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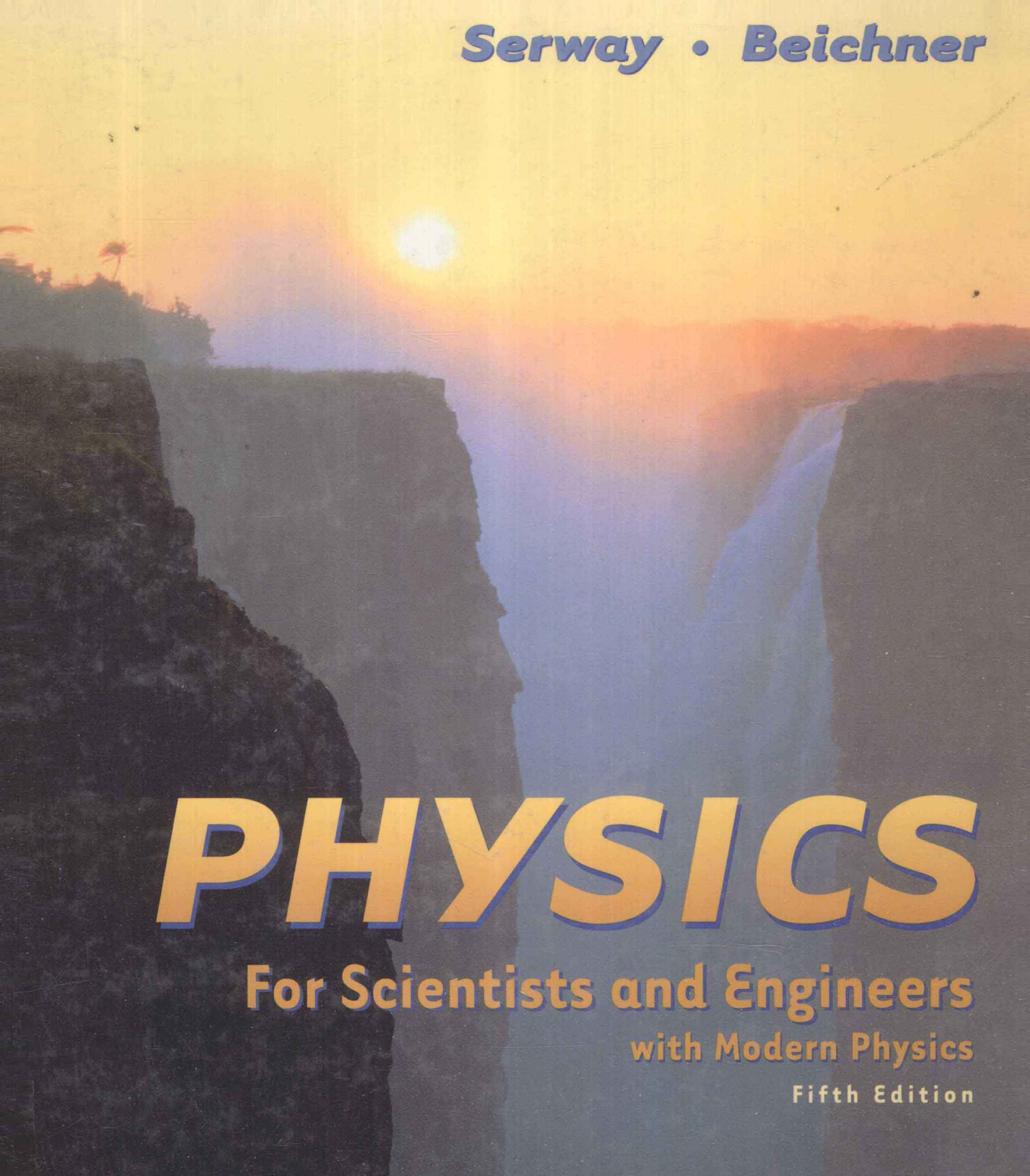

PHYSICS

For Scientists and Engineers

with Modern Physics

Fifth Edition

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For Scientists and Engineers with Modern Physics

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Raymond A. Serway

Robert J. Beichner

North Carolina State University

John W. Jewett, Jr., Cont

California State Polytechnic University

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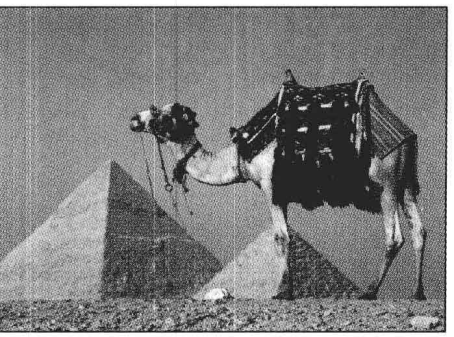
Preface

In writing this fifth edition of *Physics for Scientists and Engineers*, we have made a major effort to improve the clarity of presentation and to include new pedagogical features that help support the learning and teaching processes. Drawing on positive feedback from users of the fourth edition and reviewers' suggestions, we have made refinements in order to better meet the needs of students and teachers. We have also streamlined the supplements package, which now includes a CD-ROM containing student tutorials and interactive problem-solving software, as well as offerings on the World Wide Web.

This textbook is intended for a course in introductory physics for students majoring in science or engineering. The entire contents of the text could be covered in a three-semester course, but it is possible to use the material in shorter sequences with the omission of selected chapters and sections. The mathematical background of the student taking this course should ideally include one semester of calculus. If that is not possible, the student should be enrolled in a concurrent course in introductory calculus.



OBJECTIVES

This introductory physics textbook has two main objectives: 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 these objectives, we have placed emphasis on 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, including engineering, chemistry, and medicine.

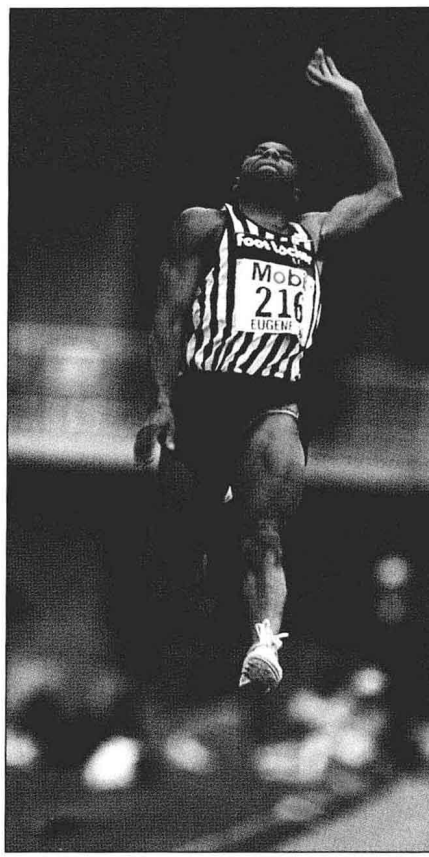
CHANGES IN THE FIFTH EDITION

A large number of changes and improvements have been made in preparing the fifth edition of this text. Some of the new features are based on our experiences and on current trends in science education. Other changes have been incorporated in response to comments and suggestions offered by users of the fourth edition and by reviewers of the manuscript. The following represent the major changes in the fifth edition:

Improved Illustrations

- **Time-sequenced events** are represented by circled letters in selected mechanics illustrations. For example, Figure 2.1b (see page 25) shows such letters at the appropriate places on a position–time graph. This construction helps students "translate" the observed motion into its graphical representation.

- **Motion diagrams** are used early in the text to illustrate the difference between velocity and acceleration, concepts easily confused by beginning students. (For example, see Figure 2.9 on page 34, Figure 4.5 on page 81, and Figure 4.8 on page 84.) Students will benefit greatly from sketching their own motion diagrams, as they are asked to do in the Quick Quizzes found in Chapter 4.
- **Greater realism** is achieved with the superimposition of photographs and line art in selected figures (see pages 96 and 97). Also, the three-dimensional appearance of "blocks" in figures accompanying examples and problems in mechanics has been improved (see pages 142 and 143).



More Realistic Worked Examples Readers familiar with the fourth edition may recall that Example 12.5 involved raising a cylinder onto a step of height h. In this idealized example, we calculated the minimum force **F** necessary to raise the cylinder, as well as the reaction force exerted by the step on the cylinder. In the fifth edition, we are pleased to present the revised Example 12.5 (see page 370), in which we calculate the force that a person must apply to a wheelchair's main wheel to roll it up over an uncut sidewalk curb. Although the revised Example 12.5 involves essentially the same calculation as its fourth-edition predecessor (with some changes in notation), we think that the increased realism makes the example more interesting and provides new motivation for studying physics.

Puzzlers Every chapter begins with an interesting photograph and a caption that includes a Puzzler. Each Puzzler poses a thought-provoking question that is intended to motivate students' curiosity and enhance their interest in the chapter's subject matter. Part or all of the answer to each Puzzler is contained within the chapter text and is indicated by the icon.

Chapter Outlines The opening page of each chapter now includes an outline of the chapter's major headings. This outline gives students and instructors a preview of the chapter's content.

QuickLabs This new feature encourages students to perform simple experiments on their own, thereby engaging them actively in the learning process. Most QuickLab experiments can be performed with low-cost items such as string, rubber bands, tape, a ruler, drinking straws, and balloons. In most cases, students are asked to observe the outcome of an experiment and to explain their results in terms of what they have learned in the chapter. When appropriate, students are asked to record data and to graph their results.

Quick Quizzes Several Quick Quiz questions are included in each chapter to provide students with opportunities to test their understanding of the physical concepts presented. Many questions are written in multiple-choice format and require students to make decisions and defend them on the basis of sound reasoning. Some of them have been written to help students overcome common misconceptions. (Instructors should look to the Instructor's Notes in the margins of the Instructor's Annotated Edition for tips regarding certain Quick Quizzes.) Answers to all Quick Quiz questions are found at the end of each chapter.

Marginal Comments and Icons To provide students with further guidance, common misconceptions and pitfalls are pointed out in comments in the margin of the text. Often, references to the *Saunders Core Concepts in Physics CD-ROM* and useful World Wide Web site addresses are given in these comments to encourage students to expand their understanding of physical concepts. The icon in the text margin refers students to the specific module and screen number(s) of the *Saunders Core*

Concepts in Physics CD-ROM that deals with the topic under discussion. A text illustration, example, Quick Quiz, or problem marked with the icon indicates that it is accompanied by an Interactive Physics™ simulation that can be found on the *Student Tools CD-ROM*. See the Student Ancillaries section (page xviii) for descriptions of these two electronic learning packages.

Applications Some chapters include Applications, which are about the same length as or slightly longer than worked examples. The Applications demonstrate to students how the physical principles covered in a chapter apply to practical problems of everyday life or engineering. For instance, Applications discuss antilock brakes within the context of static and kinetic friction (see Chapter 5); analyze the tension and compressional forces on the structural components of a truss bridge (see Chapter 12); explore the power delivered in automobile and diesel engine cycles (see Chapter 22); and discuss the construction and circuit wiring of holiday lightbulb strings (see Chapter 28).

Problems A substantial revision of the end-of-chapter problems was made in an effort to improve their clarity and quality. Approximately 20 percent of the problems (about 650) are new, and most of these new problems are at the intermediate level (as identified by blue problem numbers). Many of the new problems require students to make order-of-magnitude calculations. All problems have been carefully edited and reworded when necessary. Solutions to approximately 20 percent of the end-of-chapter problems are included in the *Student Solutions Manual and Study Guide*. These problems are identified in the text by boxes around their numbers. A smaller subset of solutions are posted on the World Wide Web **(http://www.saunderscollege.com/physics/)** and are accessible to students and instructors using *Physics for Scientists and Engineers*. These problems are identified in the text by the **WEB** icon. See the next section for a complete description of other features of the problem set.

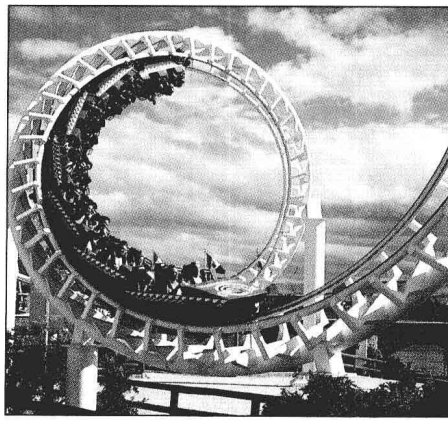
Line-by-Line Revision The entire text has been carefully edited to improve clarity of presentation and precision of language. We believe that the result is a book that is both accurate and enjoyable to read.

Typographical and Notation Changes The Text Features section (see page xvi) mentions the use of **boldface** type and screens for emphasizing important statements and definitions. Boldfaced passages in the text of the fifth edition replace the less legible passages appearing in italics in the fourth edition. Similarly, the symbols for vectors stand out very clearly from the surrounding text owing to the strong boldface type used in the fifth edition. As a step toward making equations more transparent and therefore more easily understood, the use of the subscripts "i" and "f" for initial and final values replaces the fourth edition's older notation, which makes use of subscript 0 (usually pronounced "naught") for an initial value and no subscript for a final value. In equations describing motion or direction, variables carry the subscripts x, y, or z whenever added clarity is needed.

Content Changes Examination of the full Table of Contents might lead one to the impression that the content and organization of the textbook are essentially the same as those of the fourth edition. However, a number of subtle yet significant improvements in content have been made. Following are some examples:

- Section 16.8 contains a more complete and careful derivation of the power or rate of energy transfer for sinusoidal waves on strings. A similar development occurs in Section 17.3, which deals with the intensity of periodic sound waves.

- Section 18.2 contains an improved discussion of the envelope function of a standing wave.
- Chapter 20 contains an updated discussion of the distinction between heat and internal energy. Both heat and work are described and clarified as means of changing the energy of a system.
- Chapter 22 contains a new description of microstates and macrostates of a system, beginning with Section 22.6 on entropy and continuing through the end of the chapter.
- Section 24.3 contains a new list of guidelines for choosing a gaussian surface, allowing the student to take advantage of the symmetry of a charge distribution when determining the electric field.
- Chapter 25 contains new two- and three-dimensional graphs of the electric potential near a point charge and an electric dipole.
- In Chapter 27 and in following chapters, we use "Ohm's law" to refer only to the direct proportionality between current density and electric field seen in some (but not all) materials. See Section 27.2 and the corresponding Instructor's Note for a full explanation.
- Section 29.3 now makes explicit comparison between the potential energy of an electric dipole in an electric field and that of a magnetic dipole in a magnetic field. The section also contains new examples on satellite attitude control and the d'Arsonval galvanometer.
- Chapter 33 contains new information on rectifier circuits, including diodes. The material on rectifiers and filter circuits is now included in Optional Section 33.9, which follows the section on transformers and power transmission.
- In Chapter 35, reflection and refraction are now covered in separate sections, and discussion of Huygens's principle now precedes the section on dispersion and prisms. New Figure 35.8 illustrates retroreflection, which has many practical applications.
- Section 38.2 contains a new subsection considering two-slit diffraction patterns, in which the effects of diffraction and interference are combined.
- Within Section 39.4, new subsections cover space–time graphs and the relativistic Doppler effect. References to the concept of "rest mass" have been deleted.

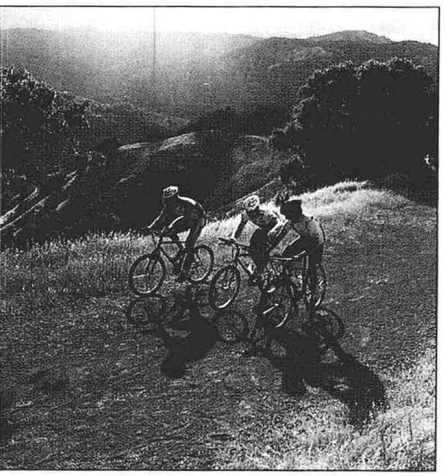


Many sections in these and other chapters have been streamlined, deleted, or combined with other sections to allow for a more balanced presentation. In this extended version of the text, the former Chapter 44 on superconductivity in the fourth edition of *Physics for Scientists and Engineers with Modern Physics* has been deleted, and an abridged section on this topic has been added to Chapter 43. Some of the sections deleted from the fourth edition may be found on the textbook's Web sites for both instructors and students.

Instructor's Notes For the first time, tips and comments are offered to instructors in blue marginal Instructor's Notes, which appear only in the Instructor's Annotated Edition. These annotations expand on common student misconceptions; call attention to certain worked examples, QuickLabs, and Quick Quizzes; or cite key physics education research literature that bears on the topic at hand. In some chapters, Instructor's Notes appear as footnotes in the end-of-chapter problem sets; these notes point out related groups of problems found in other chapters of the textbook. The Instructor's Annotated Edition includes Chapters 1 to 39.

CONTENT

The material in this book covers fundamental topics in classical physics and provides an introduction to modern physics. The book is divided into six parts. Part 1 (Chapters 1 to 15) deals with the fundamentals of Newtonian mechanics and the physics of fluids, Part 2 (Chapters 16 to 18) covers wave motion and sound, Part 3 (Chapters 19 to 22) addresses heat and thermodynamics, Part 4 (Chapters 23 to 34) treats electricity and magnetism, Part 5 (Chapters 35 to 38) covers light and optics, and Part 6 (Chapters 39 to 46) deals with relativity and modern physics. Each part opener includes an overview of the subject matter covered in that part, as well as some historical perspectives.



TEXT FEATURES

Most instructors would agree that the textbook selected for a course should be the student's primary guide for understanding and learning the subject matter. Furthermore, the textbook should be easily accessible and should be styled and written to facilitate instruction and learning. With these points in mind, we have included many pedagogical features in the textbook that are intended to enhance its usefulness to both students and instructors. These features are as follows:

Previews Most chapters begin with a brief preview that includes a discussion of the chapters' objectives and content.

Important Statements and Equations Most important statements and definitions are set in boldface type or are highlighted with a tan background screen for added emphasis and ease of review. Similarly, important equations are highlighted with a tan background screen to facilitate location.

Problem-Solving Hints We have included general strategies for solving the types of problems featured both in the examples and in the end-of-chapter problems. This feature helps students to identify necessary steps in problem-solving and to eliminate any uncertainty they might have. Problem-Solving Hints are highlighted with a light blue-gray screen for emphasis and ease of location.

Marginal Notes Comments and notes appearing in the margin can be used to locate important statements, equations, and concepts in the text.

Illustrations The three-dimensional appearance of many illustrations has been improved in this fifth edition.

Mathematical Level We have introduced calculus gradually, keeping in mind that students often take introductory courses in calculus and physics concurrently. Most steps are shown when basic equations are developed, and reference is often made to mathematical appendices at the end of the textbook. Vector products are introduced later in the text, where they are needed in physical applications. The dot product is introduced in Chapter 7, which addresses work and energy; the cross product is introduced in Chapter 11, which deals with rotational dynamics.

Worked Examples A large number of worked examples of varying difficulty are presented to promote students' understanding of concepts. In many cases, the examples serve as models for solving the end-of-chapter problems. The examples are set off in boxes, and the answers to examples with numerical solutions are highlighted with a light blue-gray screen.

Worked Example Exercises Many of the worked examples are followed immediately by exercises with answers. These exercises are intended to promote interactivity between the student and the textbook and to immediately reinforce the student's understanding of concepts and problem-solving techniques. The exercises represent extensions of the worked examples.

Conceptual Examples As in the fourth edition, we have made a concerted effort to emphasize critical thinking and the teaching of physical concepts. We have accomplished this by including Conceptual Examples (for instance, see page 41). These examples provide students with a means of reviewing and applying the concepts presented in a section. Some Conceptual Examples demonstrate the connection between concepts presented in a chapter and other disciplines. The Conceptual Examples can serve as models for students when they are asked to respond to end-of-chapter questions, which are largely conceptual in nature.

Questions Questions requiring verbal responses are provided at the end of each chapter. Over 1,000 questions are included in this edition. Some questions provide students with a means of testing their mastery of the concepts presented in the chapter. Others could serve as a basis for initiating classroom discussions. Answers to selected questions are included in the *Student Solutions Manual and Study Guide.*

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.

Problems An extensive set of problems is included at the end of each chapter; in all, over 3,000 problems are given throughout the text. Answers to odd-numbered problems are provided at the end of the book in a section whose pages have colored edges for ease of location. For the convenience of both the student and the 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.

Usually, the problems within a given section are presented so that the straightforward problems (those with black problem numbers) appear first; these straightforward problems are followed by problems of increasing difficulty. For ease of identification, the numbers of intermediate-level problems are printed in blue, and those of a small number of challenging problems are printed in magenta.

Review Problems Many chapters include review problems that require the student to draw on numerous concepts covered in the chapter, as well as on those discussed in previous chapters. These problems could be used by students in preparing for tests and by instructors for special assignments and classroom discussions.

Paired Problems Some end-of-chapter numerical problems are paired with the same problems in symbolic form. Two paired problems are identified by a common tan background screen.

Computer- and Calculator-Based Problems Most chapters include one or more problems whose solution requires the use of a computer or graphing calculator. These problems are identified by the icon. Modeling of physical phenomena enables students to obtain graphical representations of variables and to perform numerical analyses.

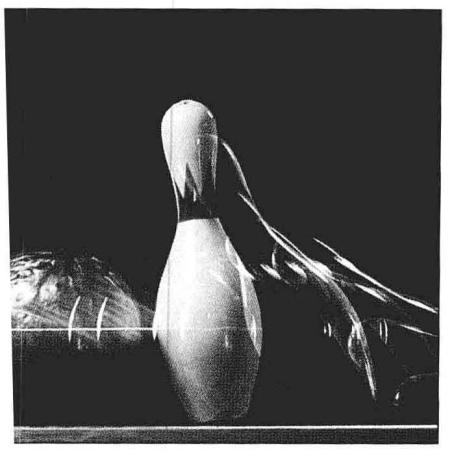
Units The international system of units (SI) is used throughout the text. The British engineering system of units (conventional system) is used only to a limited extent in the chapters on mechanics, heat, and thermodynamics.

Summaries Each chapter contains a summary that reviews the important concepts and equations discussed in that chapter.

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 throughout the text. Most mathematical review sections in the appendices include worked examples and exercises with answers. In addition to the mathematical reviews, the appendices contain tables of physical data, conversion factors, atomic masses, and the SI units of physical quantities, as well as a periodic table of the elements. Other useful information, including fundamental constants and physical data, planetary data, a list of standard prefixes, mathematical symbols, the Greek alphabet, and standard abbreviations of units of measure, appears on the endpapers.

ANCILLARIES

The ancillary package has been updated substantially and streamlined in response to suggestions from users of the fourth edition. The most essential changes in the student package are a *Student Solutions Manual and Study Guide* with a tighter focus on problem-solving, the *Student Tools CD-ROM,* and the *Saunders Core Concepts in Physics CD-ROM* developed by Archipelago Productions. Instructors will find increased support for their teaching efforts with new electronic materials.



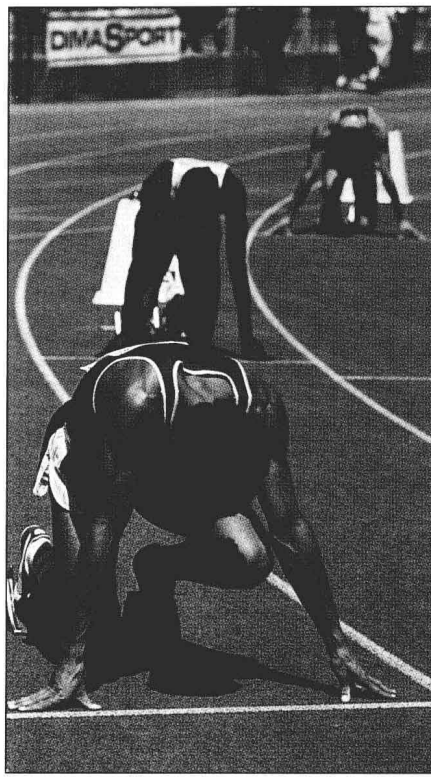
Student Ancillaries

Student Solutions Manual and Study Guide by John R. Gordon, Ralph McGrew, and Raymond A. Serway, with contributions by Duane Deardorff. This two-volume manual features detailed solutions to 20 percent of the end-of-chapter problems from the textbook. Problems in the textbook whose complete solutions are found in the manual are identified by boxes around their numbers. The solutions to many problems follow the **GOAL** protocol described in the textbook (see page 47). The manual also features a list of important equations and concepts, as well as answers to selected end-of-chapter questions.

Pocket Guide by V. Gordon Lind. This 5″ × 7″ paperback is a section-by-section capsule of the textbook and serves as a handy guide for looking up important concepts, formulas, and problem-solving hints.

Student Tools CD-ROM This CD-ROM contains tools that are designed to enhance the learning of physical concepts and train students to become better problem-solvers. It includes a textbook version of the highly acclaimed Interactive Physics™ software by MSC Working Knowledge and more than 100 Interactive Physics™ simulations keyed to appropriate figures, worked examples, Quick Quizzes, and selected end-of-chapter problems (as identified by the icon).

Saunders Core Concepts in Physics CD-ROM This CD-ROM package developed by Archipelago Productions applies the power of multimedia to the introductory physics course, offering full-motion animation and video, engaging interactive graphics, clear and concise text, and guiding narration. *Saunders Core Concepts in Physics CD-ROM* focuses on those concepts students usually find most difficult in the course, drawing from topics in mechanics, thermodynamics, electric fields, magnetic fields, and optics. The animations and graphics are presented to aid the student in developing accurate conceptual models of difficult topics—topics often too complex to be explained in words or chalkboard illustrations. The CD-ROM also presents step-by-step explorations of problem-solving strategies and provides animations of problems in order to promote conceptual understanding and sharpen problem-solving skills. Topics in the textbook that are further explored on the CD-ROM are identified by marginal icons that give the appropriate module and screen number(s). Students should look to the CD-ROM to aid in their understanding of these topics.



Student Web Site Students will have access to an abundance of material at **http://www.saunderscollege.com/physics/.** The Web Site features special topic essays by guest authors, practice problems with answers, and optional topics that accompany selected chapters of the textbook. Also included are selected solutions from the *Student Solutions Manual and Study Guide,* a sampling of the *Pocket Guide,* and a glossary that includes more than 300 physics terms. Students also can take practice quizzes in our Practice Exercises and Testing area.

Physics Laboratory Manual, Second Edition by David Loyd. Updated and redesigned, this manual supplements the learning of basic physical principles while introducing laboratory procedures and equipment. Each chapter includes a pre-laboratory assignment, objectives, an equipment list, the theory behind the experiment, step-by-step experimental procedures, and questions. A laboratory report form is provided for each experiment so that students can record data and make calculations. Students are encouraged to apply statistical analysis to their data so that they can develop their ability to judge the validity of their results.

So You Want to Take Physics: A Preparatory Course with Calculus by Rodney Cole. This introductory-level book is useful to those students who need additional preparation before or during a calculus-based course in physics. The friendly, straightforward style makes it easier to understand how mathematics is used in the context of physics.

Life Science Applications for Physics by Jerry Faughn. This book provides examples, readings, and problems from the biological sciences as they relate to physics. Topics include "Friction in Human Joints," "Physics of the Human Circulatory System," "Physics of the Nervous System," and "Ultrasound and Its Applications." This supplement is useful in those courses taken by a significant number of pre-med students.

Instructor's Ancillaries

Instructor's Manual with Solutions by Ralph McGrew, Jeff Saul, and Charles Teague, with contributions by Duane Deardorff and Rhett Allain. This manual contains chapter summaries, answers to even-numbered problems, and complete worked solutions to all the problems in the textbook. The solutions to problems new to the fifth edition are marked for easy identification by the instructor. New to this edition of the manual are suggestions on how to teach difficult topics and how to help stu-

dents overcome common misconceptions. These suggestions are based on recent research in physics education.

Instructor's Web Site The instructor's area at **http://www.saunderscollege.com/physics/** includes a listing of overhead transparencies; a guide to relevant experiments in David Loyd's *Physics Laboratory Manual, Second Edition*; a correlation guide between sections in *Physics for Scientists and Engineers* and modules in the *Saunders Core Concepts in Physics CD-ROM*; supplemental problems with answers; optional topics to accompany selected chapters of the textbook; and a problems correlation guide.

Instructor's Resource CD-ROM This CD-ROM accompanying the fifth edition of *Physics for Scientists and Engineers* has been created to provide instructors with an exciting new tool for classroom presentation. The CD-ROM contains a collection of graphics files of line art from the textbook. These files can be opened directly, can be imported into a variety of presentation packages, or can be used in the presentation package included on the CD-ROM. The labels for each piece of art have been enlarged and boldfaced to facilitate classroom viewing. The CD-ROM contains electronic files of the *Instructor's Manual, Test Bank,* and *Practice Problems with Solutions.*

CAPA: A Computer-Assisted Personalized Approach CAPA is a network system for learning, teaching, assessment, and administration. It provides students with personalized problem sets, quizzes, and examinations consisting of qualitative conceptual problems and quantitative problems, including problems from *Physics for Scientists and Engineers.* CAPA was developed through a collaborative effort of the Physics–Astronomy, Computer Science, and Chemistry Departments at Michigan State University. Students are given instant feedback and relevant hints via the Internet and may correct errors without penalty before an assignment's due date. The system records each student's participation and performance on assignments, quizzes, and examinations; and records are available on-line to both the individual student and to his or her instructor. For more information, visit the CAPA Web site at **http://www.pa.msu.edu/educ/CAPA/**

WebAssign: A Web-Based Homework System WebAssign is a Web-based homework delivery, collection, grading, and recording service developed at North Carolina State University. Instructors who sign up for WebAssign can assign homework to their students, using questions and problems taken directly from *Physics for Scientists and Engineers.* WebAssign gives students immediate feedback on their homework that helps them to master information and skills, leading to greater competence and better grades. WebAssign can free instructors from the drudgery of grading homework and recording scores, allowing them to devote more time to meeting with students and preparing classroom presentations. Details about and a demonstration of WebAssign are available at **http://webassign.net/info**. For more information about ordering this service, contact WebAssign at **webassign@ncsu.edu**

Homework Service With this service, instructors can reduce their grading workload by assigning thought-provoking homework problems using the World Wide Web. Instructors browse problem banks that include problems from *Physics for Scientists and Engineers,* select those they wish to assign to their students, and then let the Homework Service take over the delivery and grading. This system was developed and is maintained by Fred Moore at the University of Texas (**moore@physics.utexas.edu**). Students download their unique problems, submit their answers, and obtain immediate feedback; if students' answers are incorrect, they can resubmit them. This rapid grading feature facilitates effective learning. After the due date of their assignments, students can obtain the solutions to their problems. Minimal on-line connect time is

required. The Homework Service uses algorithm-based problems: This means that each student solves sets of problems that are different from those given to other students. Details about and a demonstration of this service are available at **http://hw10.ph.utexas.edu/instInst.html**

Printed Test Bank by Edward Adelson. The *Printed Test Bank* contains approximately 2,300 multiple-choice questions. It is provided for the instructor who does not have access to a computer. About 20% of the old test items have been replaced with new, concept-based, thought-provoking questions.

Computerized Test Bank Available in Windows™ and Macintosh® formats, the *Computerized Test Bank* contains more than 2,300 multiple-choice questions, representing every chapter of the text. The *Computerized Test Bank* enables the instructor to create many unique tests by allowing the editing of questions and the addition of new questions. The software program solves all problems and prints each answer on a separate grading key. All questions have been reviewed for accuracy.

Overhead Transparency Acetates This collection of transparencies consists of 300 full-color figures from the text and features large print for easy viewing in the classroom.

Instructor's Manual for Physics Laboratory Manual by David Loyd. Each chapter contains a discussion of the experiment, teaching hints, answers to selected questions, and a post-laboratory quiz with short-answer and essay questions. It also includes a list of the suppliers of scientific equipment and a summary of the equipment needed for each of the laboratory experiments in the manual.

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TEACHING OPTIONS

The topics in this textbook are presented in the following sequence: classical mechanics, mechanical waves, and heat and thermodynamics, followed by electricity and magnetism, electromagnetic waves, optics, and relativity. This presentation represents a more traditional sequence, with the subject of mechanical waves being presented before the topics of electricity and magnetism. Some instructors may prefer to cover this material after completing electricity and magnetism (i.e., after Chapter 34). The chapter on relativity was placed near the end of the text because this topic often is treated as an introduction to the era of "modern physics." If time permits, instructors may choose to cover Chapter 39 in the first semester after completing Chapter 14, as it concludes the material on Newtonian mechanics.

Instructors teaching a two-semester sequence can delete sections and chapters without any loss of continuity. We have labeled these as "Optional" in the Table of Contents and in the appropriate sections of the text. For student enrichment, instructors can assign some of these sections or chapters as extra reading.

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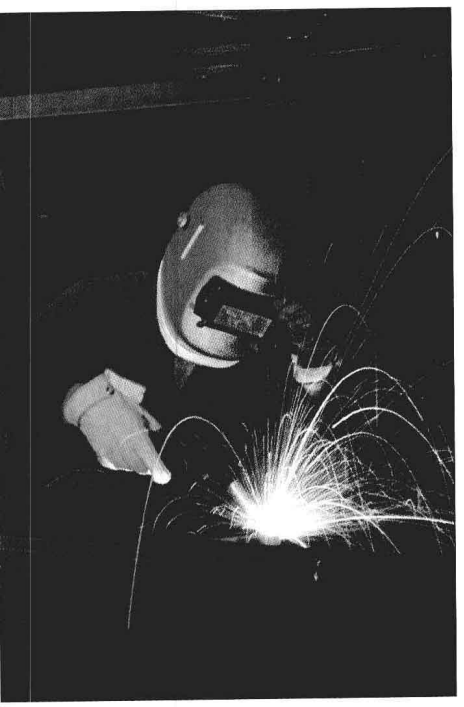
To the Student



It is appropriate to offer some words of advice that should be of benefit to you, the student. Before doing so, we assume that you have read the Preface, which describes the various features of the text that will help you through the course.

HOW TO STUDY

Very often instructors are asked, "How should I study physics and prepare for examinations?" There is no simple answer to this question, but we would like to offer some suggestions that are based on our own experiences in learning and teaching over the years.

First and foremost, maintain a positive attitude toward the subject matter, keeping in mind that physics is the most fundamental of all natural sciences. Other science courses that follow will use the same physical principles, so it is important that you understand and are able to apply the various concepts and theories discussed in the text.

CONCEPTS AND PRINCIPLES

It is essential that you understand the basic concepts and principles before attempting to solve assigned problems. You can best accomplish this goal by carefully reading the textbook before you attend your lecture on the covered material. When reading the text, you should jot down those points that are not clear to you. We've purposely left wide margins in the text to give you space for doing this. Also be sure to make a diligent attempt at answering the questions in the Quick Quizzes as you come to them in your reading. We have worked hard to prepare questions that help you judge for yourself how well you understand the material. The QuickLabs provide an occasional break from your reading and will help you to experience some of the new concepts you are trying to learn. During class, take careful notes and ask questions about those ideas that are unclear to you. Keep in mind that few people are able to absorb the full meaning of scientific material after only one reading. Several readings of the text and your notes may be necessary. Your lectures and laboratory work supplement reading of the textbook and should clarify some of the more difficult material. You should minimize your memorization of material. Successful memorization of passages from the text, equations, and derivations does not necessarily indicate that you understand the material. Your understanding of the material will be enhanced through a combination of efficient study habits, discussions with other students and with instructors,

and your ability to solve the problems presented in the textbook. Ask questions whenever you feel clarification of a concept is necessary.

STUDY SCHEDULE

It is important that you set up a regular study schedule, preferably one that is daily. Make sure that you to read the syllabus for the course and adhere to the schedule set by your instructor. The lectures will be much more meaningful if you read the corresponding textual material before attending them. As a general rule, you should devote about two hours of study time for every hour you are in class. If you are having trouble with the course, seek the advice of the instructor or other students who have taken the course. You may find it necessary to seek further instruction from experienced students. Very often, instructors offer review sessions in addition to regular class periods. It is important that you avoid the practice of delaying study until a day or two before an exam. More often than not, this approach has disastrous results. Rather than undertake an all-night study session, briefly review the basic concepts and equations and get a good night's rest. If you feel you need additional help in understanding the concepts, in preparing for exams, or in problem-solving, we suggest that you acquire a copy of the *Student Solutions Manual and Study Guide* that accompanies this textbook; this manual should be available at your college bookstore.

USE THE FEATURES

You should make full use of the various features of the text discussed in the preface. For example, marginal notes are useful for locating and describing important equations and concepts, and **boldfaced** type indicates important statements and definitions. Many useful tables are contained in the Appendices, but most are incorporated in the text where they are most often referenced. Appendix B is a convenient review of mathematical techniques.

Answers to odd-numbered problems are given at the end of the textbook, answers to Quick Quizzes are located at the end of each chapter, and answers to selected end-of-chapter questions are provided in the *Student Solutions Manual and Study Guide*. The exercises (with answers) that follow some worked examples represent extensions of those examples; in most of these exercises, you are expected to perform a simple calculation (see Example 4.7 on page 90). Their purpose is to test your problem-solving skills as you read through the text. Problem-Solving Hints are included in selected chapters throughout the text and give you additional information about how you should solve problems. The Table of Contents provides an overview of the entire text, while the Index enables you to locate specific material quickly. Footnotes sometimes are used to supplement the text or to cite other references on the subject discussed.

After reading a chapter, you should be able to define any new quantities introduced in that chapter and to discuss the principles and assumptions that were used to arrive at certain key relations. The chapter summaries and the review sections of the *Student Solutions Manual and Study Guide* should help you in this regard. In some cases, it may be necessary for you to refer to the index of the text to locate certain topics. You should be able to correctly associate with each physical quantity the symbol used to represent that quantity and the unit in which the quantity is specified. Furthermore, you should be able to express each important relation in a concise and accurate prose statement.