Preface

College Physics is intended for a two-semester college course in introductory physics using algebra and trigonometry. Our main goals in writing this book are

- to present the basic concepts of physics that students need to know for later courses and future careers,
- to emphasize that physics is a tool for understanding the real world, and
- to teach transferable problem-solving skills that students can use throughout their lives.

We have kept these goals in mind while developing the main themes of the book.

NEW TO THIS EDITION

Although the fundamental philosophy of the book has not changed, detailed feedback from over 130 reviewers (many of whom used the second edition in the classroom) has enabled us to fine-tune our approach to make the text even more user-friendly, conceptually based, and relevant for students. The third edition also has some added features to further facilitate student learning.

A greater emphasis has been placed on fundamental physics concepts:

- **Connections identify areas in each chapter where important concepts are revisited.** A marginal Connections heading and summary adjacent to the coverage in the main text help students easily recognize that a previously introduced concept is being applied to the current discussion. Knowledge is being revisited and further developed—not newly introduced.
- **Checkpoint** questions have been added to applicable sections of the text to **allow students to pause and test their understanding of the concept** explored within the current section. The answers to the Checkpoints are found at the end of the chapter so that students can confirm their knowledge without jumping too quickly to the provided answer.
- The exercises in the **Review & Synthesis** sections have been revised to concentrate even more heavily on **helping students to realize through practice problems how the concepts in the previously covered group of chapters are interrelated**. The number of problems in the Review & Synthesis sections has also been increased in the new edition. (The MCAT review problems have been retained to also help pre-med students focus on the concepts covered in the upcoming exam.)
- **Nonessential coverage and derivations have been moved to the text's website.** This will help students not only to focus further on the fundamental, core concepts in their reading of the text but also allow them to go online for additional information or explanation on topics of interest. identifiers in the text direct students to additional information online.

"Trust me, College Physics *by G/R/R is as good as it gets as far as a college textbook in physics goes. One of the coauthors of this book has been teaching a course at this level for 30 years. This book is a direct result of her 30 years' worth of personal experience, and there is no better substitute for that. It is, without any doubt, one of the best of its kind."*

Dr. Abu Fasihuddin, University of Connecticut

In addition, the following general revisions occur in chapters of the text:

- The topical question from the chapter-opening vignette now appears in the margin (along with a reduced version of the chapter-opening image) to help students identify where in the main text the answer to the chapter-opening question is addressed.
- Applications have been clearly identified as such in the text with a complete listing in the front matter.
- Many helpful subheadings have been added to the text to help students quickly identify new subtopics.
- Portions of the text now caption images to establish a visual connection between the text's concepts and terms and the art and photos.

- Great care was taken by both the authors and the contributors to the third edition to revise the end-of-chapter and Review & Synthesis problems. Approximately 150 problems are new, and an emphasis has been placed on progressing difficulty level to help students gain confidence and reinforce new skills before tackling more challenging problems.

  The following lists major chapter-specific revisions to the text:

Chapter 2: A discussion of unit vectors has been added. Sections 2.1 through 2.4 have been reorganized for a more intuitive presentation.
Chapter 4: A more concise section on air resistance is provided with a more detailed discussion available online.
Chapter 7: Section 7.6 Motion of the Center of Mass has been simplified.
Chapter 8: Example 8.1 has been replaced with a new problem on the rotational inertia of a barbell.
Chapter 10: Section 10.8 The Pendulum has been made much more concise with a more detailed discussion of the physical pendulum available online.
Chapter 11: A new "law box" highlights the physical properties that determine wave speed. The discussion on interference has been expanded for added clarity.
Chapter 12: In Section 12.9, the discussion of shock waves has been shortened. A more detailed discussion is available online.
Chapter 14: A detailed discussion of convection and Example 14.12 Roller Blading in Still Air have been moved online. Section 14.7 is now a brief, conceptual description of convection. Section 14.8 Thermal Radiation has been revised with a clearer description of solar radiation and global warming.
Chapter 15: Section 15.5 Heat Engines has been revised to include a more accurate description of the development of the steam engine. The process of the internal combustion engine is now illustrated in Figure 15.12. Details of the Carnot cycle and a discussion of the statistical interpretation of entropy are available online.
Chapter 16: A new Example 16.7 Electric Field due to Three Point Charges has been added.
Chapter 22: Section 22.1 has been simplified and is now titled Maxwell's Equations and Electromagnetic Waves. A more detailed discussion appears online. The material on antennas has been made more concise.
Chapter 27: The derivation of the radii of the Bohr orbits has been moved online. The section on atomic energy levels has been revised and made more concise.
Chapter 28: Section 28.8 Electron Energy Levels in a solid has been made much more concise with a more detailed discussion available online.
Chapter 30: The discussions of quarks and leptons have been expanded and clarified. The discussion of the standard model is significantly more concise. Twenty-first-century particle physics has been updated, and the most recent information will be provided online.

Please see your McGraw-Hill sales representative for a more detailed list of revisions.

COMPREHENSIVE COVERAGE

Students should be able to get the whole story from the book. The first edition text was tested in our self-paced course, where students must rely on the textbook as their primary learning resource. Nonetheless, completeness and clarity are equally advantageous when the book is used in a more traditional classroom setting. *College Physics* frees the instructor from having to try to "cover" everything. The instructor can then tailor class time to more important student needs—reinforcing difficult concepts, working through example problems, engaging the students in cooperative learning activities, describing applications, or presenting demonstrations.

INTEGRATING CONCEPTUAL PHYSICS INTO A QUANTITATIVE COURSE

Some students approach introductory physics with the idea that physics is just the memorization of a long list of equations and the ability to plug numbers into those equations. We want to help students see that a relatively small number of basic physics concepts are applied to a wide variety of situations. Physics education research has shown that students do not automatically acquire conceptual understanding; the concepts must be explained and the students given a chance to grapple with them. Our presentation, based on years of teaching this course, blends conceptual understanding with analytical skills. The **Conceptual Examples** and **Conceptual Practice Problems** in the text and a variety of Conceptual and Multiple-Choice Questions at the end of each chapter give students a chance to check and to enhance their conceptual understanding.

"Conceptual ideas are important, ideas must be motivated, physics should be integrated, a coherent problem-solving approach should be developed. I'm not sure other books are as explicit in these goals, or achieve them as well as Giambattista, Richardson, and Richardson."

Dr. Michael G. Strauss, University of Oklahoma

INTRODUCING CONCEPTS INTUITIVELY

We introduce key concepts and quantities in an informal way by establishing why the quantity is needed, why it is useful, and why it needs a precise definition. Then we make a transition from the informal, intuitive idea to a formal definition and name. Concepts motivated in this way are easier for students to grasp and remember than are concepts introduced by seemingly arbitrary, formal definitions.

For example, in Chapter 8, the idea of rotational inertia emerges in a natural way from the concept of rotational kinetic energy. Students can understand that a rotating rigid body has kinetic energy due to the motion of its particles. We discuss why it is useful to be able to write this kinetic energy in terms of a single quantity common to all the particles (the angular speed), rather than as a sum involving particles with many different speeds. When students understand why rotational inertia is defined the way it is, they are better prepared to move on to the concepts of torque and angular momentum.

We avoid presenting definitions or formulas without any motivation. When an equation is not derived in the text, we at least describe where the equation comes from or give a plausibility argument. For example, Section 9.9 introduces Poiseuille's law with two identical pipes in series to show why the volume flow rate must be proportional to the pressure drop per unit length. Then we discuss why $\Delta V/\Delta t$ is proportional to the fourth power of the radius (rather than to r^2, as it would be for an ideal fluid).

Similarly, we have found that the definitions of the displacement and velocity vectors seem arbitrary and counterintuitive to students if introduced without any motivation. Therefore, we precede any discussion of kinematic quantities with an introduction to Newton's laws, so students know that forces determine how the state of motion of an object changes. Then, when we define the kinematic quantities to give a precise definition of acceleration, we can apply Newton's second law quantitatively to see how forces affect the motion. We give particular attention to laying the groundwork for a concept when its name is a common English word such as *velocity* or *work.*

"The authors are clearly very able to communicate in written English. The text is well written, not concise to the point of density, but not discursive to the point of long-windedness. A real pleasure to read."

Dr. Galen T. Pickett, California State University, Long Beach

WRITTEN IN CLEAR AND FRIENDLY STYLE

We have kept the writing down-to-earth and conversational in tone—the kind of language an experienced teacher uses when sitting at a table working one-on-one with a student. We hope students will find the book pleasant to read, informative, and accurate without seeming threatening, and filled with analogies that make abstract concepts easier to grasp. We want students to feel confident that they can learn by studying the textbook.

"At this point, I have had students for both semesters of college physics. I have commented to them that G/R/R uses a nonstandard approach to physics by doing forces first. Some of them are puzzled by the standard approach of kinematics first; one even said 'how can you do anything without forces?' I agree, the authors and McGraw-Hill should be commended for their willingness to do something different."

Dr. Carl Covatto, Arizona State University

While learning correct physics terminology is essential, we avoid all *unnecessary* jargon—terminology that just gets in the way of the student's understanding. For example, we never use the term *centripetal force,* since its use sometimes leads students to add a spurious "centripetal force" to their free-body diagrams. Likewise, we use *radial component of acceleration* because it is less likely to introduce or reinforce misconceptions than *centripetal acceleration.*

INNOVATIVE ORGANIZATION

There are a few places where, for pedagogical reasons, the organization of this text differs from that of most textbooks. The most significant reorganization is in the treatment of forces and motion. In *College Physics*, the central theme of Chapters 2–4 is *force.* Kinematics is introduced as a tool to understand how forces affect motion. Overall, we spend less time on kinematics and more time on forces than other texts do. This approach has the following advantages:

- The first few chapters in any text set up student expectations that are hard to change later. If the course starts with a series of definitions of the kinematic quantities, with no explanation of *why* we are interested in those quantities, students may see physics as a series of equations to memorize and manipulate.
- We explain to students that the kinematic concepts help us understand the effect that a net force has on the motion of an object. Newton's second law is presented as the key reason why we need a precise definition of acceleration. Defining acceleration requires precise definitions of displacement and velocity. If the definitions of these quantities are imprecise, we cannot hope to understand how forces affect the motion of an object.
- Learning constant-acceleration kinematics before forces may suggest to students that physics is not connected to the real world. If they are told that objects all fall with the same acceleration—which they know from experience to be false—they learn not to trust the principles they're learning. With an understanding of forces and Newton's laws, *College Physics* shows that constant acceleration is an approximation and explains how to judge when that approximation is reasonable.
- We use correct vector notation, terminology, and methods from the very beginning. Even in a one-dimensional problem, displacements, velocities, and accelerations are always treated as vector quantities. For example, we carefully distinguish components from magnitudes by writing "$v_x = -5$ m/s" and never "$v = -5$ m/s," even if the object moves only along the x-axis. Several professors, who used our first edition in place of a previous textbook, reported a reduction in the number of students struggling with vector components.
- We begin in Chapter 2 with Newton's laws of motion so the students can build a solid conceptual framework in simpler situations before the mathematics gets more complex. If forces were not introduced until Chapter 4, the students would have much less time to overcome conceptual difficulties associated with Newton's laws and would have much less practice applying them.

"The text met my goals in teaching force and vector before getting into kinematics and paying special emphasis on conceptual understanding rather than solving equations."

Dr. Bjoern Seipel, Portland State University

"The present sequence does a better job of emphasizing fundamental topics early before the details of kinematics are handled and I believe that this is an important advance over most texts."

Dr. David V. Baxter, Indiana University

ACCURACY ASSURANCE

The authors and the publisher acknowledge the fact that inaccuracies can be a source of frustration for both the instructor and students. Therefore, throughout the writing and production of this edition, we have worked diligently to eliminate errors and inaccuracies. Bill Fellers of Fellers Math & Science conducted an independent accuracy check and worked all end-of-chapter questions and problems in the final draft of the manuscript. He then coordinated the resolution of discrepancies between accuracy checks, ensuring the accuracy of the text, the end-of-book answers, and the solutions manuals. Corrections were then made to the manuscript before it was typeset.

The page proofs of the text were double-proofread against the manuscript to ensure the correction of any errors introduced when the manuscript was typeset. The textual examples, practice problems and solutions, end-of-chapter questions and problems, and problem answers were accuracy checked by Fellers Math & Science again at the page proof stage after the manuscript was typeset. This last round of corrections was then cross-checked against the solutions manuals.

PROVIDING STUDENTS WITH THE TOOLS THEY NEED

Problem-Solving Approach

Problem-solving skills are central to an introductory physics course. We illustrate these skills in the example problems. Lists of problem-solving strategies are sometimes useful; we provide such strategies when appropriate. However, the most elusive skills—perhaps the most important ones—are subtle points that defy being put into a neat list. To develop real problem-solving expertise, students must learn how to think critically and analytically. Problem solving is a multidimensional, complex process; an algorithmic approach is not adequate to instill real problem-solving skills.

Strategy We begin each example with a discussion—in language that the students can understand—of the *strategy* to be used in solving the problem. The strategy illustrates the kind of analytical thinking students must do when attacking a problem: How do I decide what approach to use? What laws of physics apply to the problem and which of them are *useful* in this solution? What clues are given in the statement of the question? What information is implied rather than stated outright? If there are several valid approaches, how do I determine which is the most efficient? What assumptions can I make? What kind of sketch or graph might help me solve the problem? Is a simplification or approximation called for? If so, how can I tell if the simplification is valid? Can I make a preliminary estimate of the answer? Only after considering these questions can the student effectively solve the problem.

"The major strength of this text is its approach, which makes students think out the problems, rather than always relying on a formula to get an answer. The way the authors encourage students to investigate whether the answer makes sense, and compare the magnitude of the answer with common sense is good also."

Dr. Jose D'Arruda,
University of North Carolina,
Pembroke

Solution Next comes the detailed *solution* to the problem. Explanations are intermingled with equations and step-by-step calculations to help the student understand the approach used to solve the problem. We want the student to be able to follow the mathematics without wondering, "Where did that come from?"

Discussion The numerical or algebraic answer is not the end of the problem; our examples end with a *discussion.* Students must learn how to determine whether their answer is consistent and reasonable by checking the order of magnitude of the answer, comparing the answer to a preliminary estimate, verifying the units, and doing an independent calculation when more than one approach is feasible. When there are several different approaches, the discussion looks at the advantages and disadvantages of each approach. We also discuss the implications of the answer—what can we learn from it? We look at special cases and look at "what if" scenarios. The discussion sometimes generalizes the problem-solving techniques used in the solution.

"I understood the math, mostly because it was worked out step-by-step, which I like."

Student, Bradley University

Practice Problem After each Example, a Practice Problem gives students a chance to gain experience using the same physics principles and problem-solving tools. By comparing their answers to those provided at the end of each chapter, they can gauge their understanding and decide whether to move on to the next section.

Our many years of experience in teaching the college physics course in a one-on-one setting has enabled us to anticipate where we can expect students to have difficulty. In addition to the consistent problem-solving approach, we offer several other means of assistance to the student throughout the text. A boxed problem-solving strategy gives detailed information on solving a particular type of problem, while an icon for problem-solving tips draws attention to techniques that can be used in a variety of contexts. A hint in a worked example or end-of-chapter problem provides a clue on what approach to use or what simplification to make. A warning icon ⚠ emphasizes an explanation that clarifies a possible point of confusion or a common student misconception.

An important problem-solving skill that many students lack is the ability to extract information from a graph or to sketch a graph without plotting individual data points. Graphs often help students visualize physical relationships more clearly than they can do with algebra alone. We emphasize the use of graphs and sketches in the text, in worked examples, and in the problems.

"The warning signs about many of the misconceptions, traps, and common mistakes is a very helpful and novel idea. Those of us who have taught undergraduate students in service courses have spent considerable time on these. It is good to see them in a book."

Dr. H.R. Chandrasekhar, University of Missouri, Columbia

Using Approximation, Estimation, and Proportional Reasoning

College Physics is forthright about the constant use of simplified models and approximations in solving physics problems. One of the most difficult aspects of problem solving that students need to learn is that some kind of simplified model or approximation is usually required. We discuss how to know when it is reasonable to ignore friction, treat g as constant, ignore viscosity, treat a charged object as a point charge, or ignore diffraction.

Some Examples and Problems require the student to make an estimate—a useful skill both in physics problem solving and in many other fields. Similarly, we teach proportional reasoning as not only an elegant shortcut but also as a means to understanding patterns. We frequently use percentages and ratios to give students practice in using and understanding them.

"I have tried a number of texts in this course over the past 30 years that I have taught Physics 116–117, and I can assure you that G/R/R is the one I (and the students . . .) like the best. The explanations are clear, and the graphics are excellent—the best I have seen anywhere. And the structure of the question and problem sets is very good. G/R/R is the best standard algebra-based text I have ever seen."

Dr. Carey E. Stronach, Virginia State University

Showcasing an Innovative Art Program

To help show that physics is more than a collection of principles that explain a set of contrived problems, in every chapter we have developed a system of illustration's, ranging from simpler diagrams to ellaborate and beautiful illustrations, that brings to life the connections between physics concepts and the complex ways in which they are applied. We believe these illustrations, with subjects ranging from three-dimensional views of electric field lines to the biomechanics of the human body and from representations of waves to the distribution of electricity in the home, will help students see the power and beauty of physics.

Helping Students See the Relevance of Physics in Their Lives

Students in an introductory college physics course have a wide range of backgrounds and interests. We stimulate interest in physics by relating the principles to applications relevant to students' lives and in line with their interests. The text, examples, and end-of-chapter problems draw from the everyday world; from familiar technological applications; and from other fields such as biology, medicine, archaeology, astronomy, sports, environmental science, and geophysics. (Applications in the text are identified with a text heading or marginal note. An icon (⚕) identifies applications in the biological or medical sciences.)

The **Physics at Home** experiments give students an opportunity to explore and see physics principles operate in their everyday lives. These activities are chosen for their simplicity and for the effective demonstration of physics principles.

Each **Chapter Opener** includes a photo and vignette, designed to capture student interest and maintain it throughout the chapter. The vignette describes the situation shown in the photo and asks the student to consider the relevant physics. A reduced version of the chapter opener photo and question marks where the topic from the vignette is addressed within the chapter.

Focusing on the Concepts

To focus on the basic, core concepts of physics and reinforce for students that all of physics is based on a few, fundamental ideas, within chapters we have developed **Connections** to identify areas where important concepts are revisited. A marginal Connections heading and summary adjacent to the coverage in the main text help students easily recognize that a previously introduced concept is being applied to the current discussion. Knowledge is being built-up—not newly introduced.

The exercises in the **Review & Synthesis sections** have been revised to increase the number of available exercises and to also concentrate even more heavily on helping students to realize through practice problems how the concepts in the previously covered group of chapters are interrelated.

Checkpoint questions have been added to applicable sections of the text to allow students to pause and test their understanding of the concept explored within the current section. The answers to the Checkpoints are found at the end of the chapter so that students can confirm their knowledge without jumping too quickly to the provided answer.

Applications are clearly identified as such in the text with a complete listing in the front matter. With Applications, students have the opportunity to see how physics concepts are experienced through their everyday lives.

icons identify opportunities for students to access additional information or explanation of topics of interest online. This will help students to focus even further on just the very fundamental, core concepts in their reading of the text.

ADDITIONAL RESOURCES FOR INSTRUCTORS AND STUDENTS

Online Homework and Resources

McGraw-Hill's *College Physics* website offers online electronic homework along with a myriad of resources for both instructors and students. Instructors can create homework with easy-to-assign algorithmically generated problems from the text and the simplicity of automatic grading and reporting:

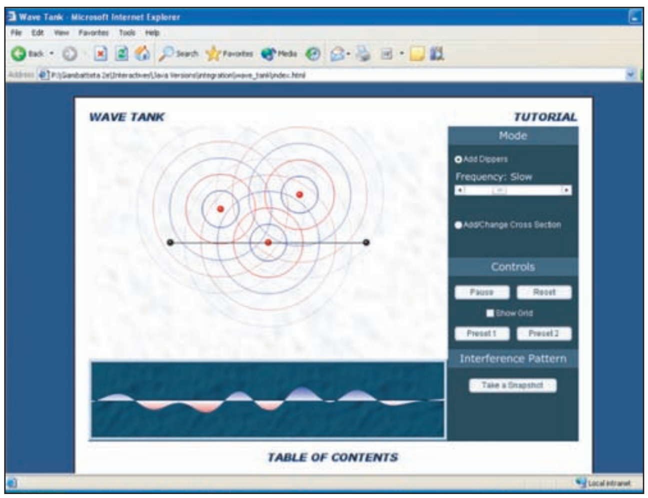
- The end-of-chapter problems and Review & Synthesis exercises appear in the online homework system in diverse formats and with various tools.
- The online homework system incorporates new and exciting interactive tools and problem types: ranking problems, a graphing tool, a free-body diagram drawing tool, symbolic entry, a math palette, and multi-part problems.

Instructors also have access to PowerPoint lecture outlines, an Instructor's Resource Guide with solutions, suggested demonstrations, electronic images from the text, clicker questions, quizzes, tutorials, interactive simulations, and many other resources directly tied to text-specific materials in *College Physics*. Students have access to self-quizzing, interactive simulations, tutorials, selected solutions for the text's problems, and more.

See www.mhhe.com/grr to learn more and register.

Electronic Media Integrated with the Text

McGraw-Hill is proud to bring you an assortment of outstanding interactives and tutorials like no other. These activities offer a fresh and dynamic method to teach the physics basics by providing students with activities that work with real data. icons identify areas in the text where additional understanding can be gained through work with an interactive or tutorial on the text website.



The interactives allow students to manipulate parameters and gain a better understanding of the more difficult physics concepts by watching the effect of these manipulations. Each interactive includes:

- Analysis tool (interactive model)
- Tutorial describing its function
- Content describing its principle themes

The text website contains accompanying interactive quizzes. An instructor's guide for each interactive with a complete overview of the content and navigational tools, a quick demonstration description, further study with the textbook, and suggested end-of-chapter follow-up questions is also provided as an online instructor's resource.

The tutorials, developed and integrated by Raphael Littauer of Cornell University, provide the opportunity for students to approach a concept in steps. Detailed feedback is provided when students enter an incorrect response, which encourages students to further evaluate their responses and helps them progress through the problem.

Electronic Book Images and Assets for Instructors

Build instructional materials wherever, whenever, and however you want!

Accessed from the *College Physics* website, an online digital library containing photos, artwork, interactives, and other media types can be used to create customized lectures, visually enhanced tests and quizzes, compelling course websites, or attractive printed support materials. Assets are copyrighted by McGraw-Hill Higher Education, but can be used by instructors for classroom purposes. The visual resources in this collection include

- **Art** Full-color digital files of all illustrations in the book can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. In addition, all files are preinserted into PowerPoint slides for ease of lecture preparation.
- **Active Art Library** These key art pieces—formatted as PowerPoint slides—allow you to illustrate difficult concepts in a step-by-step manner. The artwork is broken into small, incremental pieces, so you can incorporate the illustrations into your lecture in whatever sequence or format you desire.
- **Photos** The photos collection contains digital files of photographs from the text, which can be reproduced for multiple classroom uses.
- **Worked Example Library, Table Library, and Numbered Equations Library** Access the worked examples, tables, and equations from the text in electronic format for inclusion in your classroom resources.
- **Interactives** Flash files of the physics interactives described earlier are included so that you can easily make use of the interactives in a lecture or classroom setting.

Also residing on your textbook's website are

- **PowerPoint Lecture Outlines** Ready-made presentations that combine art and lecture notes are provided for each chapter of the text.
- **PowerPoint Slides** For instructors who prefer to create their lectures from scratch, all illustrations and photos are preinserted by chapter into blank PowerPoint slides.

Computerized Test Bank Online

A comprehensive bank of over 2000 test questions in multiple-choice format at a variety of difficulty levels is provided within a computerized test bank powered by McGraw-Hill's flexible electronic testing program—EZ Test Online (www.eztestonline.com). EZ Test Online allows you to create paper and online tests or quizzes in this easy-to-use program!

Imagine being able to create and access your test or quiz anywhere, at any time without installing the testing software. Now, with EZ Test Online, instructors can select questions from multiple McGraw-Hill test banks or create their own, and then either print the test for paper distribution or give it online. See www.mhhe.com/grr for more information.

Electronic Books

If you or your students are ready for an alternative version of the traditional textbook, McGraw-Hill brings you innovative and inexpensive electronic textbooks. By purchasing

E-books from McGraw-Hill, students can save as much as 50% on selected titles delivered on the most advanced E-book platforms available.

E-books from McGraw-Hill are smart, interactive, searchable, and portable, with such powerful built-in tools as detailed searching, highlighting, note taking, and student-to-student or instructor-to-student note sharing. E-books from McGraw-Hill will help students to study smarter and quickly find the information they need. E-books also saves students money. Contact your McGraw-Hill sales representative to discuss E-book packaging options.

Personal Response Systems

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

Instructor's Resource Guide

The *Instructor's Resource Guide* includes many unique assets for instructors, such as demonstrations, suggested reform ideas from physics education research, and ideas for incorporating just-in-time teaching techniques. It also includes answers to the end-of-chapter conceptual questions and complete, worked-out solutions for all the end-of-chapter problems from the text. The Instructors Resource Guide is available in the Instructor Resources on the text's website.

ALEKS®

Help students master the math skills needed to understand difficult physics problems. ALEKS® [Assessment and LEarning in Knowledge Spaces] is an artificial intelligence–based system for individualized math learning available via the World Wide Web.

ALEKS® is

- A robust course management system. It tells you exactly what your students know and don't know.
- Focused and efficient. It enables students to quickly master the math needed for college physics.
- Artificial intelligence. It totally individualizes assessment and learning.
- Customizable. Click on or off each course topic.
- Web based. Use a standard browser for easy Internet access.
- Inexpensive. There are no setup fees or site license fees.

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Student Solutions Manual

The *Student Solutions Manual* contains complete worked-out solutions to selected end-of-chapter problems and questions, selected Review & Synthesis problems, and the MCAT Review Exercises from the text. The solutions in this manual follow the problem-solving strategy outlined in the text's examples and also guide students in creating diagrams for their own solutions.

For more information, contact a McGraw-Hill customer service representative at (800) 338–3987, or by email at www.mhhe.com. To locate your sales representative, go to www.mhhe.com for Find My Sales Rep.