VOLUME 2

COLLEGE PHYSICS

SERWAY / VUILLE > EIGHTH EDITION

VOLUME 2 > Chapters 15–30

COLLEGE PHYSICS

EIGHTH EDITION

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PEDAGOGICAL COLOR CHART

Mechanics

Displacement and position vectors

Linear ($\vec{\mathbf{v}}$) and angular ($\vec{\boldsymbol{\omega}}$) velocity vectors

Velocity component vectors

Force vectors ($\vec{\mathbf{F}}$)

Force component vectors

Acceleration vectors ($\vec{\mathbf{a}}$)

Acceleration component vectors

Linear ($\vec{\mathbf{p}}$) and angular ($\vec{\mathbf{L}}$) momentum vectors

Torque vectors ($\vec{\boldsymbol{\tau}}$)

Linear or rotational motion directions

Springs

Pulleys

Electricity and Magnetism

Electric fields

Magnetic fields

Positive charges

Negative charges

Resistors

Batteries and other DC power supplies

Switches

Capacitors

Inductors (coils)

Voltmeters

Ammeters

AC Sources

Ground symbol

Current

Light and Optics

Light rays

Lenses and prisms

Mirrors

Objects

Images

CONVERSION FACTORS

Length

1 m = 39.37 in. = 3.281 ft

1 in. = 2.54 cm (exact)

1 km = 0.621 mi

1 mi = 5 280 ft = 1.609 km

1 lightyear (ly) = 9.461×10^{15} m

1 angstrom (Å) = 10^{-10} m

Mass

1 kg = 10^3 g = 6.85×10^{-2} slug

1 slug = 14.59 kg

1 u = 1.66×10^{-27} kg = 931.5 MeV/c^2

Time

1 min = 60 s

1 h = 3 600 s

1 day = 24 h = 1.44×10^3 min = 8.64×10^4 s

1 yr = 365.242 days = 3.156×10^7 s

Volume

1 L = 1 000 cm^3 = 0.035 3 ft^3

1 ft^3 = 2.832×10^{-2} m^3

1 gal = 3.786 L = 231 in.^{3}

Angle

180° = π rad

1 rad = 57.30°

1° = 60 min = 1.745×10^{-2} rad

Speed

1 km/h = 0.278 m/s = 0.621 mi/h

1 m/s = 2.237 mi/h = 3.281 ft/s

1 mi/h = 1.61 km/h = 0.447 m/s = 1.47 ft/s

Force

1 N = 0.224 8 lb = 10^5 dynes

1 lb = 4.448 N

1 dyne = 10^{-5} N = 2.248×10^{-6} lb

Work and energy

1 J = 10^7 erg = 0.738 ft · lb = 0.239 cal

1 cal = 4.186 J

1 ft · lb = 1.356 J

1 Btu = 1.054×10^3 J = 252 cal

1 J = 6.24×10^{18} eV

1 eV = 1.602×10^{-19} J

1 kWh = 3.60×10^6 J

Pressure

1 atm = 1.013×10^5 N/m^2 (or Pa) = 14.70 lb/in.^{2}

1 Pa = 1 N/m^2 = 1.45×10^{-4} lb/in.^{2}

1 lb/in.^{2} = 6.895×10^3 N/m^2

Power

1 hp = 550 ft · lb/s = 0.746 kW

1 W = 1 J/s = 0.738 ft · lb/s

1 Btu/h = 0.293 W

We dedicate this book
to our colleague Jerry S. Faughn, whose dedication
to all aspects of the project and tireless efforts through the years
are deeply appreciated.

PREFACE

College Physics is written for a one-year course in introductory physics usually taken by students majoring in biology, the health professions, and other disciplines including environmental, earth, and social sciences, and technical fields such as architecture. The mathematical techniques used in this book include algebra, geometry, and trigonometry, but not calculus.

This textbook, which covers the standard topics in classical physics and 20th-century physics, is divided into six parts. Part 1 (Chapters 1–9) deals with Newtonian mechanics and the physics of fluids; Part 2 (Chapters 10–12) is concerned with heat and thermodynamics; Part 3 (Chapters 13 and 14) covers wave motion and sound; Part 4 (Chapters 15–21) develops the concepts of electricity and magnetism; Part 5 (Chapters 22–25) treats the properties of light and the field of geometric and wave optics; and Part 6 (Chapters 26–30) provides an introduction to special relativity, quantum physics, atomic physics, and nuclear physics.

OBJECTIVES

The main objectives of this introductory textbook are twofold: to provide the student with a clear and logical presentation of the basic concepts and principles of physics, and to strengthen an understanding of the concepts and principles through a broad range of interesting applications to the real world. To meet those objectives, we have emphasized sound physical arguments and problem-solving methodology. At the same time we have attempted to motivate the student through practical examples that demonstrate the role of physics in other disciplines.

CHANGES TO THE EIGHTH EDITION

A number of changes and improvements have been made to this edition. Based on comments from users of the seventh edition and reviewers' suggestions, a major effort was made to increase the emphasis on conceptual understanding, to add new end-of-chapter questions and problems that are informed by research, and to improve the clarity of the presentation. The new pedagogical features added to this edition are based on current trends in science education. The following represent the major changes in the eighth edition.

Questions and Problems

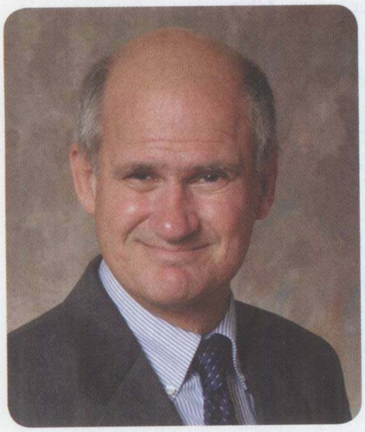
We have substantially revised the end-of-chapter questions and problems for this edition. Three new types of questions and problems have been added:

- **Multiple-Choice Questions** have been introduced with several purposes in mind. Some require calculations designed to facilitate students' familiarity with the equations, the variables used, the concepts the variables represent, and the relationships between the concepts. The rest are conceptual and are designed to encourage conceptual thinking. Finally, many students are required to take multiple-choice tests, so some practice with that form of question is desirable. Here is an example of a multiple-choice question:

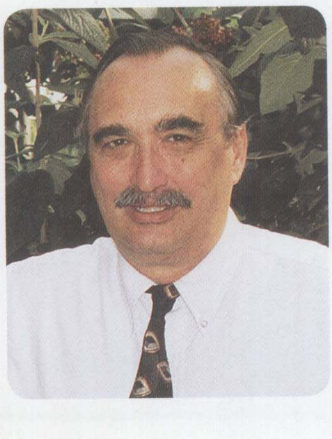
  12. A truck loaded with sand accelerates along a highway. The driving force on the truck remains constant. What happens to the acceleration of the truck as its trailer leaks sand at a constant rate through a hole in its bottom? (a) It decreases at a steady rate. (b) It increases at a steady rate. (c) It increases and then decreases. (d) It decreases and then increases. (e) It remains constant.

About the Authors

Raymond A. Serway received his doctorate at Illinois Institute of Technology and is Professor Emeritus at James Madison University. In 1990 he received the Madison Scholar Award at James Madison University, where he taught for 17 years. Dr. Serway began his teaching career at Clarkson University, where he conducted research and taught from 1967 to 1980. He was the recipient of the Distinguished Teaching Award at Clarkson University in 1977 and of the Alumni Achievement Award from Utica College in 1985. As Guest Scientist at the IBM Research Laboratory in Zurich, Switzerland, he worked with K. Alex Müller, 1987 Nobel Prize recipient. Dr. Serway also was a visiting scientist at Argonne National Laboratory, where he collaborated with his mentor and friend, Sam Marshall. In addition to earlier editions of this textbook, Dr. Serway is the coauthor of *Principles of Physics*, fourth edition; *Physics for Scientists and Engineers*, seventh edition; *Essentials of College Physics*; and *Modern Physics*, third edition. He also is the coauthor of the high school textbook *Physics*, published by Holt, Rinehart and Winston. In addition, Dr. Serway has published more than 40 research papers in the field of condensed matter physics and has given more than 70 presentations at professional meetings. Dr. Serway and his wife, Elizabeth, enjoy traveling, golf, gardening, singing in a church choir, and spending time with their four children and eight grandchildren.



Chris Vuille is an associate professor of physics at Embry-Riddle Aeronautical University (ERAU), Daytona Beach, Florida, the world's premier institution for aviation higher education. He received his doctorate in physics from the University of Florida in 1989 and moved to Daytona after a year at ERAU's Prescott, Arizona, campus. Although he has taught courses at all levels, including postgraduate, his primary interest has been the delivery of introductory physics. He has received several awards for teaching excellence, including the Senior Class Appreciation Award (three times). He conducts research in general relativity and quantum theory, and was a participant in the JOVE program, a special three-year NASA grant program during which he studied neutron stars. His work has appeared in a number of scientific journals, and he has been a featured science writer in *Analog Science Fiction/Science Fact* magazine. In addition to this textbook, he is coauthor of *Essentials of College Physics.* Dr. Vuille enjoys tennis, swimming, and playing classical piano, and he is a former chess champion of St. Petersburg and Atlanta. In his spare time he writes fiction and goes to the beach. His wife, Dianne Kowing, is an optometrist for a local Veterans' Administration clinic. His daughter, Kira Vuille-Kowing, is a meteorology/communications double major at ERAU and a graduate of her father's first-year physics course. He has two sons, Christopher, a cellist and fisherman, and James, avid reader of Disney comics.



Jerry S. Faughn earned his doctorate at the University of Mississippi. He is Professor Emeritus and former chair of the Department of Physics and Astronomy at Eastern Kentucky University. Dr. Faughn has also written a microprocessor interfacing text for upper-division physics students. He is coauthor of a nonmathematical physics text and a physical science text for general education students, and (with Dr. Serway) the high-school textbook *Physics,* published by Holt, Reinhart and Winston. He has taught courses ranging from the lower division to the graduate level, but his primary interest is in students just beginning to learn physics. Dr. Faughn has a wide variety of hobbies, among which are reading, travel, genealogy, and old-time radio. His wife, Mary Ann, is an avid gardener, and he contributes to her efforts by staying out of the way. His daughter, Laura, is in family practice, and his son, David, is an attorney.

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The instructor may select multiple-choice questions to assign as homework or use them in the classroom, possibly with "peer instruction" methods or in conjunction with "clicker" systems. More than 180 multiple-choice questions are included in Volume 2. Answers to odd-numbered multiple-choice questions are included in the Answers section at the end of the book and answers to all questions are found in the *Instructor's Solutions Manual* and on the instructor's *PowerLecture CD-ROM.*

- **Enhanced Content problems** require symbolic or conceptual responses from the student.

A *symbolic Enhanced Content problem* requires the student to obtain an answer in terms of symbols. In general, some guidance is built into the problem statement. The goal is to better train the student to deal with mathematics at a level appropriate to this course. Most students at this level are uncomfortable with symbolic equations, which is unfortunate because symbolic equations are the most efficient vehicle for presenting relationships between physics concepts. Once students understand the physical concepts, their ability to solve problems is greatly enhanced. As soon as the numbers are substituted into an equation, however, all the concepts and their relationships to one another are lost, melded together in the student's calculator. The symbolic Enhanced Content problems train students to postpone substitution of values, facilitating their ability to think conceptually using the equations. An example of a symbolic Enhanced Content problem is provided here:

14. ecp An object of mass m is dropped from the roof of a building of height h. While the object is falling, a wind blowing parallel to the face of the building exerts a constant horizontal force F on the object. (a) How long does it take the object to strike the ground? Express the time t in terms of g and h. (b) Find an expression in terms of m and F for the acceleration a_x of the object in the horizontal direction (taken as the positive x-direction). (c) How far is the object displaced horizontally before hitting the ground? Answer in terms of m, g, F, and h. (d) Find the magnitude of the object's acceleration while it is falling, using the variables F, m, and g.

A *conceptual Enhanced Content problem* encourages the student to think verbally and conceptually about a given physics problem rather than rely solely on computational skills. Research in physics education suggests that standard physics problems requiring calculations may not be entirely adequate in training students to think conceptually. Students learn to substitute numbers for symbols in the equations without fully understanding what they are doing or what the symbols mean. The conceptual Enhanced Content problem combats this tendency by asking for answers that require something other than a number or a calculation. An example of a conceptual Enhanced Concept problem is provided here:

4. ecp A shopper in a supermarket pushes a cart with a force of 35 N directed at an angle of 25° below the horizontal. The force is just sufficient to overcome various frictional forces, so the cart moves at constant speed. (a) Find the work done by the shopper as she moves down a 50.0-m length aisle. (b) What is the net work done on the cart? Why? (c) The shopper goes down the next aisle, pushing horizontally and maintaining the same speed as before. If the work done by frictional forces doesn't change, would the shopper's applied force be larger, smaller, or the same? What about the work done on the cart by the shopper?

- **Guided Problems** help students break problems into steps. A physics problem typically asks for one physical quantity in a given context. Often, however, several concepts must be used and a number of calculations are required to get that final answer. Many students are not accustomed to this level of complexity and often don't know where to start. A *Guided Problem* breaks a standard problem into smaller steps, enabling students to grasp all the concepts and strategies required to arrive at a correct solution. Unlike standard physics problems, guidance is often built into the problem statement. For example, the problem might say "Find the speed using conservation of energy" rather than only asking for the speed. In any given chapter there are usually two or three problem types that are particularly suited to this problem form. The problem must have a certain level of complexity, with a similar problem-solving strategy involved each time it appears. Guided Problems are reminiscent of how a student might interact with a professor in an office visit. These problems help train students to break down complex problems into a series of simpler problems, an essential problem-solving skill. An example of a Guided Problem is provided here:

32. GP Two blocks of masses m_1 and m_2 ($m_1 > m_2$) are placed on a frictionless table in contact with each other. A horizontal force of magnitude F is applied to the block of mass m_1 in Figure P4.32. (a) If P is the magnitude of the contact force between the blocks, draw the free-body diagrams for each block. (b) What is the net force on the system consisting of both blocks? (c) What is the net force acting on m_1? (d) What is the net force acting on m_2? (e) Write the x-component of Newton's second law for each block. (f) Solve the resulting system of two equations and two unknowns, expressing the acceleration a and contact force P in terms of the masses and force. (g) How would the answers change if the force had been applied to m_2 instead? (*Hint*: use symmetry; don't calculate!) Is the contact force larger, smaller, or the same in this case? Why?

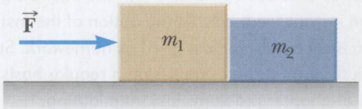

FIGURE P4.32

In addition to these three new question and problem types, we carefully reviewed all other questions and problems for this revision to improve their variety, interest, and pedagogical value while maintaining their clarity and quality. Approximately 30% of the questions and problems in this edition are new.

Examples

In the last edition all in-text worked examples were reconstituted in a two-column format to better aid student learning and help reinforce physical concepts. For this eighth edition we have reviewed all the worked examples, made improvements, and added a new *Question* at the end of each worked example. The Questions usually require a conceptual response or determination, or estimates requiring knowledge of the relationships between concepts. The answers for the new Questions can be found at the back of the book. A sample of an in-text worked example follows on the next page, with an explanation of each of the example's main parts:

The **Goal** describes the physical concepts being explored within the worked example.

The **Problem** statement presents the problem itself.

The **Strategy** section helps students analyze the problem and create a framework for working out the solution.

The **Solution** section uses a two-column format that gives the explanation for each step of the solution in the left-hand column, while giving each accompanying mathematical step in the right-hand column. This layout facilitates matching the idea with its execution and helps students learn how to organize their work. Another benefit: students can easily use this format as a training tool, covering up the solution on the right and solving the problem using the comments on the left as a guide.

EXAMPLE 13.7 Measuring the Value of g

Goal Determine g from pendulum motion.

Problem Using a small pendulum of length 0.171 m, a geophysicist counts 72.0 complete swings in a time of 60.0 s. What is the value of g in this location?

Strategy First calculate the period of the pendulum by dividing the total time by the number of complete swings. Solve Equation 13.15 for g and substitute values.

Solution

Calculate the period by dividing the total elapsed time by the number of complete oscillations:

$$T = \frac{\text{time}}{\text{\# of oscillations}} = \frac{60.0 \text{ s}}{72.0} = 0.833 \text{ s}$$

Solve Equation 13.15 for g and substitute values:

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \rightarrow \quad T^2 = 4\pi^2\frac{L}{g}$$

$$g = \frac{4\pi^2 L}{T^2} = \frac{(39.5)(0.171 \text{ m})}{(0.833 \text{ s})^2} = 9.73 \text{ m/s}^2$$

Remark Measuring such a vibration is a good way of determining the local value of the acceleration of gravity.

QUESTION 13.7

True or False: A simple pendulum of length 0.50 m has a larger frequency of vibration than a simple pendulum of length 1.0 m.

EXERCISE 13.7

What would be the period of the 0.171-m pendulum on the Moon, where the acceleration of gravity is 1.62 m/s^2?

Answer 2.04 s

Remarks follow each Solution and highlight some of the underlying concepts and methodology used in arriving at a correct solution. In addition, the remarks are often used to put the problem into a larger, real-world context.

Exercise/Answer Every worked example is followed immediately by an exercise with an answer. These exercises allow students to reinforce their understanding by working a similar or related problem, with the answers giving them instant feedback. At the option of the instructor, the exercises can also be assigned as homework. Students who work through these exercises on a regular basis will find the end-of-chapter problems less intimidating.

Question New to this edition, each worked example will feature a conceptual question that promotes student understanding of the underlying concepts contained in the example.

ENHANCED WebAssign

Many Worked Examples are also available to be assigned as Active Examples in the Enhanced WebAssign homework management system (visit **www.serwayphysics.com** for more details).

Online Homework

It is now easier to assign online homework with Serway and Vuille using the widely acclaimed program Enhanced WebAssign. All end-of-chapter problems, active figures, quick quizzes, and most questions and worked examples in this book are available in WebAssign. Most problems include hints and feedback to provide instantaneous reinforcement or direction for that problem. We have also added math remediation tools to help students get up to speed in algebra and trigonometry, animated Active Figure simulations to strengthen students' visualization skills, and video to help students better understand the concepts. Visit **www.serwayphysics.com** to view an interactive demo of this innovative online homework solution.

Content Changes

The text has been carefully edited to improve clarity of presentation and precision of language. We hope that the result is a book both accurate and enjoyable to read. Although the overall content and organization of the textbook are similar to the seventh edition, a few changes were implemented.

- Chapter 15, Electric Forces and Electric Fields, has two worked examples that were upgraded with new parts.
- Chapter 16, Electrical Energy and Capacitance, has a new worked example that illustrates particle dynamics and electric potential. Three other worked examples were upgraded with new parts, and two new quick quizzes were added.
- Chapter 17, Current and Resistance, was reorganized slightly, putting the subsection on power ahead of superconductivity. It also has two new quick quizzes.
- Chapter 18, Direct-Current Circuits, has both a new and a reorganized quick quiz.
- Chapter 19, Magnetism, has a new section on types of magnetic materials as well as a new quick quiz.
- Chapter 20, Induced Voltages and Inductance, has new material on *RL* circuits, along with a new example and quick quiz.
- Chapter 21, Alternating-Current Circuits and Electromagnetic Waves, has a new series of four quick quizzes that were added to drill the fundamentals of AC circuits. The problem-solving strategy for *RLC* circuits was completely revised, and a new physics application on using alternating electric fields in cancer treatment was added.
- Chapter 24, Wave Optics, has an improved example and two new quick quizzes.
- Chapter 26, Relativity, no longer covers relativistic addition of velocities. Three new quick quizzes were added to the chapter.
- Chapter 27, Quantum Physics, was rewritten and streamlined. Two superfluous worked examples were eliminated (old Examples 27.1 and 27.2) because both are discussed adequately in the text. One of two worked examples on the Heisenberg uncertainty principle was deleted and a new quick quiz was added. The scanning tunneling microscope application was deleted.
- Chapter 28, Atomic Physics, was rewritten and streamlined, and the subsection on spin was transferred to the section on quantum mechanics. The section on electron clouds was shortened and made into a subsection. The sections on atomic transitions and lasers were combined into a single, shorter section.
- Chapter 29, Nuclear Physics, was reduced in size by deleting less essential worked examples. Old worked examples 29.1 (Sizing a Neutron Star), 29.4 (Radon Gas), 29.6 (The Beta Decay of Carbon-14), and 29.9 (Synthetic Elements) were eliminated because they were similar to other examples already in the text. The medical application of radiation was shortened, and a new quick quiz was developed.
- Chapter 30, Nuclear Energy and Elementary Particles, was rewritten and streamlined. The section on nuclear reactors was combined with the one on nuclear fission. The historical section and old Section 30.7 on the meson were eliminated, and the beginning of the section on particle physics was eliminated. The

section on strange particles and strangeness was combined with the section on conservation laws. The sections on quarks and colored quarks were also combined into Section 30.8, Quarks and Color.

TEXTBOOK FEATURES

Most instructors would agree that the textbook assigned in a course should be the student's primary guide for understanding and learning the subject matter. Further, the textbook should be easily accessible and written in a style that facilitates instruction and learning. With that in mind, we have included many pedagogical features that are intended to enhance the textbook's usefulness to both students and instructors. The following features are included.

QUICK QUIZZES All the Quick Quizzes (see example below) are cast in an objective format, including multiple-choice, true–false, matching, and ranking questions. Quick Quizzes provide students with opportunities to test their understanding of the physical concepts presented. The questions require students to make decisions on the basis of sound reasoning, and some have been written to help students overcome common misconceptions. Answers to all Quick Quiz questions are found at the end of the textbook, and answers with detailed explanations are provided in the *Instructor's Solutions Manual*. Many instructors choose to use Quick Quiz questions in a "peer instruction" teaching style.

QUICK QUIZ 4.3 A small sports car collides head-on with a massive truck. The greater impact force (in magnitude) acts on (a) the car, (b) the truck, (c) neither, the force is the same on both. Which vehicle undergoes the greater magnitude acceleration? (d) the car, (e) the truck, (f) the accelerations are the same.

PROBLEM-SOLVING STRATEGIES A general problem-solving strategy to be followed by the student is outlined at the end of Chapter 1. This strategy provides students with a structured process for solving problems. In most chapters more specific strategies and suggestions (see example below) are included for solving the types of problems featured in both the worked examples and the end-of-chapter problems. This feature helps students identify the essential steps in solving problems and increases their skills as problem solvers.

PROBLEM-SOLVING STRATEGY

NEWTON'S SECOND LAW

Problems involving Newton's second law can be very complex. The following protocol breaks the solution process down into smaller, intermediate goals:

1. **Read** the problem carefully at least once.
2. **Draw** a picture of the system, identify the object of primary interest, and indicate forces with arrows.
3. **Label** each force in the picture in a way that will bring to mind what physical quantity the label stands for (e.g., T for tension).
4. **Draw** a free-body diagram of the object of interest, based on the labeled picture. If additional objects are involved, draw separate free-body diagrams for them. Choose convenient coordinates for each object.
5. **Apply Newton's second law**. The x- and y-components of Newton's second law should be taken from the vector equation and written individually. This usually results in two equations and two unknowns.
6. **Solve** for the desired unknown quantity, and substitute the numbers.

BIOMEDICAL APPLICATIONS For biology and pre-med students, icons point the way to various practical and interesting applications of physical principles to biology and medicine. Whenever possible, more problems that are relevant to these disciplines are included.

MCAT SKILL BUILDER STUDY GUIDE The eighth edition of *College Physics* contains a special skill-building appendix (Appendix E) to help premed students prepare for the MCAT exam. The appendix contains examples written by the text authors that help students build conceptual and quantitative skills. These skill-building examples are followed by MCAT-style questions written by test prep experts to make sure students are ready to ace the exam.

MCAT TEST PREPARATION GUIDE Located after the "To the Student" section in the front of the book, this guide outlines 12 concept-based study courses for the physics part of the MCAT exam. Students can use the guide to prepare for the MCAT exam, class tests, or homework assignments.

APPLYING PHYSICS The Applying Physics features provide students with an additional means of reviewing concepts presented in that section. Some Applying Physics examples demonstrate the connection between the concepts presented in that chapter and other scientific disciplines. These examples also serve as models for students when assigned the task of responding to the Conceptual Questions presented at the end of each chapter. For examples of Applying Physics boxes, see Applying Physics 9.5 (Home Plumbing) on page 299 and Applying Physics 13.1 (Bungee Jumping) on page 435.

TIPS Placed in the margins of the text, Tips address common student misconceptions and situations in which students often follow unproductive paths (see example at the right). Thirty-nine Tips are provided in Volume 2 to help students avoid common mistakes and misunderstandings.

TIP 4.3 Newton's Second Law Is a *Vector* Equation

In applying Newton's second law, add all of the forces on the object as vectors and then find the resultant vector acceleration by dividing by m. Don't find the individual magnitudes of the forces and add them like scalars.

MARGINAL NOTES Comments and notes appearing in the margin (see example at the right) can be used to locate important statements, equations, and concepts in the text.

← Newton's third law

APPLICATIONS Although physics is relevant to so much in our modern lives, it may not be obvious to students in an introductory course. Application margin notes (see example at the right) make the relevance of physics to everyday life more obvious by pointing out specific applications in the text. Some of these applications pertain to the life sciences and are marked with a icon.

APPLICATION

Diet Versus Exercise in Weight-loss Programs

MULTIPLE-CHOICE QUESTIONS New to this edition are end-of-chapter multiple-choice questions. The instructor may select items to assign as homework or use them in the classroom, possibly with "peer instruction" methods or with "clicker" systems. More than 180 multiple-choice questions are included in Volume 2. Answers to odd-numbered multiple-choice questions are included in the answer section at the end of the book, and answers to all questions are found in the *Instructor's Solutions Manual.*

CONCEPTUAL QUESTIONS At the end of each chapter there are 10–15 conceptual questions. The Applying Physics examples presented in the text serve as models for students when conceptual questions are assigned and show how the concepts can be applied to understanding the physical world. The conceptual questions provide the student with a means of self-testing the concepts presented in the chapter. Some conceptual questions are appropriate for initiating classroom discussions. Answers to odd-numbered conceptual questions are included in the Answers Section at the end of the book, and answers to all questions are found in the *Instructor's Solutions Manual.*

PROBLEMS An extensive set of problems is included at the end of each chapter (in all, 980 problems are provided in Volume 2 of the eighth edition). Answers to odd-numbered problems are given at the end of the book. For the convenience of both the student and instructor, about two-thirds of the problems are keyed to specific sections of the chapter. The remaining problems, labeled "Additional Problems," are not keyed to specific sections. The three levels of problems are graded according to their difficulty. Straightforward problems are numbered in black, intermediate-level problems are numbered in **blue**, and the most challenging problems are numbered in **magenta**. The icon identifies problems dealing with applications to the life sciences and medicine. Solutions to approximately 12 problems in each chapter are in the *Student Solutions Manual/Study Guide.*

STYLE To facilitate rapid comprehension, we have attempted to write the book in a style that is clear, logical, relaxed, and engaging. The somewhat informal and relaxed writing style is designed to connect better with students and enhance their reading enjoyment. New terms are carefully defined, and we have tried to avoid the use of jargon.

INTRODUCTIONS All chapters begin with a brief preview that includes a discussion of the chapter's objectives and content.

UNITS The international system of units (SI) is used throughout the text. The U.S. customary system of units is used only to a limited extent in the chapters on mechanics and thermodynamics.

PEDAGOGICAL USE OF COLOR Readers should consult the **pedagogical color chart** (inside the front cover) for a listing of the color-coded symbols used in the text diagrams. This system is followed consistently throughout the text.

IMPORTANT STATEMENTS AND EQUATIONS Most important statements and definitions are set in **boldface** type or are highlighted with a background screen for added emphasis and ease of review. Similarly, important equations are highlighted with a tan background screen to facilitate location.

ILLUSTRATIONS AND TABLES The readability and effectiveness of the text material, worked examples, and end-of-chapter conceptual questions and problems are enhanced by the large number of figures, diagrams, photographs, and tables. Full color adds clarity to the artwork and makes illustrations as realistic as possible. Three-dimensional effects are rendered with the use of shaded and lightened areas where appropriate. Vectors are color coded, and curves in graphs are drawn in color. Color photographs have been carefully selected, and their accompanying captions have been written to serve as an added instructional tool. A complete description of the pedagogical use of color appears on the inside front cover.

SUMMARY The end-of-chapter Summary is organized by individual section headings for ease of reference.

SIGNIFICANT FIGURES Significant figures in both worked examples and end-of-chapter problems have been handled with care. Most numerical examples and problems are worked out to either two or three significant figures, depending on the accuracy of the data provided. Intermediate results presented in the examples are rounded to the proper number of significant figures, and only those digits are carried forward.

APPENDICES AND ENDPAPERS Several appendices are provided at the end of the textbook. Most of the appendix material represents a review of mathematical concepts and techniques used in the text, including scientific notation, algebra, geometry, trigonometry, differential calculus, and integral calculus. Reference to these appendices is made as needed throughout the text. Most of the mathematical review sections include worked examples and exercises with answers. In addition to the mathematical review, some appendices contain useful tables that supplement textual information. For easy reference, the front endpapers contain a chart explaining the use of color throughout the book and a list of frequently used conversion factors.

ACTIVE FIGURES Many diagrams from the text have been animated to become Active Figures (identified in the figure legend), part of the *Enhanced WebAssign* online homework system. By viewing animations of phenomena and processes that cannot be fully represented on a static page, students greatly increase their conceptual understanding. In addition to viewing animations of the figures, students can see the outcome of changing variables to see the effects, conduct suggested explorations of the principles involved in the figure, and take and receive feedback on quizzes related to the figure. All Active Figures are included on the instructor's *PowerLecture CD-ROM* for in-class lecture presentation.

TEACHING OPTIONS

This book contains more than enough material for a one-year course in introductory physics, which serves two purposes. First, it gives the instructor more flexibility in choosing topics for a specific course. Second, the book becomes more useful as a resource for students. On average, it should be possible to cover about one chapter each week for a class that meets three hours per week. Those sections, examples, and end-of-chapter problems dealing with applications of physics to life sciences are identified with the DNA icon. We offer the following suggestions for shorter courses for those instructors who choose to move at a slower pace through the year.

Option A: If you choose to place more emphasis on contemporary topics in physics, you could omit all or parts of Chapter 8 (Rotational Equilibrium and Rotational Dynamics), Chapter 21 (Alternating-Current Circuits and Electromagnetic Waves), and Chapter 25 (Optical Instruments).

Option B: If you choose to place more emphasis on classical physics, you could omit all or parts of Part 6 of the textbook, which deals with special relativity and other topics in 20th-century physics.

The *Instructor's Solutions Manual* offers additional suggestions for specific sections and topics that may be omitted without loss of continuity if time presses.

COURSE SOLUTIONS THAT FIT YOUR TEACHING GOALS AND YOUR STUDENTS' LEARNING NEEDS

Recent advances in educational technology have made homework management systems and audience response systems powerful and affordable tools to enhance the way you teach your course. Whether you offer a more traditional text-based course, are interested in using or are currently using an online homework management system such as WebAssign, or are ready to turn your lecture into an interactive learning environment with an audience response system, you can be confident that the text's proven content provides the foundation for each and every component of our technology and ancillary package.