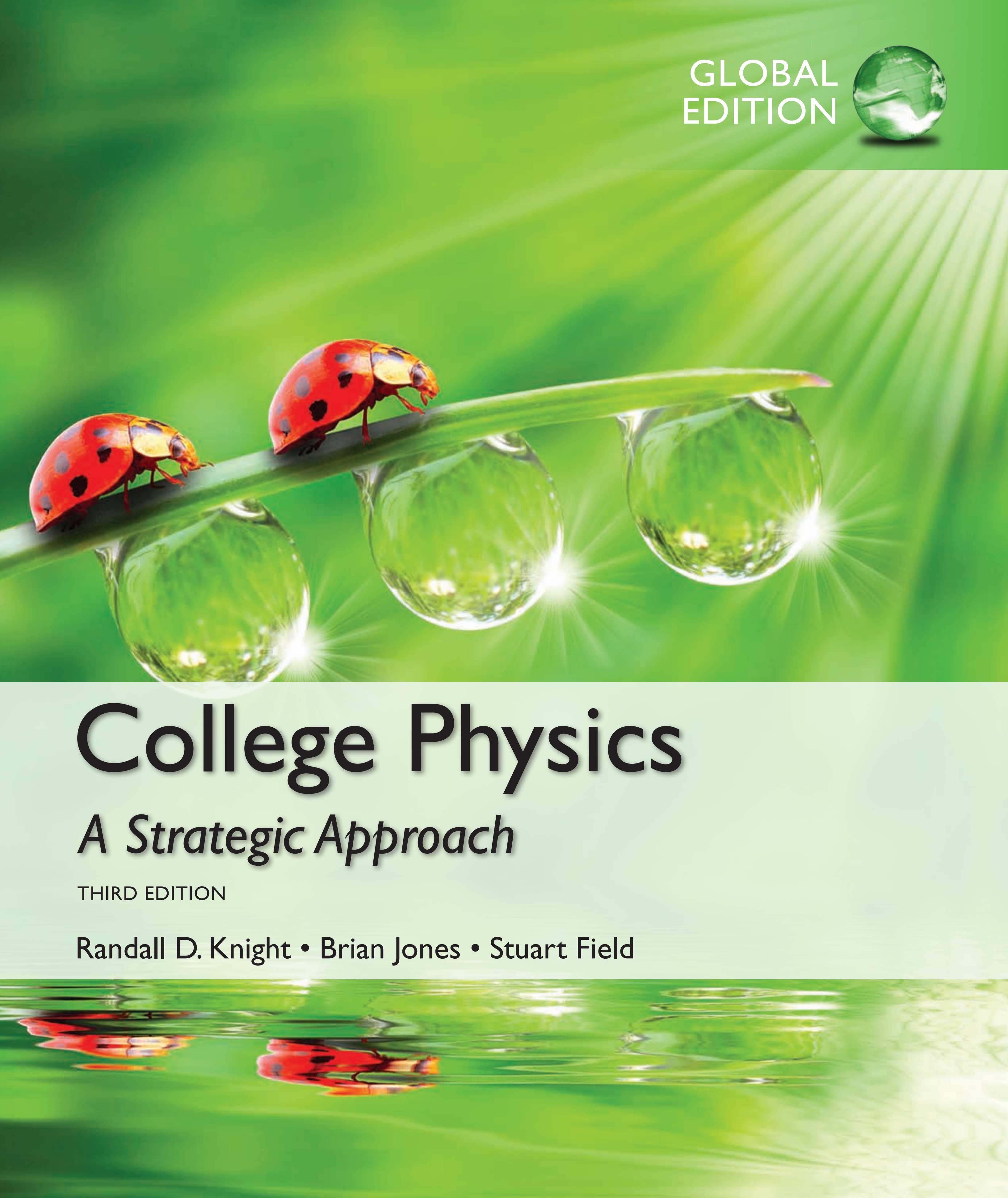


GLOBAL EDITION

College Physics

A Strategic Approach

THIRD EDITION

Randall D. Knight • Brian Jones • Stuart Field

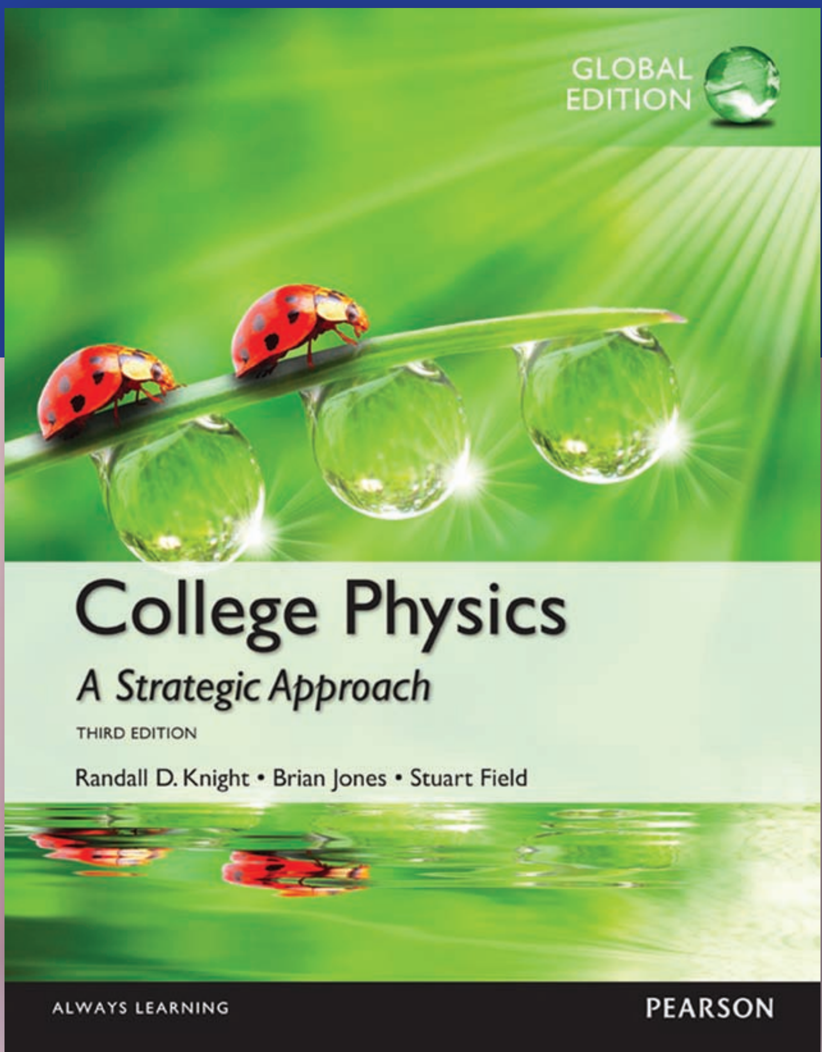
ALWAYS LEARNING

PEARSON

FOCUS ON THE BIG PICTURE

Built from the ground up for optimal learning, and refined to help students focus on the big picture.

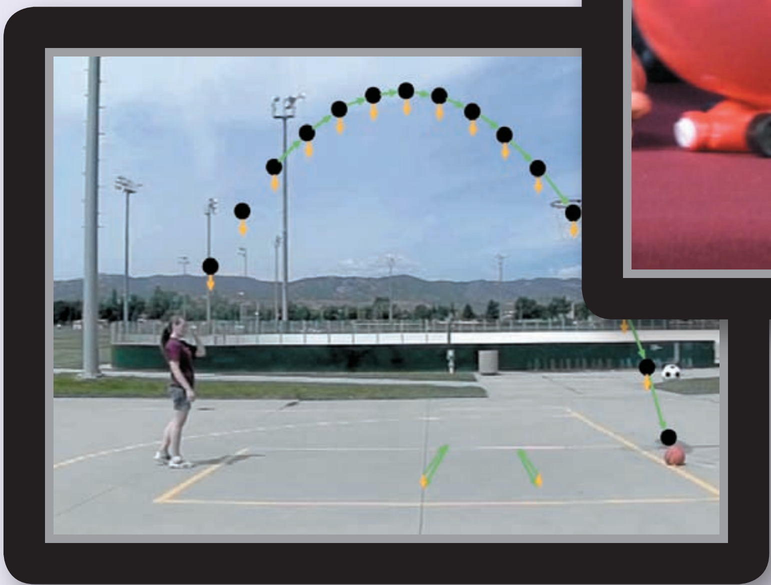
Building on the research-proven instructional techniques introduced in Knight's *Physics for Scientists and Engineers, College Physics: A Strategic Approach* sets a new standard for algebra-based introductory physics—gaining widespread critical acclaim from professors and students alike.

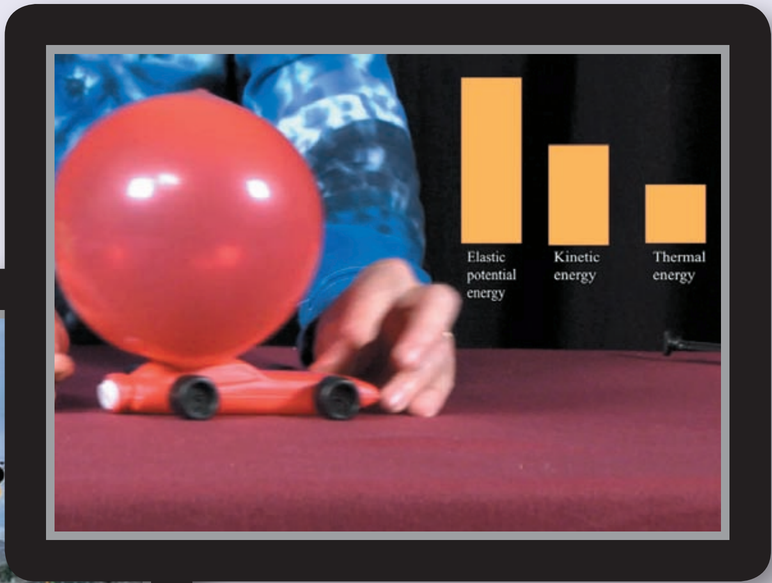


The text, supplements, and MasteringPhysics® work together to help students see and understand the big picture, gain crucial problem-solving skills and confidence, and better prepare for lecture and their future.

FOCUS STUDENTS...

BEFORE:





new PRELECTURE VIDEOS

Presented by co-author Brian Jones, these engaging videos are assignable through MasteringPhysics and expand on the ideas in the textbook's chapter previews, giving context, examples, and a chance for students to practice the concepts they are studying via short multiple-choice questions.

DURING:

new LEARNING CATALYTICS™

With Learning Catalytics, a "bring your own device" student engagement, assessment, and classroom intelligence system, you can:

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- **Understand immediately where students are** and adjust your lecture accordingly.
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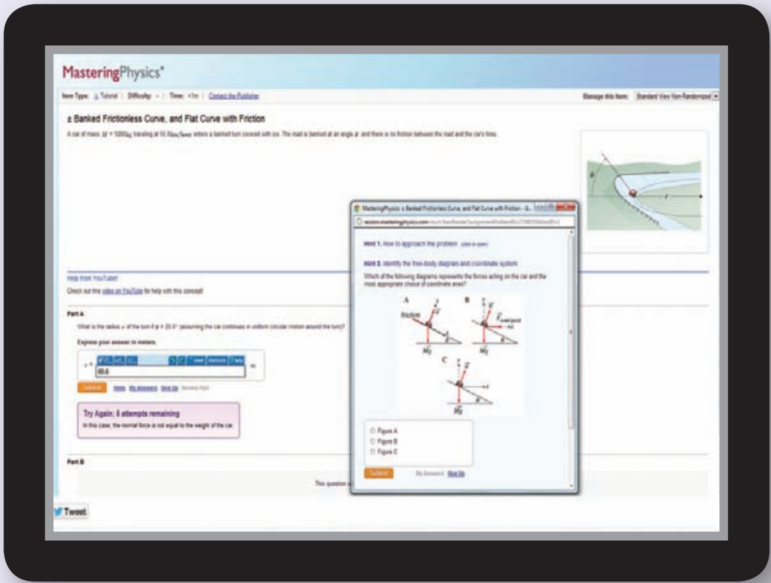

MASTERINGPHYSICS

MasteringPhysics is the leading online homework, tutorial, and assessment product, designed to improve results by helping students quickly master concepts. Students benefit from self-paced tutorials, featuring specific wrong-answer feedback, hints, and a wide variety of educationally effective content to keep them engaged and on track.

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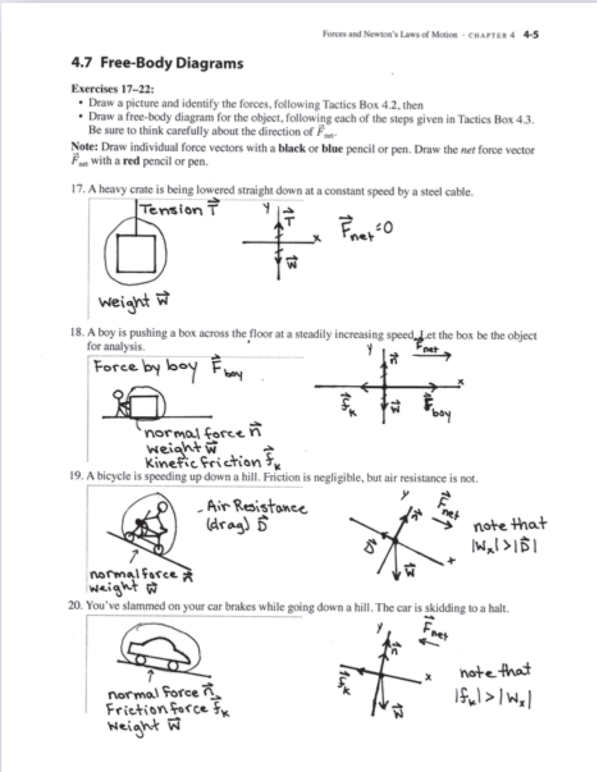


Forces and Newton's Laws of Motion · CHAPTER 4 4-5

4.7 Free-Body Diagrams

Exercises 17–22:

- Draw a picture and identify the forces, following Tactics Box 4.2, then
- Draw a free-body diagram for the object, following each of the steps given in Tactics Box 4.3. Be sure to think carefully about the direction of $\vec{F}_{net}$.

Note: Draw individual force vectors with a **black** or **blue** pencil or pen. Draw the *net* force vector $\vec{F}_{net}$ with a **red** pencil or pen.

17. A heavy crate is being lowered straight down at a constant speed by a steel cable.

18. A boy is pushing a box across the floor at a steadily increasing speed. Let the box be the object for analysis.

19. A bicycle is speeding up down a hill. Friction is negligible, but air resistance is not.

20. You've slammed on your car brakes while going down a hill. The car is skidding to a halt.

STUDENT WORKBOOK

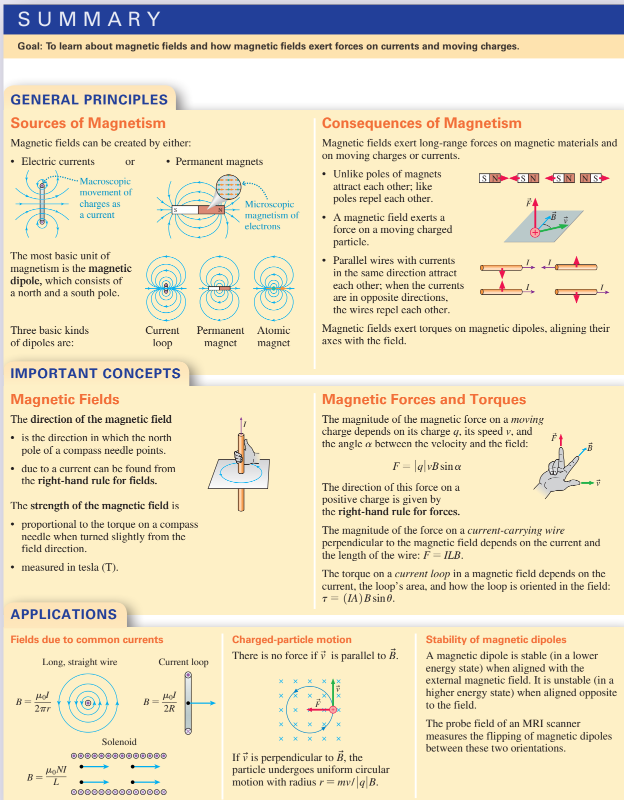
The acclaimed Student Workbook provides straightforward confidence and skill-building exercises—bridging the gap between worked examples in the textbook and end-of-chapter problems. Workbook activities are referenced throughout the text by .

new For the Third Edition are Jeopardy questions that ask students to work backwards from equations to physical situations, enhancing their understanding and critical-thinking skills.

FOCUS STUDENTS...

new ENHANCED CHAPTER PREVIEWS

Streamlined and focused on the three most important ideas in each chapter, these unique chapter previews are tied to specific learning objectives. In addition, they explicitly mention the one or two most important concepts from past chapters, and finish with a new "Stop to Think" question, giving students a chance to build on their knowledge from previous chapters and integrate it with new content they are about to read.



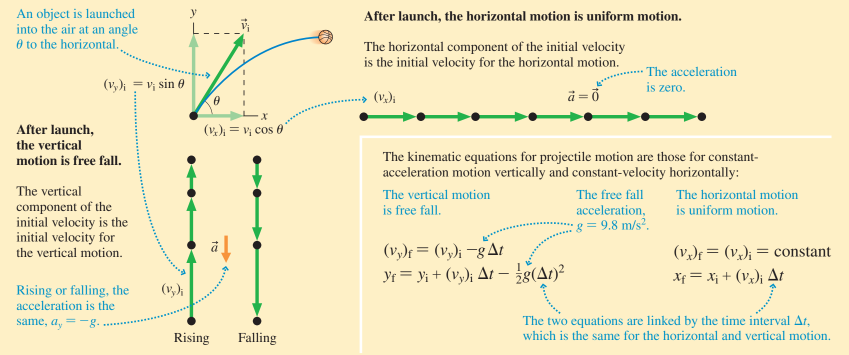
CHAPTER SUMMARIES

Chapter previews are mirrored by visual chapter summaries, helping students to review and organize what they've learned before moving ahead.
They consolidate understanding by providing each concept in words, math, and figures, and organizing these into a coherent hierarchy—from General Principles to Applications.

ON THE BIG PICTURE

SYNTHESIS 3.1 **Projectile motion**

The horizontal and vertical components of projectile motion are independent, but must be analyzed together.



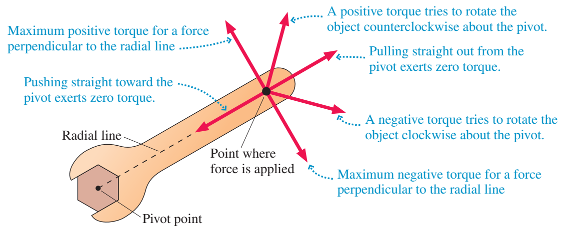
new SYNTHESIS BOXES

Bringing together key concepts, principles, and equations, this novel feature is designed to highlight connections and differences. More than a summary, they emphasize deeper relations and point out common or contrasting details.

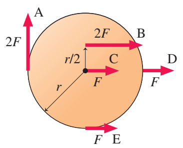
new CONCEPT CHECK FIGURES

To encourage students to actively engage with a key or complex figure, they are asked to reason with a related "Stop to Think" question.

FIGURE 7.21 Signs and strengths of the torque.



STOP TO THINK 7.3 A wheel turns freely on an axle at the center. Given the details noted in Figure 7.21, which one of the forces shown in the figure will provide the largest positive torque on the wheel?



PROBLEM-SOLVING STRATEGIES

Topic-specific Problem-Solving Strategies give students a framework and guidance for broad classes of problems. New overview statements now provide the "big picture," giving clear statements of what types of problems a strategy is intended for and/or how to use it.

PROBLEM-SOLVING STRATEGY 9.1 **Conservation of momentum problems** MP

new

We can use the law of conservation of momentum to relate the momenta and velocities of objects *after* an interaction to their values *before* the interaction.

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.

SOLVE The mathematical representation is based on the law of conservation of momentum, Equations 9.15. Because we generally want to solve for the velocities of objects, we usually use Equations 9.15 in the equivalent form

$$m_1(v_{1x})_f + m_2(v_{2x})_f + \cdots = m_1(v_{1x})_i + m_2(v_{2x})_i + \cdots$$
$$m_1(v_{1y})_f + m_2(v_{2y})_f + \cdots = m_1(v_{1y})_i + m_2(v_{2y})_i + \cdots$$

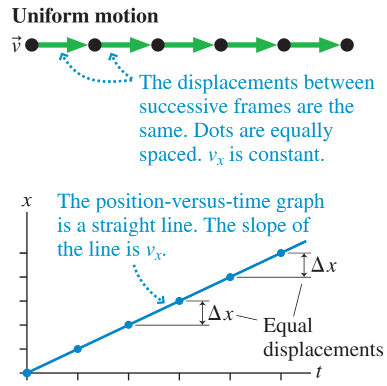
ASSESS Check that your result has the correct units, is reasonable, and answers the question.

Exercise 17

FOCUS ON STUDENTS...

Multiple Representations...

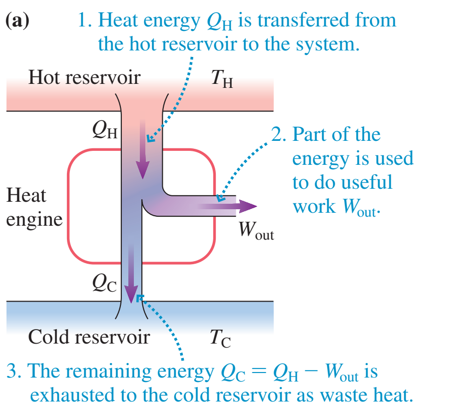
FIGURE 2.14 Motion diagram and position-versus-time graph for uniform motion.



Balancing Qualitative and Quantitative Reasoning...

Figures that Teach...

FIGURE 11.18 The operation of a heat engine.

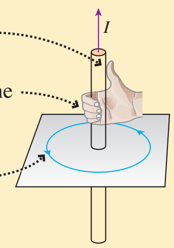


Addressing Misconceptions...

TACTICS BOX 24.1 **Right-hand rule for fields**

MP

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



Exercises 6–11

An Inductive Approach...

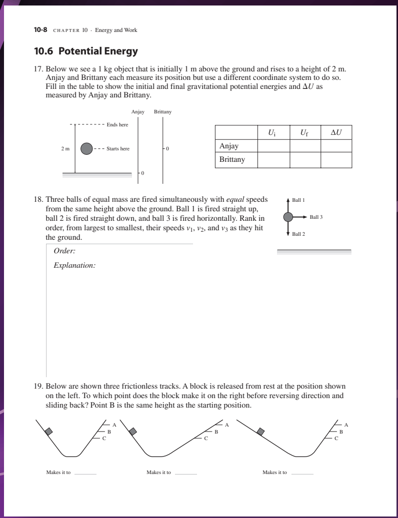
Emphasis on Explicit Skills...

RESEARCH-BASED

Knight/Jones/Field was designed from the ground up with students in mind, and is based on a solid foundation of the latest physics education research . . .

AND HOW THEY LEARN

Guided Practice...


10-8 CHAPTER 10 · Energy and Work

10.6 Potential Energy

17. Below we see a 1 kg object that is initially 1 m above the ground and rises to a height of 2 m. Anjay and Brittany each measure its position but use a different coordinate system to do so. Fill in the table to show the initial and final gravitational potential energies and ΔU as measured by Anjay and Brittany.

	U_i	U_f	ΔU
Anjay			
Brittany			

18. Three balls of equal mass are fired simultaneously with *equal* speeds from the same height above the ground. Ball 1 is fired straight up, ball 2 is fired straight down, and ball 3 is fired horizontally. Rank in order, from largest to smallest, their speeds v_1, v_2, and v_3 as they hit the ground.

Order:

Explanation:

19. Below are shown three frictionless tracks. A block is released from rest at the position shown on the left. To which point does the block make it on the right before reversing direction and sliding back? Point B is the same height as the starting position.

Makes it to ______ Makes it to ______ Makes it to ______

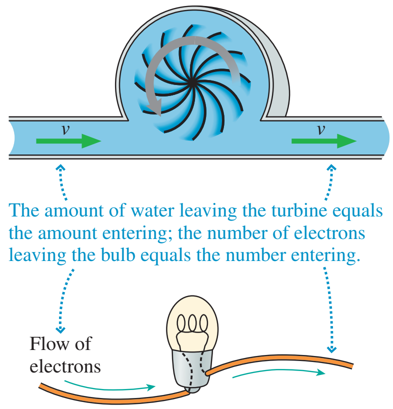
Annotated Equations...

$$F_{\text{wire}} = ILB \sin\alpha \qquad (24.9)$$

Current in wire (A) · Magnetic field (T) · Length of wire in magnetic field (m) · Angle between wire and magnetic field

Visual Analogies...

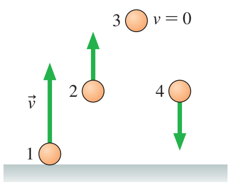
FIGURE 22.7 Water in a pipe turns a turbine.



Streamlining use of *Color*...

Active Learning...

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



Structured Problem Solving...

PEDAGOGY

. . . Evident in the text, art, design, pedagogy, and technology, using ideas from multimedia learning theory, students are given the best tools to succeed in physics.

FOCUS STUDENTS... ON THEIR GOALS

new INCREASED EMPHASIS ON CRITICAL THINKING AND REASONING

MCAT-Style 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 P11.68 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.

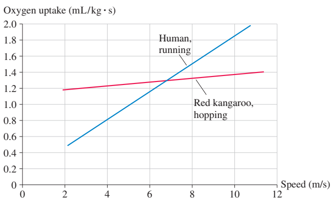


FIGURE P11.68 Oxygen uptake (a measure of energy use per second) for a running human and a hopping kangaroo.

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.

68. | 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.

69. | 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.

70. | 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.

71. | 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

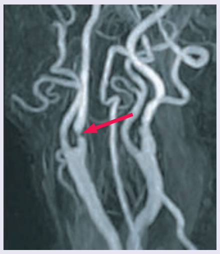
72. | At what speed does the hopping motion of the kangaroo become more efficient than the running gait of a human?
   A. 3 m/s B. 5 m/s C. 7 m/s D. 9 m/s

Students will be required to reason, to do more than simply plug in numbers into equations. Of the hundreds of new end-of-chapter problems, many require students to reason using ratios and proportionality, to reason using real-world data, and to assess answers to see if they make physical sense.

EXPANDED LIFE-SCIENCE AND BIOMEDICAL APPLICATIONS

Building on the book's acclaimed real-world focus, even more applications from the living world have been added to text, worked examples, and end-of-chapter problems, giving students essential practice in applying core physical principles to new real-world situations.

CONCEPTUAL EXAMPLE 13.13 **Blood pressure and cardiovascular disease** BIO



Cardiovascular disease is a narrowing of the arteries due to the buildup of plaque deposits on the interior walls. Magnetic resonance imaging, which you'll learn about in Chapter 24, can create exquisite three-dimensional images of the internal structure of the body. Shown are the carotid arteries that supply blood to the head, with a dangerous narrowing—a *stenosis*—indicated by the arrow.

If a section of an artery has narrowed by 8%, not nearly as much as the stenosis shown, by what percentage must the blood-pressure difference between the ends of the narrowed section increase to keep blood flowing at the same rate?

REASON According to Poiseuille's equation, the pressure difference Δp must increase to compensate for a decrease in the artery's radius R if the blood flow rate Q is to remain unchanged. If we write Poiseuille's equation as

$$R^4 \Delta p = \frac{8\eta L Q}{\pi}$$

we see that the product $R^4 \Delta p$ must remain unchanged if the artery is to deliver the same flow rate. Let the initial artery radius and pressure difference be R_i and Δp_i. Disease decreases the radius by 8%, meaning that $R_f = 0.92R_i$. The requirement

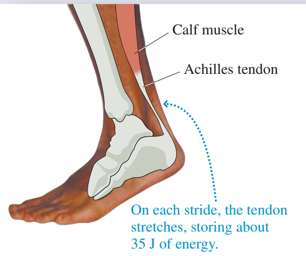
$$R_i^4 \Delta p_i = R_f^4 \Delta p_f$$

can be solved for the new pressure difference:

$$\Delta p_f = \frac{R_i^4}{R_f^4} \Delta p_i = \frac{R_i^4}{(0.92R_i)^4} \Delta p_i = 1.4\, \Delta p_i$$

The pressure difference must increase by 40% to maintain the flow.

ASSESS Because the flow rate depends on R^4, even a small change in radius requires a large change in Δp to compensate. Either the person's blood pressure must increase, which is dangerous, or he or she will suffer a significant reduction in blood flow. For the stenosis shown in the image, the reduction in radius is much greater than 8%, and the pressure difference will be large and very dangerous.



Spring in your step BIO As you run, you lose some of your mechanical energy each time your foot strikes the ground; this energy is transformed into unrecoverable thermal energy. Luckily, about 35% of the decrease of your mechanical energy when your foot lands is stored as elastic potential energy in the stretchable Achilles tendon of the lower leg. 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. This recovered energy reduces the amount of internal chemical energy you use, increasing your efficiency.

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Authorized adaptation from the United States edition, entitled College Physics: A Strategic Approach, 3rd edition, ISBN 978-0-321-87972-1, by Randall D. Knight, Brian Jones, and Stuart Field, published by Pearson Education © 2015.

ISBN 10: 1-292-05715-7
ISBN 13: 978-1-292-05715-6

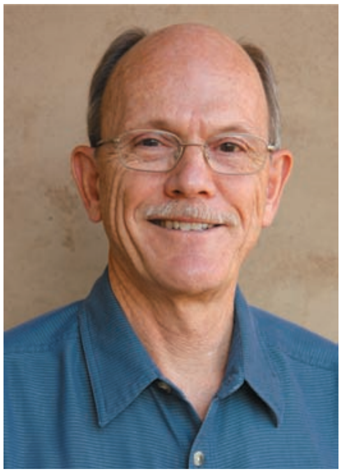
British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

10 9 8 7 6 5 4 3 2 1
14 13 12 11 10

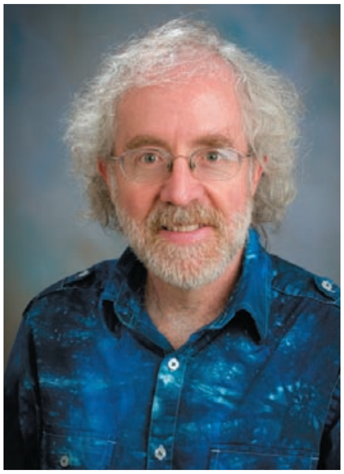
Typeset in Times Ten by Cenveo® Publisher Services

Printed and Bound in Slovakia by Neografia

About the Authors



Randy Knight taught introductory physics for 32 years at Ohio State University and California Polytechnic University, where he is Professor Emeritus of Physics. 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 fields of laser spectroscopy and environmental science. When he's not 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 25 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. In 2011, Brian was awarded the Robert A. Millikan Medal of the American Association of Physics Teachers for his work as director of the Little Shop of Physics, a hands-on science outreach program. He is actively exploring the effectiveness of methods of informal science education and how to extend these lessons to the college classroom. Brian has been invited to give workshops on techniques of science instruction throughout the United States and in Belize, Chile, Ethiopia, Azerbaijan, Mexico and Slovenia. 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.

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. Stuart enjoys Colorado's great outdoors, where he is an avid mountain biker; he also plays in local ice hockey leagues.

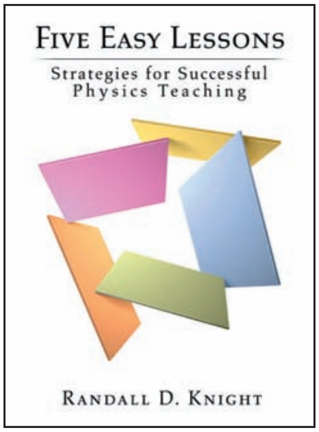
Preface to the Instructor

In 2006, we published *College Physics: A Strategic Approach,* a new algebra-based physics textbook for students majoring in the biological and life sciences, architecture, natural resources, and other disciplines. As the first such book built from the ground up on research into how students can more effectively learn physics, it quickly gained widespread critical acclaim from professors and students alike. For the second edition, and now for this third edition, we have continued to build on the research-proven instructional techniques introduced in the first edition and the extensive feedback from thousands of users to take student learning even further.

Objectives

Our primary goals in writing *College Physics: A Strategic Approach* have been:

- 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 majors—especially from biology, sports, medicine, the animal world—and that build upon 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.



A more complete explanation of these goals and the rationale behind them can be found in Randy Knight's paperback book, *Five Easy Lessons: Strategies for Successful Physics Teaching*. Please contact your local Pearson sales representative if it would be of interest to you (ISBN 978-0-805-38702-5).

What's New to This Edition

In revising the book for this third edition, we have renewed our basic focus on students and how they learn. We've considered extensive feedback from scores of instructors and thousands of students, including our student advisory panel, in order to enhance and improve the text, figures, and the end-of-chapter problems. Changes include the following:

- More focused **Chapter Previews** provide a brief, visual, and non-technical preview, proven to help students organize their thinking and improve their understanding of the upcoming material.
- New **Synthesis boxes** bring together key concepts, principles, and equations in order to highlight connections and differences.
- New **Concept Check figures** encourage students to actively engage with key or complex figures by asking them to reason with a related Stop To Think question.
- Additional **Stop To Think questions** provide students with more crucial practice and concept checks as they go through the chapters.

- New in-line **Looking Back pointers** encourage students to review important material from earlier chapters. These are given right at the moment they are needed, rather than at the start of the chapter (where they are often overlooked).
- New **Problem-Solving Strategy Overviews** give students the "big picture" of the strategy before delving into details, just as the chapter previews give the "big picture" of the chapter.
- **Streamlined text and figures** tighten and focus the presentation to be more closely matched to student needs. We've scrutinized every figure, caption, discussion, and photo in order to enhance their clarity and focus their role.
- Expanded use of **annotated equations** helps students decipher what they "say," and what the variables and units are.
- Increased emphasis on **critical thinking and reasoning,** both in worked examples and end-of-chapter problems, promotes these key skills.
- Expanded use of **realistic and real-world data** ensures students can make sense of answers that are grounded in the real world. Our examples and problems use real numbers and real data, and test different types of reasoning using equations, ratios, and graphs.
- **Enhanced end-of-chapter problems,** based on the wealth of data from MasteringPhysics, student advisory panel input, and a rigorous blind-solving and accuracy cross-checking process, optimize clarity, utility, and variety. We've added problems based on real-world and biomedical situations and problems that expand the range of reasoning skills students need to use in the solution.

We have made many small changes to the flow of the text throughout, streamlining derivations and discussions, providing more explanation for complex concepts and situations, and reordering and reorganizing material so that each section and each chapter has a clearer focus. There are small changes on nearly every page. The more significant content changes include:

- The circular motion material in Chapters 3, 6 and 7 has been reworked for a more natural progression of topics. Acceleration in circular motion is now introduced in Chapter 3, frequency and period are now introduced in Chapter 6, while angular position and angular velocity are now in Chapter 7. The treatment of circular motion in Chapter 3 emphasizes the use of vectors to understand the nature of centripetal acceleration. In Chapter 6, the focus is on dynamics, and in Chapter 7, we extend these ideas to rotational motion.
- The discussion of the law of conservation of energy in Section 10.6 has been updated to provide a more logical and coherent flow from the most general form of the law to more specialized versions for isolated systems and then to systems with only mechanical energy.
- The material in Chapter 11 making the microscopic connection between thermal energy and temperature for an ideal gas has been moved to Chapter 12, where it fits better with the atomic model of an ideal gas presented there.
- Minor topics that have been removed to focus the presentation include antinodal lines for sound waves in Chapter 16, maximum intensity of a diffraction grating's bright fringes in Chapter 17, exposure in Chapter 19, and elevation graphs in Chapter 21.
- The start of Chapter 21 has been revised to clarify the origin of electric potential energy by making a more concrete connection between electric potential energy and more familiar potential energies, such as gravitational and elastic potential energy.
- The treatment of electromagnetic waves in Chapter 25 was streamlined to focus on the nature of the waves, the meaning of polarization, and the application of these ideas to real-world situations.
- Chapters 29 and 30 have been significantly streamlined, improving the overall flow and removing some extraneous details so that students can better focus on the physics.

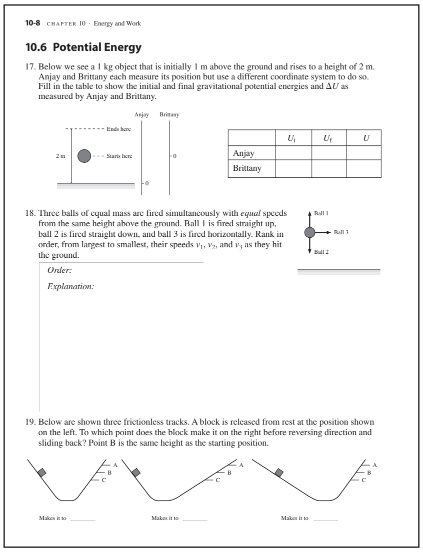
We know that students increasingly rely on sources of information beyond the text, and instructors are looking for quality resources that prepare students for engagement in lecture. The text will always be the central focus, but we are adding additional media elements closely tied to the text that will enhance student understanding. In the Technology Update to the Second Edition, we added Class Videos, Video Tutor Solutions, and Video Tutor Demonstrations. In the Third Edition, we are adding an exciting new supplement, **Prelecture Videos,** short videos with author Brian Jones that introduce the topics of each chapter with accompanying assessment questions.

Textbook Organization

College Physics: A Strategic Approach is a 30-chapter text intended for use in a two-semester 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.


10-8 CHAPTER 10 · Energy and Work

10.6 Potential Energy

17. Below we see a 1 kg object that is initially 1 m above the ground and rises to a height of 2 m. Anjay and Brittany each measure its position but use a different coordinate system to do so. Fill in the table to show the initial and final gravitational potential energies and ΔU as measured by Anjay and Brittany.

	U_i	U_f	U
Anjay			
Brittany			

18. Three balls of equal mass are fired simultaneously with *equal* speeds from the same height above the ground. Ball 1 is fired straight up, ball 2 is fired straight down, and ball 3 is fired horizontally. Rank in order, from largest to smallest, their speeds v_1, v_2, and v_3 as they hit the ground.

Order:

Explanation:

19. Below are shown three frictionless tracks. A block is released from rest at the position shown on the left. To which point does the block make it on the right before reversing direction and sliding back? Point B is the same height as the starting position.

The Student Workbook

A key component of *College Physics: A Strategic Approach* is the accompanying *Student Workbook*. The workbook bridges the gap between textbook and homework problems by providing students the opportunity to learn and practice skills prior to using those skills in quantitative end-of-chapter problems, much as a musician practices technique separately from performance pieces. 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 workbook exercises, which are generally qualitative and/or graphical, draw heavily upon the physics education research literature. The exercises deal with issues known to cause student difficulties and employ techniques that have proven to be effective at overcoming those difficulties. **New to the third edition workbook** are *jeopardy problems* that ask students to work backwards from equations to physical situations, enhancing their understanding and critical thinking skills. The workbook exercises can be used in-class as part of an active-learning teaching strategy, in recitation sections, or as assigned homework. More information about effective use of the *Student Workbook* can be found in the *Instructor's Guide*.

Instructor Supplements

NOTE ▸ For convenience, most instructor supplements can be downloaded from the "Instructor Resources" area of MasteringPhysics®. ◂

- **MasteringPhysics®** is a powerful, yet simple, online homework, tutorial, and assessment system designed to improve student learning and results. Students benefit from wrong-answer specific feedback, hints, and a huge variety of educationally effective content while unrivalled gradebook diagnostics allow an instructor to pinpoint the weaknesses and misconceptions of their class.

  NSF-sponsored published research (and subsequent studies) show that MasteringPhysics has dramatic educational results. MasteringPhysics allows instructors to build wide-ranging homework assignments of just the right difficulty and length and provides them with efficient tools to analyze in unprecedented detail both class trends and the work of any student.

  The **Instructor's Solutions Manual,** written by Professor Larry Smith, Snow College, 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. The solutions are available by chapter in Word and PDF format, and can be downloaded from the *Instructor Resource Center* (www.pearsonglobaleditions.com/knight).
- The **Instructor's Guide for *College Physics: A Strategic Approach,*** a comprehensive and highly acclaimed resource, provides chapter-by-chapter creative ideas and teaching tips for using *College Physics: A Strategic Approach* in your class. In addition, it contains an extensive review of what has been learned from physics education research, and provides guidelines for using active-learning techniques in your classroom. Instructor Guide chapters are provided in Word and PDF format, and can be downloaded from the *Instructor Resource Center* (www.pearsonglobaleditions.com/knight).
- The **Test Bank** contains 4,000 high-quality problems, with a range of multiple-choice 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 be downloaded from www.pearsonglobaleditions.com/knight. The Test Bank problems are also assignable via MasteringPhysics.

Student Supplements

- **MasteringPhysics®** is a powerful, yet simple, online homework, tutorial, and assessment system designed to improve student learning and results. Students benefit from wrong-answer specific feedback, hints, and a huge variety of educationally effective content while unrivalled gradebook diagnostics allow an instructor to pinpoint the weaknesses and misconceptions of their class. The individualized, 24/7 Socratic tutoring is recommended by 9 out of 10 students to their peers as the most effective and time-efficient way to study.
- The **Student Workbook** is a key component of *College Physics: A Strategic Approach.* The workbook bridges the gap between textbook and homework problems by providing students the opportunity to learn and practice skills prior to using those skills in quantitative end-of-chapter problems, much as a musician practices technique separately from performance pieces.
- **Pearson eText** is available through MasteringPhysics, when MasteringPhysics is packaged with new books. Allowing students access to the text wherever they have access to the Internet, Pearson eText comprises the full text, including figures that can be enlarged for better viewing. Within eText, students are also able to pop up definitions and terms to help with vocabulary and the reading of the material. Students can also take notes in eText using the annotation feature at the top of each page.
- Class Video

  Over 140 **Video Tutors** about relevant demonstrations or problem-solving strategies play directly on a smartphone or tablet via scannable QR codes in the printed book. These interactive videos are also viewable via links within the Pearson eText and the Study Area of MasteringPhysics.
- **ActivPhysics Online™** applets and applet-based tutorials, developed by education pioneers Professors Alan Van Heuvelen and Paul D'Alessandris, are available in the Study Area of MasteringPhysics. Also provided are over 70 **PhET Simulations** from the University of Colorado.

Acknowledgments

We have relied upon conversations with and, especially, the written publications of many members of the physics education community. Those who may recognize their influence include Arnold Arons, Uri Ganiel, Fred Goldberg, Ibrahim Halloun, David Hestenes, Leonard Jossem, Jill Larkin, Priscilla Laws, John Mallinckrodt, Lillian McDermott and members of the Physics Education Research Group at the University of Washington, Edward "Joe" Redish, Fred Reif, John Rigden, Rachel Scherr, Bruce Sherwood, David Sokoloff, Ronald Thornton, Sheila Tobias, and Alan Van Heuleven.

We are very grateful to Larry Smith for the difficult task of writing the *Instructor Solutions Manual*; to Scott Nutter for writing out the Student Workbook answers; to Wayne Anderson, Jim Andrews, Nancy Beverly, David Cole, Karim Diff, Jim Dove, Marty Gelfand, Kathy Harper, Charlie Hibbard, Robert Lutz, Matt Moelter, Kandiah Manivannan, Ken Robinson, and Cindy Schwarz-Rachmilowitz for their contributions to the end-of-chapter questions and problems; to Wayne again for helping with the Test Bank questions; and to Steven Vogel for his careful review of the biological content of many chapters and for helpful suggestions.

We especially want to thank our editor Becky Ruden, development editor Alice Houston, project manager Martha Steele, and all the other staff at Pearson for their enthusiasm and hard work on this project. Having a diverse author team is one of the strengths of this book, but it has meant that we rely a great deal on Becky to help us keep to a single focus, on Martha to be certain that one of us attends to all details, and on Alice's tireless efforts and keen editorial eye as she helps us synthesize our visions into a coherent whole.

Rose Kernan and the team at Nesbitt Graphics/Cenveo, copy editor Carol Reitz, and photo researcher Eric Schrader get much credit for making this complex project all come together. In addition to the reviewers and classroom testers listed below, who gave invaluable feedback, we are particularly grateful to Charlie Hibbard for his close scrutiny of every word, symbol, number, and figure.

Randy Knight: I would like to thank my Cal Poly colleagues, especially Matt Moelter, for many valuable conversations and suggestions. I am endlessly grateful to my wife Sally for her love, encouragement, and patience, and to our many cats for nothing in particular other than being cats.

Brian Jones: I would like to thank my fellow AAPT and PIRA members for their insight and ideas, the creative students and colleagues who are my partners in the Little Shop of Physics, the students in my College Physics classes who help me become a better teacher, and, most of all, my wife Carol, my best friend and gentlest editor, whose love makes the journey worthwhile.

Stuart Field: I would like to thank my wife Julie and my children, Sam and Ellen, for their love, support, and encouragement.

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Special thanks go to our third edition review panel: Taner Edis, Marty Gelfand, Jason Harlow, Charlie Hibbard, Jeff Loats, Amy Pope, and Bruce Schumm.

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Pearson would like to thank and acknowledge the following people for their work on the Global Edition:

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Poonam Tandon, *Maharaja Agrasen Institute of Technology*
S. K. Varshney, *Indian Institute of Technology Kharagpur*

Preface to the Student

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

If you are taking a course for which this book is assigned, you probably aren't a physics major or an engineering major. It's likely that you aren't majoring in a physical science. So why are you taking physics?

It's almost certain that you are taking physics because you are majoring in a discipline that requires it. Someone, somewhere, has decided that it's important for you to take this course. And they are right. There is a lot you can learn from physics, even if you don't plan to be a physicist. We regularly hear from doctors, physical therapists, biologists and others that physics was one of the most interesting and valuable courses they took in college.

So, 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.

The concepts and techniques you will learn will have a wide application. In this text we have a special emphasis on applying physics to understanding the living world. You'll use your understanding of charges and electric potential to analyze the electric signal produced when your heart beats. You'll learn how sharks can detect this signal to locate prey and, further, how and why this electric sensitivity seems to allow hammerhead sharks to detect magnetic fields, aiding navigation in the open ocean.

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; if it was, whoever required you to take this course wouldn't bother. The folks who designed your major want you to learn to *reason,* not to "plug and chug." Whatever you end up studying or doing for a career, this ability will serve you well.

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 more effective if you have prepared.
- **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.
- **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.
- **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 tell your hand to turn the pages of this book. It's a remarkable breadth of topics and techniques that is based on a very compact set of organizing principles.

Now, let's get down to work.

Real-World Applications

Applications of biological or medical interest are marked BIO in the list below, including Passage Problems. Other end-of-chapter problems of biological or medical interest are marked BIO in the chapter.

Brief Contents