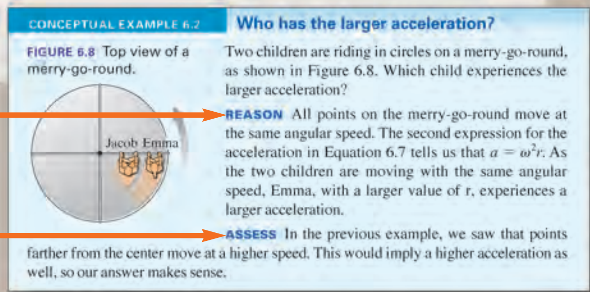
FIGURE 4.26 Free-body diagram of ...

FIGURE 2.34 Visual overview for an accelerating plane.

ASSESS The coordinate axes, with a vertical y-axis, are the ones we would use in a pictorial representation of the motion. The elevator is accelerating upward, so $\vec{F}_{net}$ must point upward. For this to be true, the magnitude of $\vec{T}$ must be larger than the magnitude of $\vec{w}$. The diagram has been drawn accordingly.

Pencil Sketches provide an explicit and accessible example of what to draw in solving a problem—steps often outlined in the Tactic Boxes.

Conceptual Examples target qualitative reasoning skills. Since no math is involved, they follow a **REASON** and **ASSESS** approach.



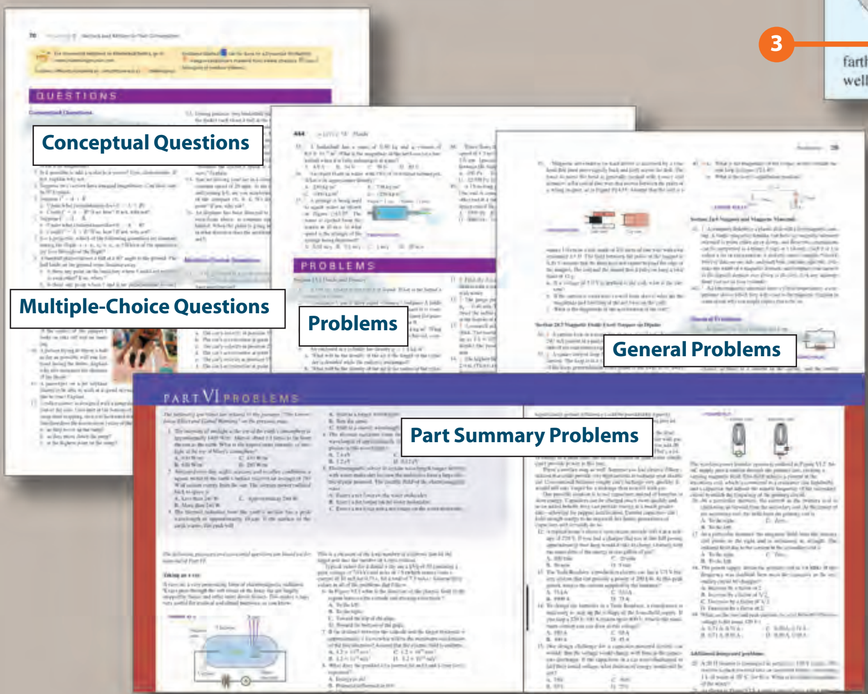
CONCEPTUAL EXAMPLE 6.2 Who has the larger acceleration?

FIGURE 6.8 Top view of a merry-go-round.

Two children are riding in circles on a merry-go-round, as shown in Figure 6.8. Which child experiences the larger acceleration?

REASON All points on the merry-go-round move at the same angular speed. The second expression for the centripetal acceleration in Equation 6.7 tells us that $a = \omega^2 r$. As the two children are moving with the same angular speed, Emma, with a larger value of r, experiences a larger acceleration.

ASSESS In the previous example, we saw that points farther from the center move at a higher speed. This would imply a higher acceleration as well, so our answer makes sense.



Conceptual Questions require thoughtful reasoning and can be used for group discussions or individual work. ***Multiple-Choice Questions*** use carefully chosen distractors to elicit common misconceptions. ***Problems***, are keyed to sections and draw on real-world applications to provide motivational examples. More advanced ***General Problems*** require the simplification and modeling of more complex real-world situations. ***Part Summary Problems*** close each of the book's seven parts and take problem-solving one step further by covering topics that span several chapters.

INTEGRATES INTERESTING AND RELEVANT TOPICS

An active, inductive approach

Drawn from various fields of study and the world around us, relevant examples and interesting topics are carefully woven into the text. These provide motivation, a means to consolidate understanding, and a clear context for understanding physics.

New concepts are introduced through observations about the real world, an inductive approach shown to improve learning (see the magnetism introduction in the sample chapter that follows).

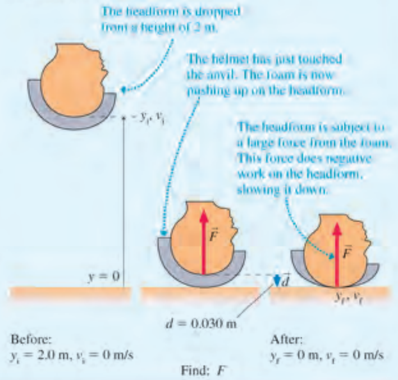
Worked Examples incorporate scenarios from everyday life and the world around us.

EXAMPLE 10.13 Protecting your head

A bike helmet is basically a shell of hard, crushable foam 3.0 cm thick. In testing, the helmet is strapped onto a 5.0 kg headform that is dropped from a height of 2.0 m onto a hard anvil. What force is encountered by the head in such a fall?

PREPARE A visual overview of the test is shown in Figure 10.31. We can use the law of conservation of en-ergy,

FIGURE 10.31 The foam in the helmet does negative work on the headform.

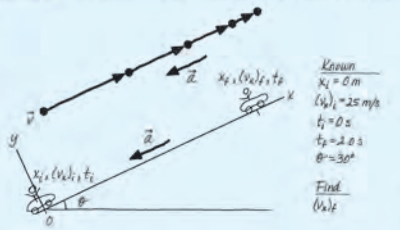


EXAMPLE 3.8 Speed of a roller coaster

A classic wooden coaster has cars that go down a big first hill, gaining speed. The cars then ascend a second hill with a slope of 30°. If the cars are going 25 m/s at the bottom and it takes them 2.0 s to climb this hill, how fast are they going at the top?

PREPARE We start with the visual overview in Figure 3.24, which includes a motion diagram, a pictorial representation, and a list of values. Notice how the motion diagram of Figure 3.24 differs from that of the previous example: The velocity decreases as the car moves up the hill, so the acceleration vector is opposite the direction of the velocity vector. The motion is along the x-axis, as before, but the acceleration vector points in the negative-x direction, so the component a_x is negative.

FIGURE 3.24 The coaster's speed decreases as it goes up the hill.



SOLVE To determine the final speed, we need to know the acceleration. We will assume that there is no friction or air resistance.

Free-standing Applications, found in the margin with photographs and a self-contained caption, connect the physical principles with the real world.

Taking a picture in a flash When you take a flash picture, the flash is fired using electric potential energy stored in a capacitor. Batteries are unable to deliver the required energy rapidly enough, but capacitors can discharge all their energy in only microseconds. A battery is used to slowly charge up the capacitor, which then rapidly discharges through the flashlamp. This slow recharging process is why you must wait some time between taking flash pictures.

TRY IT YOURSELF

Getting the ketchup out The ketchup stuck at the bottom of the bottle is initially at rest. If you hit the bottom of the bottle, the bottle suddenly moves down, taking the ketchup on the bottom of the bottle with it, so that the ketchup just stays stuck to the bottom. But if instead you hit *up* on the bottle, as shown, you force the bottle rapidly upward. By the first law, the ketchup that was stuck to the bottom stays at rest, so it separates from the upward-moving bottle: the ketchup has moved forward with respect to the bottle!

TRY IT YOURSELF

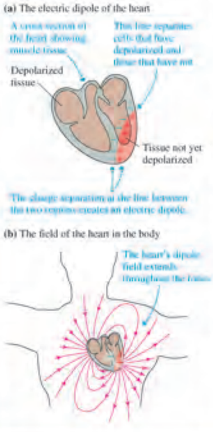
Buzzing magnets You can use two *identical* flexible refrigerator magnets for a nice demonstration of their alternating pole structure. Place the two magnets together, back to back, then quickly pull them across each other, noting the alternating attraction and repulsion from the alternating poles. If you pull them quickly enough, you will hear a buzz as the magnets are rapidly pushed apart and then pulled together.

Try It Yourself Activities throughout the text provide simple real-world experiments designed to quickly reinforce a key idea through direct experience.

Engaging treatment

Optional sections provide **in-depth coverage of key topics—**such as electrical conduction in the nervous system, the workings of an EKG, and how to correctly measure blood pressure.

FIGURE 20.35 The beating heart generates a dipole electric field.



- The electric field is created by charges. Field lines start on a positive charge and end on a negative charge.

You can use the above information as the basis of a technique for sketching a field line picture for an arrangement of charges. Draw field lines starting on positive charges and moving toward negative charges. Draw the lines tangent to the field vector at each point. Make the lines close together where the field is strong, far apart where the field is weak. For example, Figure 20.34 pictures the electric field of a dipole using electric field lines. You should compare this to Figure 20.29b, which illustrated the field with field vectors.

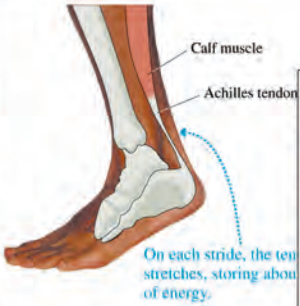
The Electric Field of the Heart

Nerve and muscle cells have a prominent electrical nature. As we will see in detail in Chapter 23, a cell membrane is an insulator that encloses a conducting fluid and is surrounded by conducting fluid. While resting, the membrane is *polarized* with positive charges on the outside of the cell, negative charges on the inside. When a nerve or a muscle cell is stimulated, the polarity of the membrane switches; we say that the cell *depolarizes*. Later, when the charge balance is restored, we say that the cell *repolarizes*.

All nerve and muscle cells generate an electrical signal when depolarization occurs, but the largest electrical signal in the body comes from the heart. The rhythmic beating of the heart is produced by a highly coordinated wave of depolarization that sweeps across the tissue of the heart. As Figure 20.35a shows, the surface of the heart is positive on one side of the boundary between tissue that is depolarized and tissue that is not yet depolarized, negative on the other. In other words, the heart is a large electric dipole. The orientation and strength of the dipole change during each beat of the heart as the depolarization wave sweeps across it.

The electric dipole of the heart generates a dipole electric field that extends throughout the torso, as shown in Figure 20.35b. As we will see in Chapter 21, an *electrocardiogram* measures the changing electric field of the heart as it beats. Measurement of the heart's electric field can be used to diagnose the operation of the heart.

Magnetotactic bacteria BIO Several organisms use the earth's magnetic field navigate. The clearest example of this is *magnetotactic bacteria*. The dark dots in image are small pieces of iron; each piec single domain and hence a very strong ma Such a bacterium possesses a very strong magnetic moment: The bacterium itself like a bar magnet, and lines up with the earth's magnetic field. In the temperate regions where such bacteria live, the earth field has a large vertical component. The bacteria use their alignment with this ver field component to navigate up and dow



Spring in your step BIO As you run, yo lose some of your mechanical energy eac time your foot strikes the ground; this en is transformed into unrecoverable therma energy. Luckily, about 35% of the decrea your mechanical energy when your foot is stored as elastic potential energy in the stretchable Achilles tendon of the lower On each plant of the foot the tendon is stretched, storing some energy. The tend springs back as you push off the ground again, helping to propel you forward. Th recovered energy reduces the amount of internal chemical energy you use, increasing your efficiency.

Dinner at a distance BIO A chameleon's tongue is a powerful tool for catching prey. Certain species can extend the tongue to a distance of over 1 ft in less than 0.1 s! A study of the kinematics of the motion of the chameleon tongue, using techniques like those in this chapter, reveals that the tongue has a period of rapid acceleration followed by a period of constant velocity. This knowledge is a very valuable clue in the analysis of the evolutionary relationships between chameleons and other animals.

Fascinating, self-contained ***Life-science Applications*** throughout the text illustrate how physics relates to the real world.

Passage Problems

Kangaroo Locomotion BIO

Kangaroos have very stout tendons in their legs that can be used to store energy. When a kangaroo lands on its feet, the tendons stretch, transforming kinetic energy of motion to elastic potential energy. Much of this energy can be transformed back into kinetic energy as the kangaroo takes another hop. The kangaroo's peculiar hopping gait is not very efficient at low speeds but is quite efficient at high speeds.

Figure P11.61 shows the energy cost of human and kangaroo locomotion. The graph shows oxygen uptake (in mL/s) per kg of body mass, allowing a direct comparison between the two species.

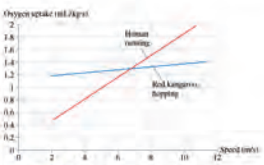


FIGURE P11.61 Oxygen uptake (a measure of energy use per second) for a running human and a hopping kangaroo.

For humans, the energy used per second (i.e., power) is proportional to the speed. That is, the human curve nearly passes through the origin, so running twice as fast takes approximately twice as much power. For a hopping kangaroo, the graph of energy use has only a very small slope. In other words, the energy used per second changes very little with speed. Going faster requires very little additional power. Treadmill tests on kangaroos and observations in the wild have shown that they do not become winded at any speed at which they are able to hop. No matter how fast they hop, the necessary power is approximately the same.

61. | A person runs 1 km. How does his speed affect the total energy needed to cover this distance?
    A. A faster speed requires less total energy.
    B. A faster speed requires more total energy.
    C. The total energy is about the same for a fast speed and a slow speed.
62. | A kangaroo hops 1 km. How does its speed affect the total energy needed to cover this distance?
    A. A faster speed requires less total energy.
    B. A faster speed requires more total energy.
    C. The total energy is about the same for a fast speed and a slow speed.
63. | At a speed of 4 m/s,
    A. A running human is more efficient than an equal-mass hopping kangaroo.
    B. A running human is less efficient than an equal-mass hopping kangaroo.
    C. A running human and an equal-mass hopping kangaroo have about the same efficiency.
64. | At approximately what speed would a human use half the power of an equal-mass kangaroo moving at the same speed?
    A. 3 m/s B. 4 m/s C. 5 m/s D. 6 m/s
65. | At approximately what speed would a human use twice the power of a kangaroo of half the mass moving at the same speed?
    A. 3 m/s B. 5 m/s C. 7 m/s D. 9 m/s

Multiple-choice and Passage Problems carefully test understanding by targeting common misconceptions and providing context-rich situations.

PROMOTES DEEPER UNDERSTANDING

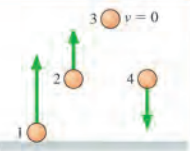
Structured learning path

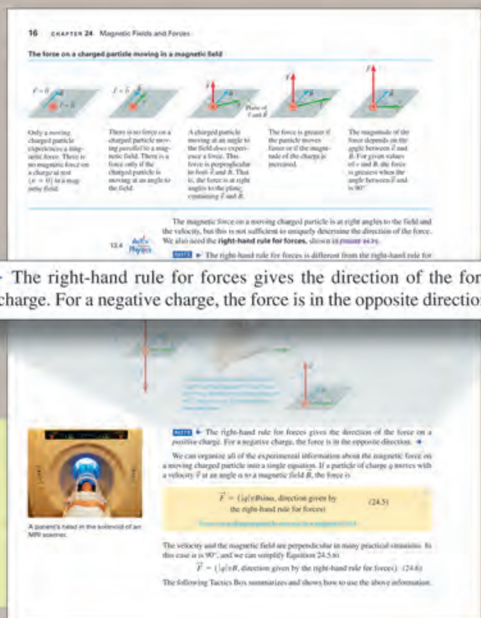
This text incorporates many subtle but powerful techniques that improve learning and retention, including a self-evident and structured learning path and a unique visual pedagogy.

Chapter Previews are based on the educational psychology concept of an "advance organizer." Each chapter begins with an illustrated preview of the upcoming ideas, setting them in context, explaining their utility, and tying them to existing knowledge (through ***Looking Back*** references).

Stop to Think Questions at the end of a section allow for a quick comprehension check before moving on. Using powerful ranking-task and graphical techniques, they efficiently probe key misconceptions and encourage active reading. (Answers are provided at the end of the chapter.)

STOP TO THINK 10.4 Rank in order, from largest to smallest, the gravitational potential energies of identical balls 1 to 4.





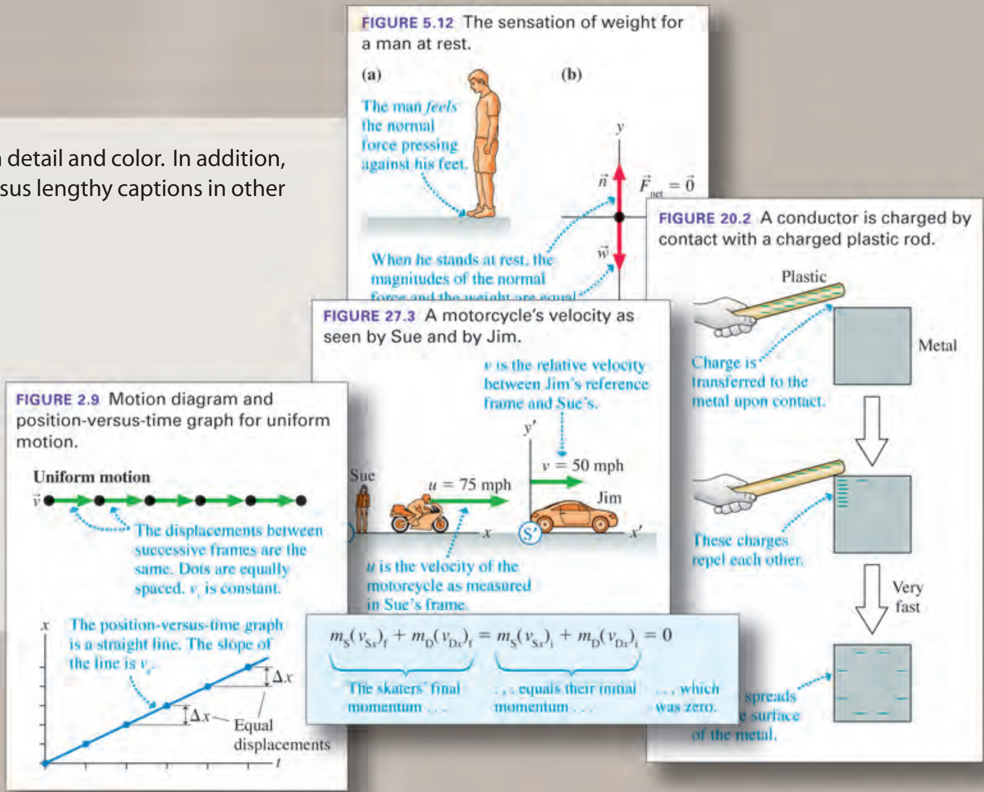
NOTE ► The right-hand rule for forces gives the direction of the force on a *positive* charge. For a negative charge, the force is in the opposite direction. ◄

NOTE Paragraphs point out common misconception, common sticking points, and highlight math-related issues that may cause difficulties.

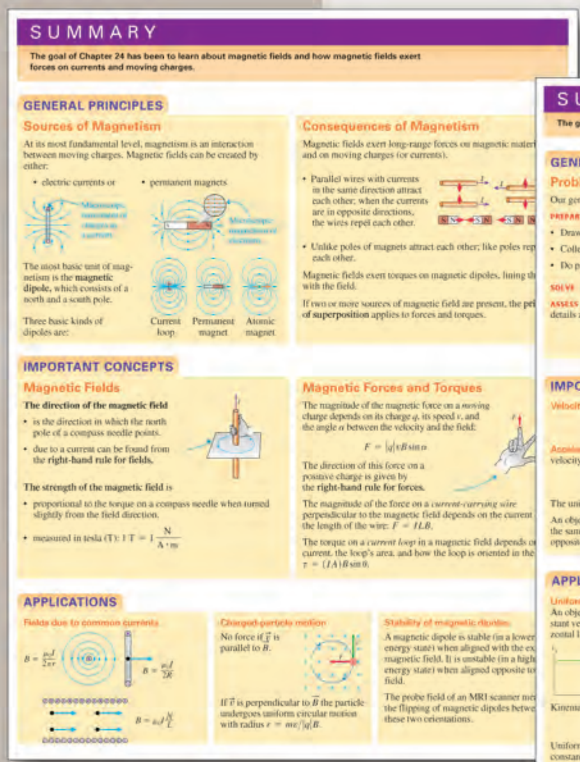
Proven visual pedagogy

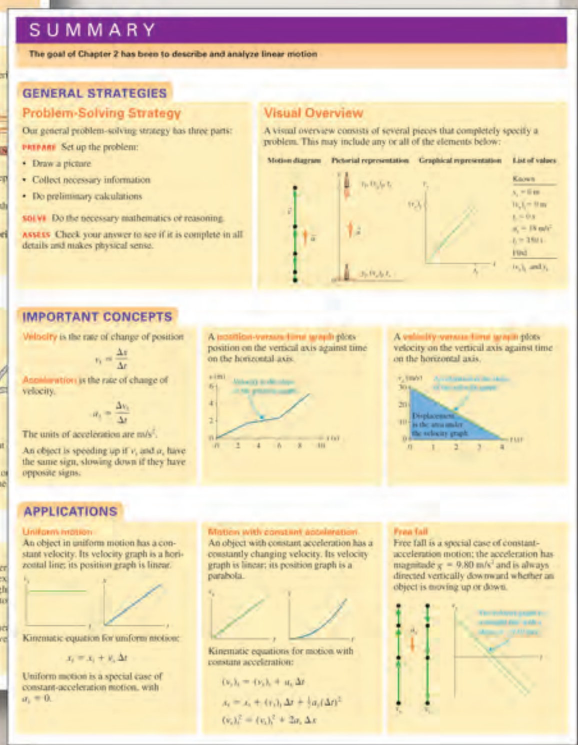
Figures are carefully streamlined in detail and color. In addition, chalkboard-like dialogue boxes (versus lengthy captions in other textbooks) are effectively used in:

- interpreting a graph, equation, or figure
- understanding a process
- translating between text, math, graphs, and figures
- grasping a difficult concept through a visual analogy



Critically acclaimed ***Visual Chapter Summaries*** consolidate understanding by providing each concept in words, math, and figures and organizing these into a coherent hierarchy—from General Principles to Applications.





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MasteringPhysics is the most effective and widely used online science tutorial, homework, and assessment system available.

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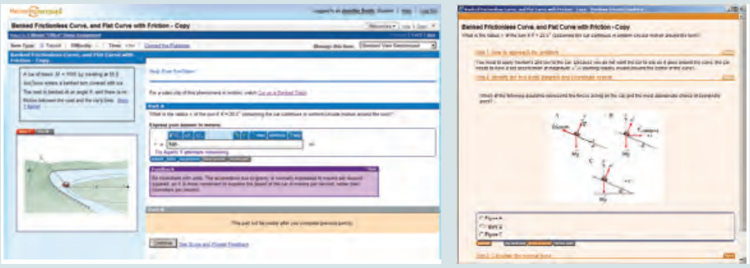
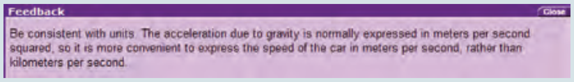
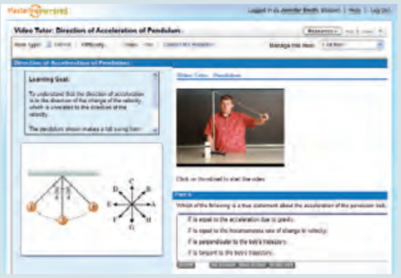
Self-Paced, Individualized Coaching

For every chapter of the book, MasteringPhysics® provides assignable, in-depth tutorials designed to coach students with hints and feedback specific to their misconceptions.

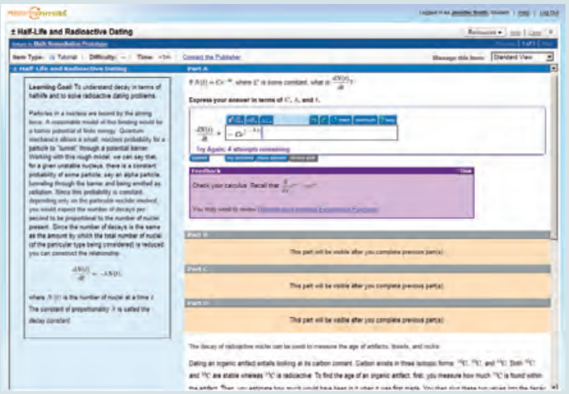






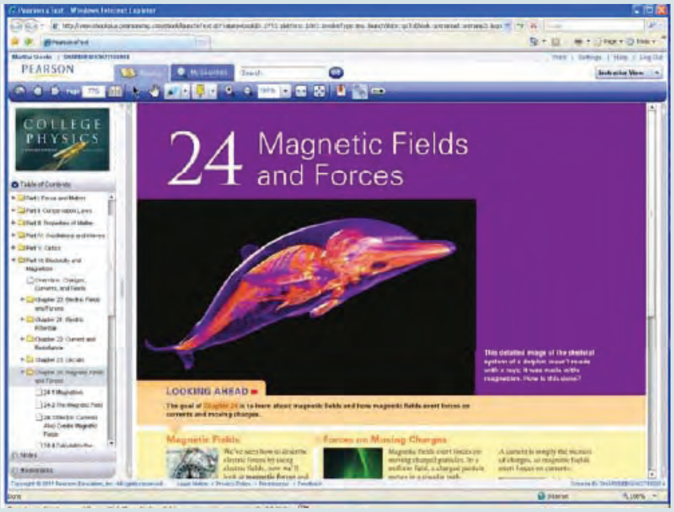
Bring Physics to Life with Dynamic Visuals

Video tutor demonstration and PhET simulations help students connect physics concepts to physics in the real world.



Get Up to Speed on Math

Math remediation found within selected tutorials provide just-in-time math help, allowing students to brush up on the most important concepts–while making connections between math and physics.

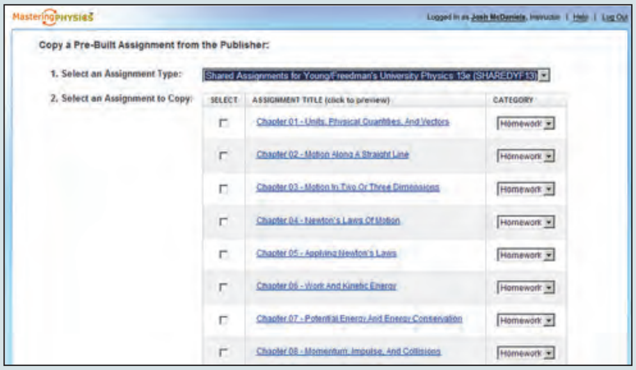


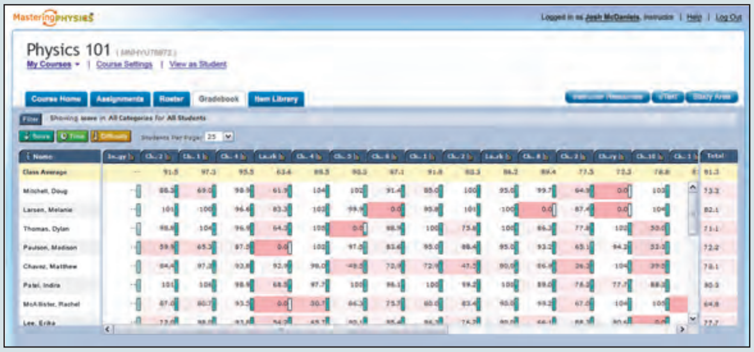
Access When You Need It

Access an interactive eText of the Student Edition 24/7. eText pages look exactly like the printed text, yet offer additional functionality.

NEW! Pre-Built Assignments

For every chapter in the book, MasteringPhysics now provides pre-built assignments that cover the material with a tested mix of tutorials and end-of-chapter problems of graded difficulty. Instructors may use these assignments as-is or take them as a starting point for modification.



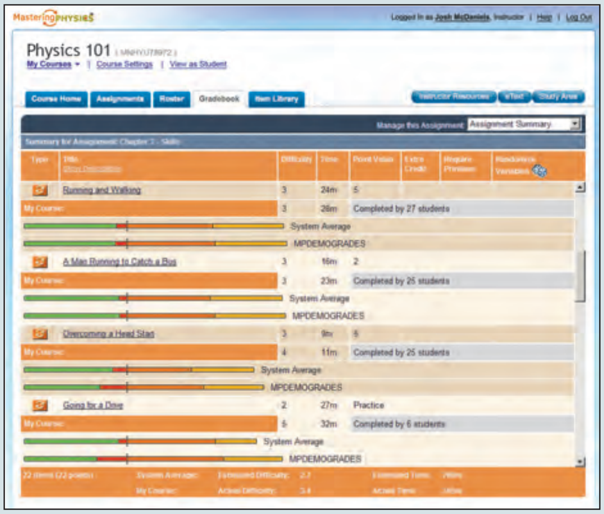


Gradebook

- Every assignment is graded automatically.
- Shades of red highlight vulnerable students and challenging assignments.

Class Performance on Assignment

Click on a problem to see which step your students struggled with most, and even their most common wrong answers. Compare results at every stage with the national average or with your previous class.



Gradebook Diagnostics

This screen provides your favorite weekly diagnostics. With a single click, charts summarize the most difficult problems, vulnerable students, grade distribution, and even improvement in scores over the course.

Preface to the AP* Edition

In 2006, we published *College Physics: A Strategic Approach*, a new algebra-based physics textbook for college students majoring in the biological and life sciences, architecture, natural resources, and other disciplines. Our goal from the beginning has been a textbook combining the best results from physics education research with inspiring photographs and examples connecting physics to the real world. Our commitment to this goal is undiminished, and with the publication of the AP* Edition of *College Physics: A Strategic Approach*, *2nd Edition*, we are pleased to provide both the motivation and the tools required for AP Physics B students to succeed in the classroom, on the AP UC Exam, and in college-level courses.

Objectives

Our primary goals in writing *College Physics: A Strategic Approach, AP* Edition* are:

- To provide students with a textbook that's a more manageable size, less encyclopedic in its coverage, and better designed for learning.
- To integrate proven techniques from physics education research into the classroom in a way that accommodates a range of teaching and learning styles.
- To help students develop both quantitative reasoning skills and solid conceptual understanding, with special focus on concepts well documented to cause learning difficulties.
- To help students develop problem-solving skills and confidence in a systematic manner using explicit and consistent tactics and strategies.
- To motivate students by integrating real-world examples relevant to their everyday experiences.
- To utilize proven techniques of visual instruction and design from educational research and cognitive psychology that improve student learning and retention and address a range of learner styles.

What's New to This Edition

This AP* Edition leverages the hallmarks of the First Edition—effective conceptual explanations and problem-solving instruction—with new pedagogical features. More than any other book, *College Physics* leads students to proficient and long-lasting problem-solving skills, a deeper and better-connected understanding of the concepts, and a broader picture of the relevance of physics to the world around them.

First and foremost, the content of the AP* Edition of *College Physics: A Strategic Approach*, *2nd Edition* is the same as the college edition—as all parties agree that AP Physics is a college-level course, and as such, its content and rigor should match the college offering. So, you ask, how is the AP* Edition different from the college edition?

- The front matter of the AP* Edition includes a detailed topic guide that correlates the Second Edition content to the current College Board AP Physics B curriculum guidelines (pp. xix–xxi). It also includes a comprehensive listing of all print and media supplements for AP students and teachers (pp. xvi–xvii).
- The AP* Edition of *College Physics: A Strategic Approach, 2nd Edition* includes multi-year access to **MasteringPhysics® with Pearson eText**—a next-generation, one-source learning and assessment system.
- The AP* Edition has a reinforced binding, which meets NASTA requirements, to withstand multiple years of high school use.
- New illustrated **Chapter Previews** at the start of each chapter provide visual, hierarchical, and non-technical previews proven to help students organize their thinking and improve their understanding of the upcoming material.
- New **Integrated Examples** at the end of each chapter give students additional help in solving general problems not tied to particular sections. Many integrate material from other chapters.
- New **Part Summary Problems** at the end of each of the seven parts of the book test students' abilities to draw on concepts and techniques from multiple chapters.
- **More streamlined presentations** throughout the text. Based on extensive feedback, we've pared some topics, reconfigured others, and provided a more readable, student-friendly text.
- **Improved and more varied end-of-chapter problems.** Using data from MasteringPhysics, we have reworked the problem sets to enhance clarity, topic coverage, and variety—adding, in particular, more problems based on real-world situations and more problems using ratio reasoning.

The more significant content changes include:

- The treatment of Newton's third law in Chapters 4 and 5 has been better focused on the types of problems that students will be asked to solve.
- Angular position and angular velocity are now developed together in Chapter 6, rather then being divided between Chapters 3 and 6. More emphasis has been given to angular position and angular velocity graphs, emphasizing the analogy with the linear position and velocity graphs of Chapter 2.
- The Chapter 10 presentation of work and energy has been streamlined and clarified. The problem-solving strategy for conservation of energy problems now plays a more prominent role.
- Chapter 11, Using Energy, is now more focused on concrete applications of energy use. All discussions of thermal properties have matter have been moved to Chapter 12, which has been reorganized to emphasize the single theme, "What happens to matter when you heat or cool it?"
- The ordering of topics within Chapters 18 and 19 has been revised. Ray tracing and the thin-lens equation are now paired together in Chapter 18; the pinhole camera and color/dispersion have moved to Chapter 19.
- Chapter 21 has been significantly rewritten to make the difficult idea of electric potential more concrete and usable.
- The section on household electricity has been moved from Chapter 23 to Chapter 26. Chapter 23 is now better focused on resistors and capacitors while Chapter 26, AC Circuits, has become a more practical chapter with sections on household electricity and electrical safety.
- Chapters 28–30 on quantum, atomic, and nuclear physics have been significantly streamlined in the hope that more instructors will be able to teach these important topics.

Textbook Organization

College Physics: A Strategic Approach is a 30-chapter text intended for use in a full-year AP Physics B course. The textbook is divided into seven parts: Part I: *Force and Motion*, Part II: *Conservation Laws*, Part III: *Properties of Matter*, Part IV: *Oscillations and Waves*, Part V: *Optics*, Part VI: *Electricity and Magnetism*, and Part VII: *Modern Physics*.

Part I covers Newton's laws and their applications. The coverage of two fundamental conserved quantities, momentum and energy, is in Part II, for two reasons. First, the way that problems are solved using conservation laws—comparing an *after* situation to a *before* situation—differs fundamentally from the problem-solving strategies used in Newtonian dynamics. Second, the concept of energy has a significance far beyond mechanical (kinetic and potential) energies. In particular, the key idea in thermodynamics is energy, and moving from the study of energy in Part II into thermal physics in Part III allows the uninterrupted development of this important idea.

Optics (Part V) is covered directly after oscillations and waves (Part IV), but *before* electricity and magnetism (Part VI). Further, we treat wave optics before ray optics. Our motivations for this organization are twofold. First, wave optics is largely just an extension of the general ideas of waves; in a more traditional organization, students will have forgotten much of what they learned about waves by the time they get to wave optics. Second, optics as it is presented in introductory physics makes no use of the properties of electromagnetic fields. The documented difficulties that students have with optics are difficulties with waves, not difficulties with electricity and magnetism. There's little reason other than historical tradition to delay optics. However, the optics chapters are easily deferred until after Part VI for instructors who prefer that ordering of topics.

AP Teacher Supplements

NOTE ► For convenience, all of the following teacher supplements (except for the Instructor Resource DVD) can be downloaded from the "Instructor Resources" area within MasteringPhysics (www.masteringphysics.com). In addition, many of the teacher supplements and resources for this text are available electronically to qualified adopters on the Instructor Resource Center (IRC). Upon adoption or to preview, please go to www.PearsonSchool.com/Access_Request and select "Instructor Resource Center." You will be required to complete a brief one-time registration. Upon verification of educator status, access information and instructions will be sent to you via email. Once logged into the IRC, enter your text ISBN in the "Search Our Catalog" box to locate your resources. ◄

- The **Instructor Guide** provides chapter-by-chapter creative ideas and teaching tips. In addition, it contains an extensive review of what has been learned from physics education research, and provides guidelines for using active-learning techniques.
- The **Instructor Solutions Manual,** provides *complete* solutions to all the end-of-chapter questions and problems. All solutions follow the Prepare/Solve/Assess problem-solving strategy used in the textbook for quantitative problems, and Reason/ Assess strategy for qualitative ones.

MasteringPhysics® (www.masteringphysics.com) is a homework, tutorial, and assessment system designed to assign, assess, and track each student's progress using a wide diversity of tutorials and extensively pre-tested problems. In addition to the textbook's end-of-chapter and new end-of-part problems, MasteringPhysics for *College Physics, Second Edition*, also includes author-selected prebuilt assignments, specific tutorials for all the textbook's Problem-Solving Strategies, Tactics Boxes, and Math Relationship boxes, as well as Reading Quizzes and Test Bank questions for each chapter.

MasteringPhysics provides instructors with a fast and effective way to assign uncompromising, wide-ranging online homework assignments of just the right difficulty and duration. The tutorials coach 90% of students to the correct answer with specific wrong-answer feedback. The powerful post-assignment diagnostics allow instructors to assess the progress of their class as a whole or to quickly identify individual student's areas of difficulty.

- Upon textbook purchase, students and teachers are granted access to MasteringPhysics®. High school teachers can obtain preview or adoption access for MasteringPhysics in one of the following ways:

Preview Access

- Teachers can request preview access online by visiting PearsonSchool.com/Access_Request (choose option 4). Preview Access information will be sent to the teacher via email.

Adoption Access

- A Pearson Adoption Access Card, with codes and complete instructions, will be delivered with your textbook purchase. (ISBN: 0-13-034391-9)
  OR
- Visit PearsonSchool.com/Access_Request (choose option 2/3). Adoption access information will be sent to the teacher via email.

- The cross-platform **Instructor Resource DVD** (ISBN 978-0-321-59628-4) provides invaluable and easy-to-use resources for your class, organized by textbook chapter. The contents include a comprehensive library of more than 220 applets from **ActivPhysics OnLine™,** as well as all figures, photos, tables, and summaries from the textbook in JPEG format. In addition, all the Problem-Solving Strategies, Math Relationships Boxes, Tactics Boxes, and Key Equations are provided in editable Word and JPEG formats. The **Instructor Guide** is also included as editable Word files, along with pdfs of answers to the **Student Workbook** exercises, and **Lecture Outlines (with Classroom Response System "Clicker" Questions)** in PowerPoint.
- The **Test Bank**, contains more than 2,000 high-quality problems, with a range of multiple-choice, true/false, short-answer, and regular homework-type questions. Test files are provided in both TestGen (an easy-to-use, fully networkable program for creating and editing quizzes and exams) and Word format, and can also be downloaded from the Instructor Resource Center.
- **ActivPhysics OnLine™** (accessed through the Self Study area within www.masteringphysics.com) provides a comprehensive library of more than 420 tried and tested *ActivPhysics* applets updated for web delivery using the latest online technologies. In addition, it provides a suite of highly regarded applet-based tutorials developed by education pioneers Professors Alan Van Heuvelen and Paul D'Alessandris. The *ActivPhysics* margin icon directs students to specific exercises that complement the textbook discussion.

  The online exercises are designed to encourage students to confront misconceptions, reason qualitatively about physical processes, experiment quantitatively, and learn to think critically. They cover all topics from mechanics to electricity and magnetism and from optics to modern physics. More than 220 applets from the *ActivPhysics OnLine* library are also available on the *Instructor Resource DVD*.

Student Supplements

(available for purchase)

- The **Student Workbooks** (Volume 1, Chapters 1–16, ISBN: 978-0-321-59632-1 and Volume 2, Chapters 17–30, ISBN: 978-0-321-59633-8) bridge the gap between textbook and homework problems. The workbook exercises, which are keyed to each section of the textbook, focus on developing specific skills ranging from identifying forces and drawing free-body diagrams to interpreting field diagrams.
- The **Student Solutions Manuals Chapters 1–16** (ISBN 978-0-321-59629-1) and **Chapters 17–30** (ISBN 978-0-321-59630-7), provide *detailed* solutions to more than half of the odd-numbered end-of-chapter problems. Following the problem-solving strategy presented in the text, thorough solutions are provided to carefully illustrate both the qualitative (Reason/Assess) and quantitative (Prepare/Solve/Assess) steps in the problem-solving process.
- **MasteringPhysics®** (www.masteringphysics.com) is a homework, tutorial, and assessment system based on years of research into how students work physics problems and precisely where they need help. Studies show that students who use MasteringPhysics significantly increase their final scores compared to hand-written homework. MasteringPhysics achieves this improvement by providing students with instantaneous feedback specific to their wrong answers, simpler sub-problems upon request when they get stuck, and partial credit for their method(s) used. This individualized, 24/7 Socratic tutoring is recommended by nine out of ten students to their peers as the most effective and time-efficient way to study.
- **Pearson eText** is available through MasteringPhysics. Allowing students access to the text wherever they have access to the Internet, Pearson eText comprises the full student text, including figures that can be enlarged for better viewing. Students are also able to pop up definitions and terms to help with vocabulary and the reading of the material, as well as take notes using the annotation feature at the top of each page.
- **ActivPhysics OnLine™** (accessed via www.masteringphysics.com), provides students with a suite of highly regarded applet-based tutorials. The *ActivPhysics* margin icons throughout the book direct students to specific exercises that complement the textbook discussion.

How to Succeed in AP Physics

The most incomprehensible thing about the universe is that it is comprehensible.
—Albert Einstein

What can you expect to learn in this course? Let's start by talking about what physics is. Physics is a way of thinking about the physical aspects of nature. Physics is not about "facts." It's far more focused on discovering *relationships* between facts and the *patterns* that exist in nature than on learning facts for their own sake. Our emphasis will be on thinking and reasoning. We are going to look for patterns and relationships in nature, develop the logic that relates different ideas, and search for the reasons *why* things happen as they do. Once we've figured out a pattern, a set of relationships, we'll look at applications to see where this understanding takes us.

Like any subject, physics is best learned by doing. "Doing physics" in this course means solving problems, applying what you have learned to answer questions at the end of the chapter. When you are given a homework assignment, you may find yourself tempted to simply solve the problems by thumbing through the text looking for a formula that seems like it will work. This isn't how to do physics—you want to learn to **reason**, not to "plug and chug."

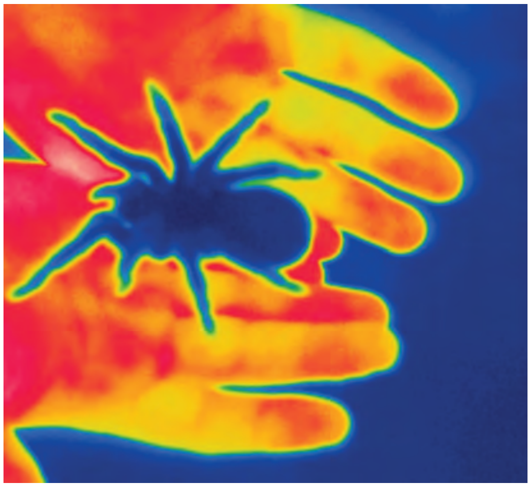
How do you learn to reason in this way? There's no single strategy for studying physics that will work for all students, but we can make some suggestions that will certainly help:

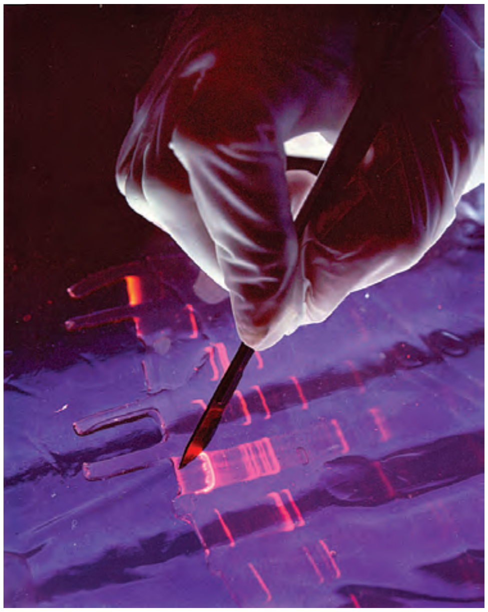
- **Read each chapter *before* it is discussed in class.** Class attendance is much less effective if you have not prepared. When you first read a chapter, focus on learning new vocabulary, definitions, and notation. You won't understand what's being discussed or how the ideas are being used if you don't know what the terms and symbols mean.
- **Participate actively in class.** Take notes, ask and answer questions, take part in discussion groups. There is ample scientific evidence that *active participation* is far more effective for learning science than is passive listening.
- **After class, go back for a careful rereading of the chapter.** In your second reading, pay close attention to the details and the worked examples. Look for the *logic* behind each example, not just at what formula is being used. We have a three-step process by which we solve all of the worked examples in the text. Most chapters have detailed Problem-Solving Strategies to help you see how to apply this procedure to particular topics, and Tactics Boxes that explain specific steps in your analysis.
- **Apply what you have learned to the homework problems at the end of each chapter.** By following the techniques of the worked examples, applying the tactics and problem-solving strategies, you'll learn how to apply the knowledge you are gaining. In short, you'll learn to reason like a physicist.
- **Form a study group with two or three classmates.** There's good evidence that students who study regularly with a group do better than the rugged individualists who try to go it alone.

And we have one final suggestion. As you read the book, take part in class, and work through problems, step back every now and then to appreciate the big picture. You are going to study topics that range from motions in the solar system to the electrical signals in the nervous system that let you order your hand to turn the pages of this book. You will learn quantitative methods to calculate things such as how far a car will move as it brakes to a stop and how to build a solenoid for an MRI machine. It's a remarkable breadth of topics and techniques that is based on a very compact set of organizing principles. It's quite remarkable, really, well worthy of your study.

Now, let's get down to work.

Detailed Contents





PART VII Modern Physics