

# BUILT FROM THE GROUND UP FOR MORE EFFECTIVE LEARNING

- An NSF-funded educational research program
- Input from an unprecedented 4,500 student
- Detailed reviews by 250 instructors

This is just some of the unusual history that shaped *Physics for Scientists and Engineers* by Randy Knight into the most widely adopted new physics text published in more than 30 years. In *College Physics: A Strategic Approach*, Randy Knight is joined by Brian Jones and Stuart Field to apply the best solutions from educational research to the algebra-based introductory physics course and the particular needs of these students.

Built from the ground up on a wealth of research into how students learn physics, and how they can be taught more effectively, *College Physics*:

- **builds** students' problem-solving abilities and confidence
- **integrates** relevant examples and interesting topics
- **promotes** deeper understanding by explicitly addressing students' preconceptions, misconceptions, and common stumbling-blocks
- **provides** a highly readable text and research-based visual pedagogy

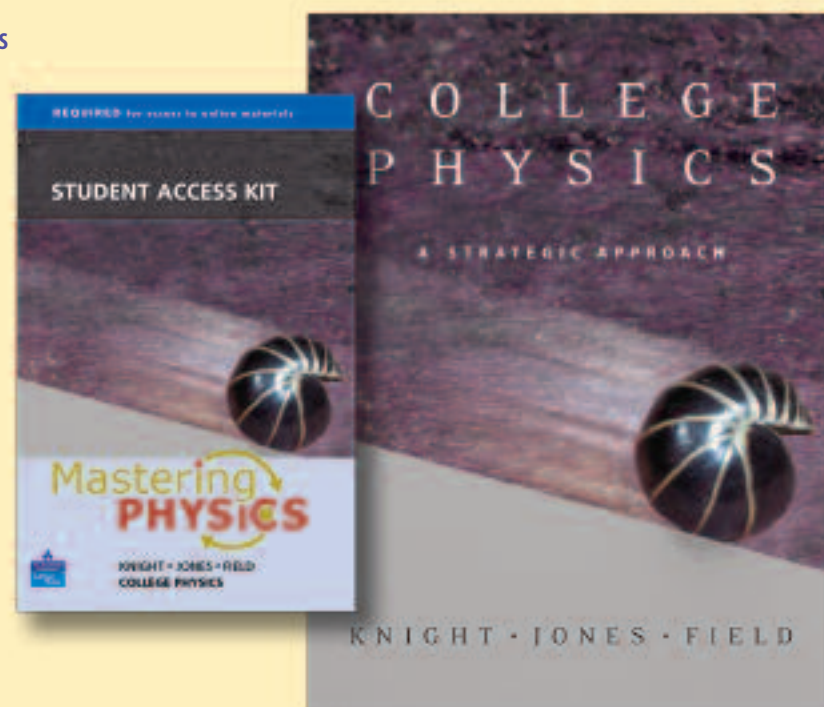
The following pages provide an overview of how *College Physics* is designed to achieve these goals based on input from thousands of students and hundreds of instructors to date.

"Visual pedagogy is a critical feature of physics textbooks because so much of physics is expressed in graphics. I am extremely impressed with the care and research-based ideas that have gone into the unique instructional design of the graphics in Knight's textbooks. His physics textbooks are leaders in applying research-based principles of visual pedagogy to support student learning."

—Richard E. Mayer, Professor of Psychology, University of California, Santa Barbara

"No text I have seen has done more to lead students to thinking than Knight/Jones/Field."

—Dieter R. Brill, University of Maryland



## Clear, consistent instruction

Students build confidence and success through a consistent 3-step approach that encourages them to **Prepare** the problem, before trying to **Solve it** and **Assess** their answer.

Topic-specific **Problem-Solving Strategies** follow the same 3-step framework and provide more detailed guidance.

- PREPARE** reinforces the value of gathering information, drawing figures, making assumptions, and planning—key steps research shows students otherwise skip.
- SOLVE** carefully works through the mathematical steps of the solution, explaining algebraic manipulations and use of key information.
- ASSESS** reminds the student to verify whether their answer makes sense—numerically and in context.

**Strategy 17-22: Drawing magnetic fields**

- Identify all forces acting on the object. This step was described in Tactics Box 4.2.
- Draw a coordinate system. Use the axes defined in your visual overview (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.
- Represent the object as a dot at the origin of the coordinate axes. This is the particle model.
- Draw a vector for each force.
- Draw a diagram to check that the forces add to zero.

**Strategy 7-12: Right-hand rule**

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

**Tactics Boxes** provide step-by-step procedures that build key skills the student will use over and over—such as drawing free-body diagrams, and using ray tracing.

**Math Relationship Boxes** ensure the student is confident 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 help students see connections in the math they use.

**Strategy 10.1: Magnetic field problems**

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.

- Strategy 10.1: Use the right-hand rule.
- Solve for the magnetic field.
- Make a before-and-after visual overview.

**Strategy 10.6: Conservation of energy problems**

Choose what to include in your system (see Tactics Box 10.1). Draw a before-and-after visual overview, as outlined in Tactics Box 9.1. Note known quantities, and determine what quantity you're trying to find. If the system is isolated and if there is no friction, your solution will be based on Equation 10.7, otherwise you should use Equation 10.6. Identify which mechanical energies in the system are changing:

- If the speed of the object is changing, include  $K_i$  and  $K_f$  in your solution.
- If the height of the object is changing, include  $(U_g)_i$  and  $(U_g)_f$ .
- If the length of a spring is changing, include  $(U_s)_i$  and  $(U_s)_f$ .
- If kinetic friction is present,  $\Delta E_{th}$  will be positive. Some kinetic or potential energy will be transformed into thermal energy.

If an external force acts on the system, you'll need to include the work  $W$  done by this force in Equation 10.6.

Depending on the problem, you'll need to calculate initial and/or final values of these energies and insert them into Equation 10.6 or 10.7. Then you can solve for the unknown energies, and from these any unknown speeds (from  $K$ ), positions (from  $U$ ), or displacements or forces (from  $W$ ).

Check the signs of your energies. Kinetic energy, as we'll see, is always positive. In the systems we'll study in this chapter, thermal energy can only increase, so that its change is positive. In Chapters 11 and 12 we'll study systems for which the thermal energy can decrease.

"The Prepare, Solve, and Assess steps are right on, not too many steps to confuse the students, but enough to thoroughly discuss the problem. The strategies are well thought-out and expertly executed."

—Toby Moleski, Muskegon Community College

**Strategy 14.10: Quadratic relationships**

Two quantities are said to have a **quadratic relationship** if  $y$  is proportional to the square of  $x$ . We write the mathematical relationship as  $y = Ax^2$ .

$y$  is a quadratic function of  $x$ .

The graph of a quadratic relationship is a parabola.

Suppose we double  $x$ :

$$x_f = 2x_i$$

This will change  $y$  as well:

$$y_f = Ax_f^2 = A(2x_i)^2 = 2^2Ax_i^2 = 2^2y_i = 4y_i$$

Increasing  $x$  by a factor of 2 causes  $y$  to increase by a factor of  $2^2$ , or 4. Generally, we can say that

Changing  $x$  by a factor  $C$  changes  $y$  by a factor  $C^2$ .

## 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 the student through the underlying reasoning and pitfalls to avoid.

**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.

Figure 4.26 illustrates the steps outlined in Tactics Box 4.3.

**Force identification:** Identify all forces acting on the object.

**Free-body diagram:** Draw a vector for each force. Draw a coordinate system. Represent the object as a dot at the origin. Draw and label  $\vec{F}_{net}$  beside the diagram.

**Pencil Sketches** provide students with an explicit and accessible example of what to draw in solving a problem—a key step research indicates students often skip—often following steps outlined in Tactics Boxes.

**Energy Worksheet**

**1. PREPARE**

**2. SOLVE**

**3. ASSESS**

**Example 2.4: Calculating the minimum length of a runway**

A fully-loaded 747 with all engines at full thrust accelerates at  $2.6 \text{ m/s}^2$ . Its minimum takeoff speed is  $70 \text{ m/s}$ . How much time will the plane take to reach its takeoff speed? What minimum length of runway does the plane require for takeoff?

**PREPARE** The visual overview of Figure 2.34 summarizes the important details of the problem. We set  $x_i$  and  $v_i$  equal to zero and the starting point of the motion, when the plane is at rest and the acceleration begins. The final point of the motion is when the plane achieves the necessary takeoff speed of  $70 \text{ m/s}$ . The plane is accelerating to the right, so we will compute the time for the plane to reach velocity of  $70 \text{ m/s}$  and the position of the plane at this time, giving us the minimum length of the runway.

**SOLVE** First we solve for the time required for the plane to reach takeoff speed. We can use the first equation in Table 2.4 to compute this time:

$$v_f = v_i + a \Delta t$$

$$70 \text{ m/s} = 0 \text{ m/s} + (2.6 \text{ m/s}^2) \Delta t$$

$$\Delta t = 26.9 \text{ s}$$

We keep an extra significant figure here as we will use this result in the next step of the calculation.

Given the time that the plane takes to reach takeoff speed, we can compute the position of the plane when it reaches this speed using the second equation in Table 2.4:

$$x_f = x_i + v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$= 0 \text{ m} + (0 \text{ m/s})(26.9 \text{ s}) + \frac{1}{2} (2.6 \text{ m/s}^2)(26.9 \text{ s})^2$$

$$= 940 \text{ m}$$

Our final answers are that the plane will take  $27 \text{ s}$  to reach takeoff speed, with a minimum runway length of  $940 \text{ m}$ .

**ASSESS** Think about the last time you flew:  $27 \text{ s}$  seems like a reasonable time for a plane to accelerate on takeoff. Actual runway lengths at major airports are  $3000 \text{ m}$  or more, a few times greater than the minimum length, because they have to allow for emergency stops during an aborted takeoff. (If we had calculated a distance greater than  $3000 \text{ m}$ , we would know we had done something wrong!)

**Conceptual Examples** target students' qualitative reasoning skills. Since no math is involved, they follow a Reason and Assess approach.

**Conceptual Example 34.1: Cancelling a magnetic field**

A current loop carries a counter-clockwise current of  $3 \text{ A}$ . A second current-carrying loop with twice the radius is placed outside the first loop, as shown in Figure 34.25. What current in the outer loop will exactly cancel the field in the center of the first loop?

**REASON** The inner loop produces a magnetic field at its center of magnitude  $B$ . By the right-hand rule for fields, the direction of this field is out of the page. To make the total field at the center zero, the outer loop must produce a field at the center that has the same magnitude  $B$  but pointing in the opposite direction, into the page. Equation 34.2 shows that the field at the center of a loop is inversely proportional to its radius. So if the outer loop also carried  $3 \text{ A}$ , its field at the center would be only  $B/2$ .

**CONCEPTUAL EXAMPLE 34.2: Energy transfers and the body**

Why—in physics terms—is it more tiring on the body to exercise in very hot weather?

**REASON** Your body continuously converts chemical energy to thermal energy, as we have seen. In order to maintain a constant body temperature, your body must continuously transfer heat to the environment. This is a simple matter in cool weather when heat is spontaneously transferred to the environment, but when the air temperature is higher than your body temperature, your body cannot cool itself this way and must use other mechanisms to transfer this energy, such as perspiring. These mechanisms require additional energy expenditure.

**ASSESS** Strenuous exercise in hot weather can easily lead to a rise in body temperature if the body cannot exhaust heat quickly enough.

The **Student Workbook** provides straightforward confidence- and skill-building exercises—bridging the gap between worked examples and end-of-chapter problems. Also included are worksheets—research-based templates that help students structure their approach to solving problems. Workbook activities are referenced throughout the text by .

# INTEGRATES INTERESTING AND RELEVANT TOPICS

## An active, inductive approach

Drawing from students' majors and the world around them, relevant examples and interesting topics are carefully woven into the text. These provide students with motivation, a means to consolidate their understanding, and a clear context for how physics is valuable to them.

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

### EXAMPLE 3.8 Speed of a roller coaster

A classic wooden roller coaster has cars that go down a big first hill, gaining speed. The cars then ascend a second hill with a slope of  $30^\circ$ . 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?



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

**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.

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

### 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, as in (a), 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 in (b), you force the bottle rapidly upward. By the first law, the ketchup that was stuck on the bottom stays at rest, so that it separates from the upward-moving bottle: the ketchup has moved forward with respect to the bottle!

### TRY IT YOURSELF



**Noisy magnets** The striped pole structure of neodymium magnets can be demonstrated by using two identical such magnets. Place them together, back to back, then pull them quickly across each other as shown by the arrows. The magnets alternately attract and repel as they bump past each other. If you pull them quickly enough, you will actually hear an audible tone as the rapidly passing magnets are alternately pulled together and pushed apart.

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

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

"The writing is clear and engaging. The coverage is well thought-out. *College Physics* is better than any other text I have encountered for algebra-based physics."

—Bruce A. Schumm, *University of California, Santa Cruz*

### EXAMPLE 10.11 Protecting your head

A bike helmet is basically a shell of foam, crushable from 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 text is shown in Figure 10.21. The foam inside a bike helmet is designed to crush upon

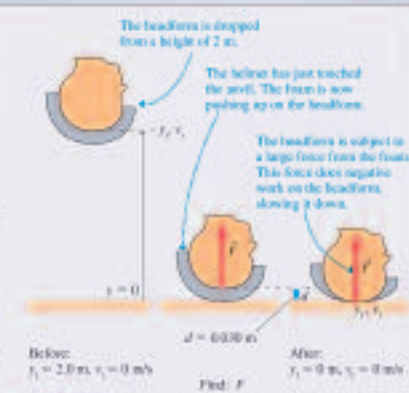


FIGURE 10.21 The foam in the helmet does negative work on the headform.



**Less of a drag** At the high speeds attained by racing cyclists, air drag can become very significant. The world record for the farthest distance traveled in one hour on an ordinary bicycle is 56.38 km, set by Chris Boardman in 1996. But a bicycle with an aerodynamic shell has a much lower drag force, allowing it to attain significantly higher speeds. The bike shown here was pedaled 84.22 km in one hour by Sam Whittingham in 2004, for an amazing average speed of 52.3 mph!

"Extremely readable and instructive."

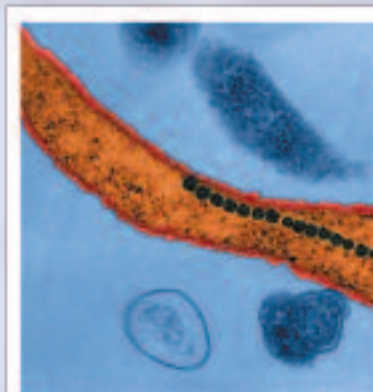
—Tiffany Landry, *Folsom Lake College*

## Engaging life-science students

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

"*College Physics* answers better than other texts I've seen the issues particular to teaching physics to life science students."

—Robert W. Lutz, *Drake University*



**Magnetotactic Bacteria** Several organisms use the earth's magnetic field to navigate. The clearest example of this is *magnetotactic bacteria*. The dark areas in this image are small pieces of iron; each piece is a single domain and hence a very strong magnet. Such a bacterium possesses a very strong magnetic moment: It acts like a bar magnet, lining up with the earth's magnetic field! In the temperate regions where such bacteria live, the earth's field has a large vertical component. The bacteria use their alignment with this vertical field component to navigate up and down.



**Spring in your step** As you run, some of your mechanical energy is lost when your foot strikes the ground; this energy is transformed into unrecoverable thermal energy. Luckily, about 35% of the deceleration energy is stored as elastic potential energy in the stretchable Achilles tendon of the foot. On each plant of the foot the tendon is stretched, storing some energy. The tendon springs back as you push off the ground again, helping to propel you forward. The recovered energy reduces the amount of internal chemical energy you use, increasing your efficiency.



**Dinner at a distance** 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** are provided throughout the text to illustrate how physics helps students understand the world around them and life-science students with their chosen career.

The electric field is created by charges. Field lines start on a positive charge and end on a negative charge. We can combine the above information into a technique for drawing electric field lines for an arrangement of charges. For example, Figure 20.34 pictures the electric field of a dipole using electric field lines. You should compare this to Figure 20.28b, which illustrates the field with field vectors.

**The Electric Field of the Heart**  
Nerve and muscle cells have a protoplasmic 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 is reversed; 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.

**Passage Problems**

**Range of Motion** A kangaroo has only one leg and it is very long. It can jump to a height of 1.0 m. (a) How long is the kangaroo's leg? (b) How long does it take for the kangaroo to reach the top of its jump? (c) How long does it take for the kangaroo to fall back to the ground? (d) How long does it take for the kangaroo to complete one full cycle of jumping and falling?

**Energy and Power** A kangaroo has a mass of 10 kg. (a) How much kinetic energy does it have when it is jumping to a height of 1.0 m? (b) How much potential energy does it have at the top of its jump? (c) How much energy is lost to air resistance during the jump? (d) How much energy is lost to air resistance during the fall? (e) How much energy is lost to air resistance during the entire cycle?

**Force and Motion** A kangaroo has a mass of 10 kg. (a) How much force does it exert on the ground when it is jumping to a height of 1.0 m? (b) How much force does it exert on the ground when it is falling back to the ground? (c) How much force does it exert on the ground when it is standing still? (d) How much force does it exert on the ground when it is running? (e) How much force does it exert on the ground when it is swimming?

"The authors' use of everyday and especially biological examples is superior to any other text I've seen. Students with biomedical interests will have plenty to sink their teeth into."

—Taner Edis, *Truman State University*

**Multiple-choice and Passage Problems** are designed to carefully test student understanding by targeting common misconceptions and providing context-rich situations—modeling the latest MCAT and other progressive physics exams.

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

“Clearly written by experienced, knowledgeable teachers who have spent time in the trenches... *College Physics* sets a new standard.”

—Marlin L. Simon, *Auburn University*

“The text is exceptionally easy to read... and takes special care to explain the fundamentals and debunk common misconceptions...”

—Michael Pravica, *University of Nevada—Las Vegas*

**Stop to Think Questions** at the end of a section allow the student to quickly check their understanding. Using powerful ranking-task and graphical techniques, they are designed to efficiently probe key misconceptions and encourage active reading. (Answers are provided at the end of the chapter.)

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

**STOP TO THINK 2** Four wires carry currents in the directions shown. A uniform magnetic field is directed into the paper as shown. Which wire experiences a force to the left?

**NOTE Paragraphs** throughout guide students away from known preconceptions, around common sticking points, and highlight many math-related issues that cause difficulties.

### 3 VECTORS AND MOTION IN TWO DIMENSIONS

**Looking Ahead** The goals of Chapter 3 are to learn more about vectors and to use vectors as a tool to analyze motion in two dimensions. In this chapter, you will learn to:

- Work with vectors, coordinate systems, and components.
- Find acceleration vectors on motion diagrams.
- Use vectors to understand motion on a ramp and relative velocity.
- Solve problems involving projectiles following parabolic paths.
- Understand the basic ideas of motion in a circle.

**Looking Back** This chapter will build naturally on the material from the previous two chapters. Please review:

- Sections 1.1–1.2 Basic motion concepts.
- Section 1.5 Vectors.
- Sections 2.4–2.5 Acceleration and free fall.

Each chapter begins with a motivational roadmap—**Looking Ahead** provides learning goals to keep the student focused on the key ideas, and **Looking Back** consolidates connections with earlier material.

**STOP TO THINK 3** Since the right-hand rule for forces specifies the orientation of the force on a positive charge, the force on a negative charge will be in the opposite direction. A negatively charged particle will orbit in the opposite sense from that shown in Figure 24.32 for a positive charge.

**STOP TO THINK 4** A particle moves in a circular path in a magnetic field directed into the page. The particle's velocity vector is shown at the instant shown. In which direction is the magnetic force on the particle?

**Figures** are carefully streamlined in detail and color so students focus on the physics—for instance, the object of interest in mechanics—using an instructional approach well documented to improve learning.

The proven technique of annotation—adding chalkboard-like dialog onto the figure (rather than providing as a lengthy caption beneath)—is used to more effectively guide students in:

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

**FIGURE 4.13** External forces and action/reaction pairs.

**FIGURE 4.14** The sensation of weight for a man at rest.

**FIGURE 2.21** Approximating a velocity-versus-time graph with a series of constant-velocity steps.

“The summaries are very effective in helping students to identify the key ideas and unifying principles of the chapter.”

—Kristi D. Concannon, *King's College*

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.

**SUMMARY**

The goal of Chapter 2 has been to describe and analyze these motions.

**GENERAL STRATEGIES**

- Use general problem-solving strategy for these topics.
- Draw pictures.
- Use free-body diagrams.
- Check your answer to see if it is sensible or violates any physical laws.

**IMPORTANT CONCEPTS**

- Acceleration is the rate of change of velocity.
- Velocity is the rate of change of position.
- Displacement is the change in position.

**APPLICATIONS**

- Uniform motion: constant velocity.
- Constant acceleration: constant acceleration.
- Free fall: constant acceleration.

**SUMMARY**

The goal of Chapter 24 has been to learn about magnetic fields and how magnetic fields exert forces on currents and moving charges.

**GENERAL PRINCIPLES**

- Magnetic fields exert forces on moving charges.
- Magnetic fields exert forces on currents.

**IMPORTANT CONCEPTS**

- The direction of the magnetic field is the direction in which a north pole of a magnetic dipole would point.
- The magnitude of the magnetic force on a moving charge depends on the charge, the speed, the angle between the velocity and the field, and the length of the wire.

**APPLICATIONS**

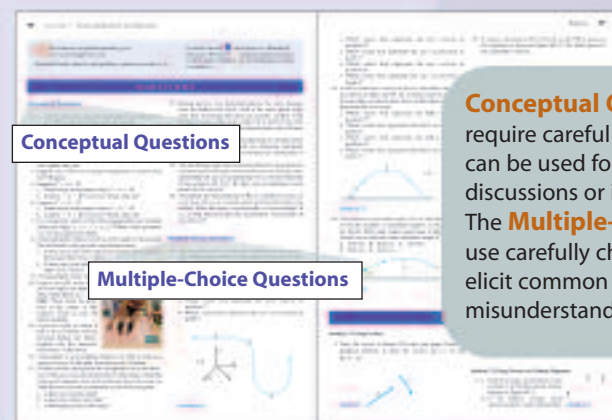
- Force on a current-carrying wire.
- Force on a moving charge.



# THE BEST-TESTED PROBLEMS

*Enhanced by analysis*

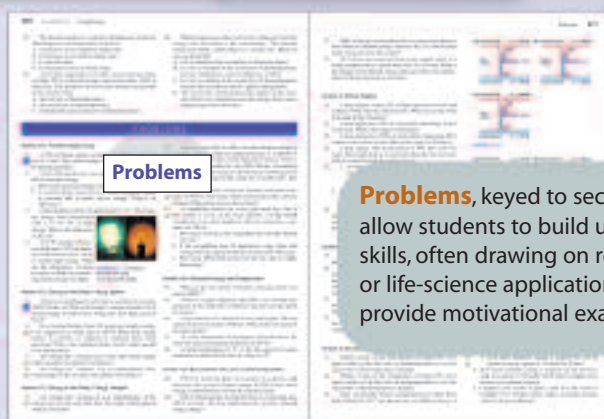
End-of-chapter problems of superior quality and diversity have been carefully crafted to exercise and test the full range of qualitative and quantitative problem-solving skills. The wealth of 3,000 problems in *College Physics: A Strategic Approach* are the first problems to be pre-tested for reliability, difficulty, and duration on thousands of students nationally before publication in a new textbook. (See pull-out grid inside front cover for more details).



Conceptual Questions

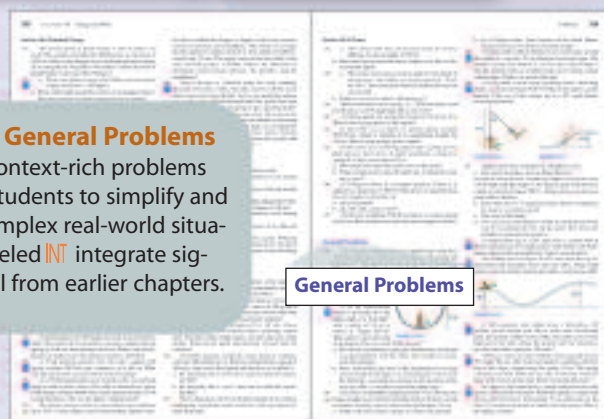
Multiple-Choice Questions

**Conceptual Questions** require careful reasoning and can be used for either group discussions or individual work. The **Multiple-Choice Questions** use carefully chosen distractors to elicit common misconceptions and misunderstandings.



Problems

**Problems**, keyed to sections, allow students to build up their skills, often drawing on real-world or life-science applications to provide motivational examples.



General Problems

More advanced **General Problems** include many context-rich problems which require students to simplify and model more complex real-world situations. Those labeled **INT** integrate significant material from earlier chapters.

**Simpler subproblems** are provided upon request when a student gets stuck.



**Students select** only the specific help they need. Thousands of solution paths are allowed.

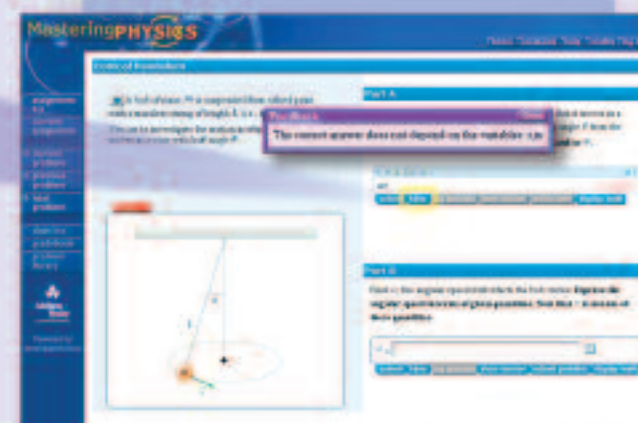
See the *MasteringPhysics™* brochure for more details on how it enables instructors to more quickly build assignments of just the right coverage, difficulty, and duration, and the time-saving and probing diagnostics it provides (including most-common wrong answers by a class at each step, the step-by-step work of each student, even national average comparison data).

# INTEGRATED WITH MASTERINGPHYSICS™

*Unparalleled teaching diagnostics and individualized tutoring*

**MasteringPhysics™** is the most widely used and educationally proven physics homework and tutorial system in the world. NSF-sponsored research and independent studies at a wide range of schools show that students who use MasteringPhysics™ significantly improve their scores on final exams and conceptual tests such as the Force Concept Inventory. Drawing from the world's largest metadatabase of the step-by-step work of how real students solve problems, accumulated over eight years of research, MasteringPhysics™ offers unparalleled individualized guidance.

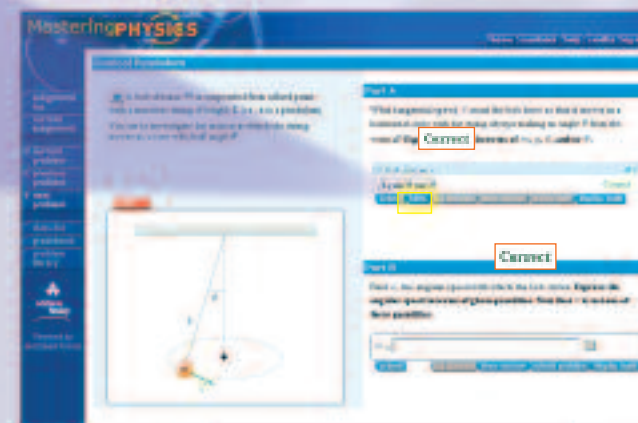
**Instantaneous feedback** is provided specific to the most common wrong answers.



**MasteringPhysics™** provides instructors with more than 3,000 problems from which to build wide-ranging weekly assignments that include:

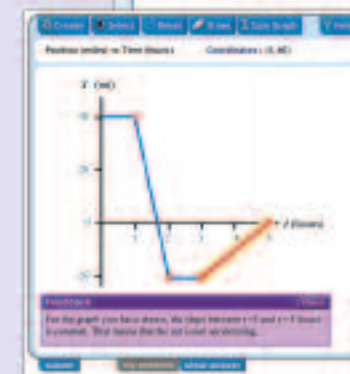
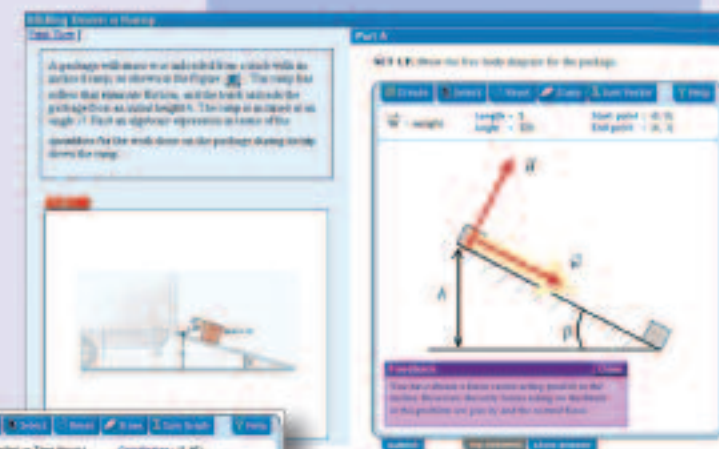
- end-of-chapter textbook problems
- tutorials for practicing the Problem-Solving Strategies, Conceptual Analysis, and Quantitative Analysis problems in every chapter
- skill-building tutorials for mastering key concepts, and self-tutoring problems for guided practice
- math-specific skill-building tutorials, ranking task problems, even essay questions

Numerical problems provide randomized numbers and sig-fig feedback, and tutorial problems provide wrong-answer specific feedback and simpler subproblems upon request.



**Partial credit** is provided for the method, not just the final numerical answer.

A **vector-drawing tool** provides grading and feedback on student-drawn free-body diagrams embedded in the tutorials.



A **graph-drawing tool** provides similar grading and feedback in tutorials that develop students' graph-reading skills.

**MasteringPHYSICS**  
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# WE TAKE THE GUESSWORK OUT OF CHOOSING GREAT HOMEWORK PROBLEMS



## THE BEST PHYSICS PROBLEMS—ENHANCED THROUGH ANALYSIS

*College Physics: A Strategic Approach* provides the first problems to be pre-tested on students nationally for reliability, difficulty, and duration *before* publication in a new textbook.

Pre-testing by Two-Way Learning™ is the most sophisticated problem approval and improvement procedure ever developed. Utilizing the most advanced item-analysis tool in the world—**MasteringPhysics™**—these textbook problems have been pre-tested on a wide variety of students.

Sophisticated analysis of the captured student metadata of difficulty, time spent, most common wrong answers, and comment rate on every step of every problem has been used to systematically improve quality, educational effectiveness, efficiency of teaching and learning, and assessment accuracy to provide you with:

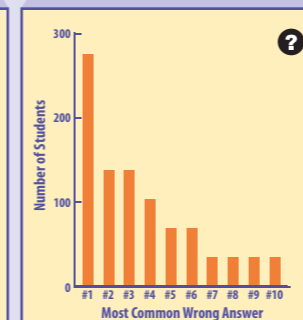
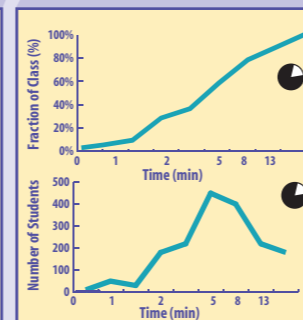
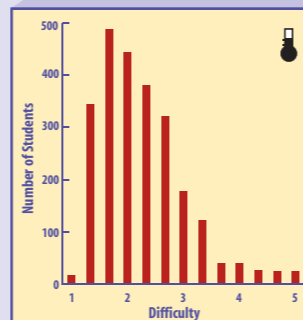
- the best physics problems
- the most accurate solutions
- the most reliable assessment items
- the only problems with accurate, student-calibrated difficulty and duration (time-to-complete) ratings

### PART I: FORCE AND MOTION Chapter 2: Motion in One Dimension

Sample End-of-chapter Questions and Problems starting on page 61.	Difficulty (1-5)	Time	Student Metadata
P 2.4 Write a short description of a real object...	1	4 min.	
P 2.5 Suppose a car is moving with constant velocity...	2	4 min.	
P 2.6 A car starts at the origin and moves...	1	1 min.	
P 2.8 Alan leaves Los Angeles at 8:00 A.M....	2	4 min.	
P 2.9 Richard is driving home to visit his parents...	3	5 min.	
P 2.11 In an 8.00 km race, one runner runs...	5	5 min.	
P 2.12 A bicyclist has the position-versus-time graph...	2	4 min.	
P 2.14 A car starts from $x_i = 10$ m...	3	8 min.	
P 2.16 The figure shows the velocity graph of a train...	1	1 min.	
P 2.17 The figure shows the velocity graph of a bicycle...	2	3 min.	
P 2.20 A Thompson's gazelle can reach a speed...	1	1 min.	
P 2.21 When striking, the pike, a predatory fish...	2	4 min.	
P 2.22 What constant acceleration, in SI units, must a car...	3	10 min.	
P 2.23 A car travels with constant acceleration...	3	5 min.	
P 2.24 A jet plane is cruising at 250 m/s...	4	5 min.	
P 2.25 A speed skater moving across the frictionless ice...	3	6 min.	

### PART II: CONSERVATION LAWS Chapter 10: Energy and Work

Sample End-of-chapter Questions and Problems starting on page 327.	Difficulty (1-5)	Time	Student Metadata
Q 10.28 If you walk up a flight of stairs...	2	2 min.	
Q 10.30 A woman uses a pulley and a rope...	1	2 min.	
Q 10.31 A hockey puck sliding along frictionless ice...	1	2 min.	
Q 10.33 A wrecking ball is suspended...	2	5 min.	
P 10.1 During an etiquette class, you walk slowly...	1	2 min.	
P 10.5 At the airport, you ride a "moving sidewalk"...	3	9 min.	
P 10.6 A boy flies a kite...	1	4 min.	
P 10.10 Sam's job at the amusement park...	3	4 min.	
P 10.12 The turntable in a microwave oven...	1	1 min.	
P 10.13 An energy storage system...	1	3 min.	
P 10.19 A car is parked at the top...	2	3 min.	
P 10.21 A 1500 kg car is approaching the hill...	3	6 min.	
P 10.27 The elastic energy stored in your tendons...	4	7 min.	
P 10.32 A fireman of mass 80 kg...	3	5 min.	
P 10.36 Two balls undergo a perfectly elastic...	1	4 min.	
P 10.41 A 1000 kg sports car accelerates...	3	5 min.	
P 10.42 In just 0.30 s, you compress...	3	6 min.	
P 10.43 In the winter sport of curling...	4	6 min.	



### PART III: PROPERTIES OF MATTER Chapter 12: Thermal Properties of Matter

Sample End-of-chapter Questions and Problems starting on page 406.	Difficulty (1-5)	Time	Student Metadata
Q 12.28 Suppose you do a calorimetry experiment...	1	1 min.	
P 12.2 How many grams of water (H <sub>2</sub> O)...	4	5 min.	
P 12.3 How many atoms of hydrogen are in 100 g...	3	3 min.	
P 12.6 A straight rod consists of a 1.2-cm-long piece...	1	1 min.	
P 12.10 If a container holds 0.865 L of ethyl alcohol...	3	2 min.	
P 12.15 7.5 mol of helium are in a 15 L cylinder...	4	13 min.	
P 12.19 10 g of liquid water is placed in a flexible bag...	5	7 min.	
P 12.20 A cylinder contains 3.0 L of oxygen...	2	3 min.	
P 12.29 It is possible to make a thermometer...	3	3 min.	
P 12.30 How much energy must be removed...	2	2 min.	
P 12.37 A copper block is removed from a 300°C oven...	5	3 min.	
P 12.39 A 500 g metal sphere is heated to 300°C...	1	1 min.	
P 12.40 Marianne really likes coffee, but on summer days...	5	8 min.	
P 12.49 What is the rate of energy transfer...	3	6 min.	
P 12.61 Suppose you inflate your tires to 35 psi...	5	4 min.	
P 12.73 Suppose you drop a water balloon...	3	7 min.	
P 12.84 What is the heat Q <sub>H</sub> extracted...	4	7 min.	

98% of students ultimately answered correctly

2% of students ultimately requested solution

Average of 0.26 wrong answers per student

For more details, go to [www.masteringphysics.com](http://www.masteringphysics.com)



**PART IV: OSCILLATIONS AND WAVES**  
**Chapter 14: Oscillations**

Sample End-of-chapter Questions and Problems starting on page 477.	Difficulty (1-5)	Time	Student Metadata
Q 14.18 A string has an unstretched length...	1	5 min.	
Q 14.19 The figure represents the motion of a mass...	2	4 min.	
Q 14.20 A ball of mass $m$ oscillates on a spring...	1	10 min.	
P 14.2 In the aftermath of an intense earthquake...	1	2 min.	
P 14.3 You hear a faucet dripping steadily...	1	1 min.	
P 14.5 Make a table with 3 columns and 8 rows...	1	9 min.	
P 14.6 An air-track glider attached to a spring oscillates...	2	8 min.	
P 14.8 What are the (a) amplitude and (b) frequency...	1	2 min.	
P 14.13 Some passengers on an ocean cruise...	2	4 min.	
P 14.19 The position of a 50 g oscillating mass...	4	20 min.	
P 14.20 A 200 g mass attached to a horizontal spring...	2	14 min.	
P 14.21 A 507 g mass oscillates with an amplitude...	3	14 min.	
P 14.25 The angle of a pendulum is given by...	3	7 min.	
P 14.26 It is said that Galileo discovered a basic principle...	1	1 min.	
P 14.27 The acceleration due to gravity on the moon...	2	3 min.	
P 14.29 A building is being knocked down....	2	3 min.	
P 14.30 Interestingly, there have been several studies...	1	3 min.	
P 14.31 A pendulum clock keeps time...	3	10 min.	
P 14.32 A thin, circular hoop with a radius of 0.22 m...	1	2 min.	
P 14.37 A 25 kg child sits on a 2.0-m-long rope...	1	2 min.	
P 14.38 Vision is blurred if the head is vibrated...	2	5 min.	
P 14.40 A 0.40 kg ball is attached to a spring...	1	3 min.	
P 14.48 Astronauts in space cannot weigh themselves...	1	4 min.	
P 14.49 A 100 g ball attached to a spring...	4	14 min.	
P 14.55 The figure shows two springs, each with spring constant...	5	7 min.	

**PART V: OPTICS**  
**Chapter 18: Ray Optics**

Sample End-of-chapter Questions and Problems starting on page 609.	Difficulty (1-5)	Time	Student Metadata
Q 18.18 In the figure, a beam of light in the air...	1	<1 min.	
Q 18.20 Is there an angle of incidence between...	2	<1 min.	
Q 18.22 You are 2.4 m from a plane mirror...	2	1 min.	
Q 18.24 A real image of an object can be formed by...	1	1 min.	
P 18.2 A student has built a 20-cm-long pinhole camera...	1	9 min.	
P 18.5 The human eye has a lot in common with...	1	3 min.	
P 18.6 The mirror in the figure deflects a horizontal laser...	1	1 min.	
P 18.8 A light ray leaves point A in the figure...	3	5 min.	
P 18.9 It is 165 cm from your eyes to your toes...	2	4 min.	
P 18.12 An underwater diver sees the sun...	3	9 min.	
P 18.14 A 1.0-cm-thick layer of water...	5	2 min.	
P 18.18 The glass core of an optical fiber...	3	1 min.	
P 18.19 A thin glass rod is submerged in oil...	5	12 min.	
P 18.20 A narrow beam of light with wavelengths from...	5	5 min.	
P 18.27 An object is 30 cm in front of a converging lens...	1	1 min.	
P 18.28 An object is 6.0 cm in front of a converging lens...	1	2 min.	
P 18.31 A concave cosmetic mirror...	1	4 min.	
P 18.32 A light bulb is 50 cm from a concave mirror...	1	3 min.	
P 18.36 An object is 6 cm in front of a convex mirror...	2	2 min.	
P 18.46 A ray of light traveling through air...	1	3 min.	
P 18.49 A 1.0-cm-thick layer of water stands...	3	10 min.	
P 18.59 There is just one angle of incidence...	2	8 min.	
P 18.62 A microscope is focused on an amoeba...	1	5 min.	
P 18.63 A ray diagram can be used to find...	2	12 min.	
P 18.64 A 2.0-cm-tall object is located 8.0 cm in front...	1	6 min.	

**PART VI: ELECTRICITY AND MAGNETISM**  
**Chapter 20: Electric Forces and Fields**

Sample End-of-chapter Questions and Problems starting on page 677.	Difficulty (1-5)	Time	Student Metadata
Q 20.23 Two lightweight, electrically neutral conducting balls...	1	1 min.	
Q 20.24 All the charges in the figure have the same magnitude...	1	<1 min.	
P 20.1 A glass rod is charged to +5.0 nC...	2	4 min.	
P 20.4 A plastic rod that has been charged...	1	5 min.	
P 20.6 Two identical metal spheres...	5	14 min.	
P 20.9 Two 1.0 kg masses are 1.0 m apart...	1	4 min.	
P 20.10 Two small plastic spheres each have a mass...	2	8 min.	
P 20.11 A small plastic sphere with a charge of -5.0 nC...	2	5 min.	
P 20.12 The figure shows the magnitude of the attractive...	4	7 min.	
P 20.13 A small glass bead has been charged to +20 nC...	4	7 min.	
P 20.14 What are the magnitude and direction of the electric force...	1	4 min.	

**PART VII: MODERN PHYSICS**  
**Chapter 28: Quantum Physics**

Sample End-of-chapter Questions and Problems starting on page 961.	Difficulty (1-5)	Time	Student Metadata
Q 28.26 A light sensor is based on a photodiode...	2	2 min.	
Q 28.29 In the photoelectric effect, the frequency...	1	1 min.	
Q 28.31 Two radio stations have the same power output...	1	1 min.	
Q 28.34 Photon P in the figure moves an electron...	1	1 min.	
P 28.11 Zinc has a work function of 4.3 eV...	1	7 min.	
P 28.14 When an ultraviolet photon is absorbed...	1	1 min.	
P 28.15 A firefly glows by the direct conversion...	1	1 min.	
P 28.22 550 nm is the average wavelength...	1	2 min.	
P 28.39 An electron with a 2.0 eV of kinetic energy...	1	1 min.	