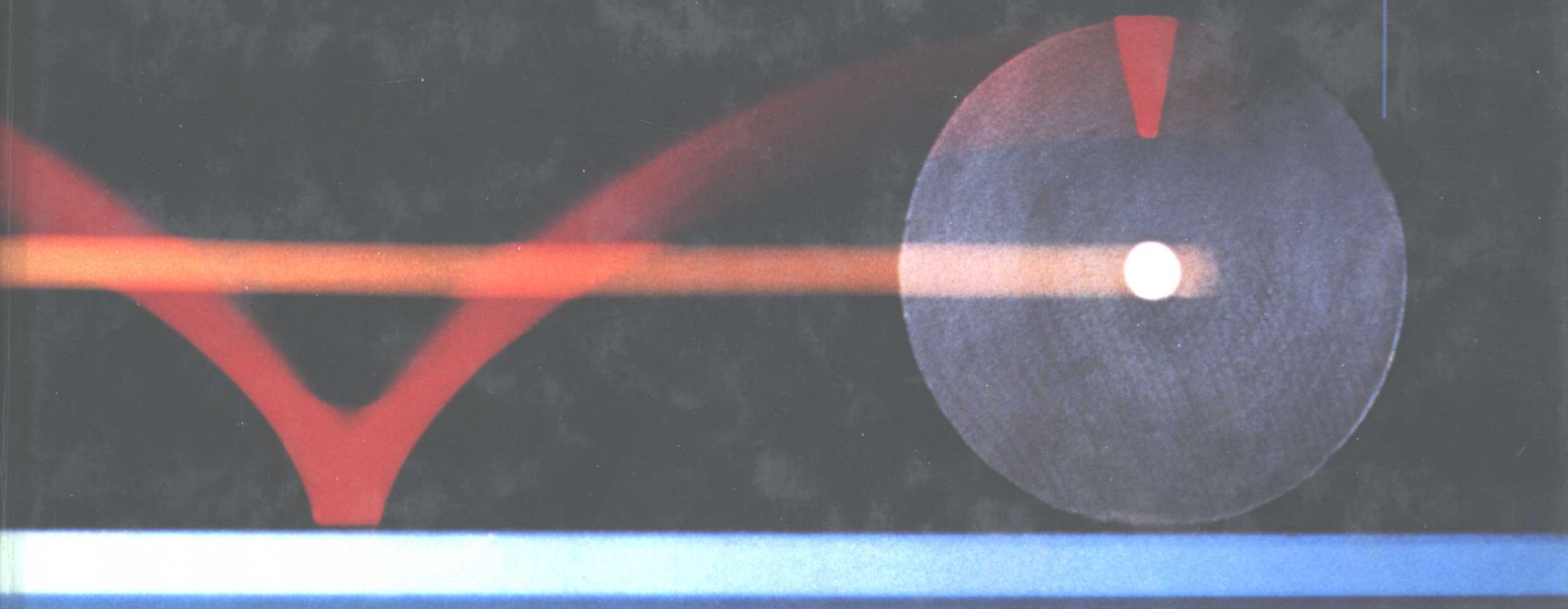
Volume 1

Physics

FOR SCIENTISTS AND ENGINEERS

Fourth Edition



Serway

PHYSICS

For Scientists & Engineers

Fourth Edition

VOLUME 1

SAUNDERS GOLDEN SUNBURST SERIES

SAUNDERS COLLEGE PUBLISHING
Philadelphia Fort Worth Chicago San Francisco
Montreal Toronto London Sydney Tokyo

Text Typeface: New Baskerville
Composition and Layout: Progressive Information Technologies
Publisher: John Vondeling
Developmental Editor: Laura Maier
Senior Project Editor: Sally Kusch
Copy Editor: Charlotte Nelson
Managing Editor: Carol Field
Manager of Art and Design: Carol Bleistine
Associate Art Director: Sue Kinney
Art and Design Coordinator: Kathleen Flanagan
Text Designer: Rebecca Lemna
Cover Designer: Lawrence R. Didona
Text Artwork: Rolin Graphics
Photo Researcher: Sue Howard
Director of EDP: Tim Frelick
Production Manager: Charlene Squibb
Marketing Manager: Marjorie Waldron

Cover and title page: Rolling motion of a rigid body: disk by Richard Megna, © Fundamental Photographs, NYC

Printed in the United States of America

Physics for Scientists and Engineers, Volume I, Fourth edition

ISBN 0-03-015657-2

Library of Congress Catalog Card Number: 95-069566

6789012345 032 10 98765432

The publisher and author have gone to extreme measures in attempting to ensure the publication of an error-free text. The manuscript, galleys, and page proofs have been carefully checked by the author, the editors, and a battery of reviewers. While we realize that a 100% error-free text may not be humanly possible, Serway's *Physics for Scientists and Engineers* is very close. Confirmed in this belief, we are offering $5.00 for any first-time error you may find. (Note that we will only pay for each error the first time it is brought to our attention.) Please write to John Vondeling, Publisher.

Preface

Physics for Scientists and Engineers has been used successfully at over 700 colleges and universities over the course of three editions. This fourth edition has many new pedagogical features, and a major effort was made to improve clarity of presentation, precision of language, and accuracy throughout. Based on comments from users of the third edition and reviewers' suggestions, refinements have been added such as an increased emphasis on teaching concepts. The fourth edition has also integrated several new interactive software products that will be useful in courses using computer-assisted instruction.

This two-volume textbook is intended for a course in introductory physics for students majoring in science or engineering. The book is an extended version of *Physics for Scientists and Engineers* in that Volume II includes eight additional chapters covering selected topics in modern physics. This material on modern physics has been added to meet the needs of those universities that choose to cover the basic concepts of quantum physics and its application to atomic, molecular, solid state, and nuclear physics as part of their curriculum.

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 introduction to calculus.

(Richard Megna/Fundamental Photographs)

OBJECTIVES

The main objectives of this introductory physics 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. In order to meet these objectives, emphasis is placed on sound physical arguments. At the same time, I have attempted to motivate the student through practical examples that demonstrate the role of physics in other disciplines including engineering, chemistry, and medicine.

CHANGES TO THE FOURTH EDITION

A number of changes and improvements have been made in preparing the fourth edition of this text. Many changes are in response to comments and suggestions offered by instructors and students using the third edition and by reviewers of the manuscript. The following represent the major changes in the fourth edition:

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

• Organization The organization of the textbook is essentially the same as that of the third edition with one exception. Chapters 2 and 3 have been interchanged, so that the treatment of vectors precedes the discussion of motion in two dimensions, where vectors and their

components are first used. Many sections have been streamlined or combined with other sections to allow for a more balanced presentation.

• Problems A substantial revision of the end-of-chapter problems and questions was made in an effort to provide a greater variety and to reduce repetition. Approximately 25 percent of the problems (approximately 800), most of which are at the intermediate level, are new. The remaining problems have been carefully edited and reworded where necessary. All new problems are marked with an asterisk in the Instructors Manual. Solutions to approximately 25 percent of the problems are included in the Student Solutions Manual and Study Guide. These problems are identified by boxes around their numbers.

• 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.

• Visual Presentation Most of the line art and many of the color photographs have been replaced or modified to improve the clarity of presentation, pedagogy, and visual appeal of the text. As in the third edition, color is used primarily for pedagogical purposes. A chart explaining the pedagogical use of color is included after the To the Student section following the preface.

NEW FEATURES IN THE FOURTH EDITION

• Integrated Software The textbook is accompanied by two interactive software packages. *SD2000* is a self-contained software package of physics simulations and demonstrations that have been developed exclusively to accompany this textbook. Concepts and examples are presented and explained in an interactive format. Simulations developed for the Interactive Physics II™ program are keyed to appropriate worked-example problems and to selected end-of-chapter problems. Both packages are provided on disks and are described in more detail in the section dealing with ancillaries.

• Conceptual Examples Approximately 150 conceptual examples have been included in this edition. These examples, which include reasoning statements, provide students with a means of reviewing the concepts presented in that section. The examples could also serve as models when students are asked to respond to end-of-chapter questions, which are largely conceptual in nature.

• Review Problems Many chapters now include a multi-part review problem located prior to the list of end-of-chapter problems. The review problem requires the student to draw on numerous concepts covered in the chapter as well as those discussed in previous chapters. These problems can be used by students in preparing for tests, and by instructors in classroom discussions and review.

• Paired Problems Several end-of-chapter problems have been paired with the same problem in symbolic form. For example, numerical Problem 9 may be followed by symbolic Problem 9A. If Problem 9 is assigned, Problem 9A can be used to test the student's understanding of the concepts used in solving the problem.

• Spreadsheet Problems Most chapters will include several spreadsheet problems following the end-of-chapter problem sets. Spreadsheet modeling of physical phenomena enables the student to obtain graphical representations of physical quantities and perform numeri-

cal analyses of problems without the burden of having to learn a high-level computer language. Spreadsheets are particularly valuable in exploratory investigations; "what if" questions can be addressed easily and depicted graphically.

Level of difficulty in the spreadsheet problems, as with all end-of-chapter problems, is indicated by the color of the problem number. For the most straightforward problems (black) a disk with spreadsheet templates is provided. The student must enter the pertinent data, vary the parameters, and interpret the results. Intermediate level problems (blue) usually require students to modify an existing template to perform the required analysis. The more challenging problems (magenta) require students to develop their own spreadsheet templates. Brief instuctions on using the templates are provided in Appendix F.

COVERAGE

The material covered in this book is concerned with fundamental topics in classical physics and an introduction to modern physics. The book is divided into six parts. In the first volume, Part I (Chapters 1–15) deals with the fundamentals of Newtonian mechanics and the physics of fluids; Part II (Chapters 16–18) covers wave motion and sound; Part III (Chapters 19–22) is concerned with heat and thermodynamics. In the second volume, Part IV (Chapters 23–34) treats electricity and magnetism, Part V (Chapters 35–38) covers light and optics, and Part VI (Chapters 39–47) deals with relativity, quantum physics, and selected topics in modern physics. Each part opener includes an overview of the subject matter to be covered in that part and 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, a textbook should be easily accessible and should be styled and written for ease in instruction. With these points in mind, I have included many pedagogic features in the textbook which are intended to enhance its usefulness to both the student and instructor. These are as follows:

Style As an aid for rapid comprehension, I have attempted to write the book in a style that is clear, logical, and engaging. The writing style is somewhat informal and relaxed, which I hope students will find appealing and enjoyable to read. New terms are carefully defined, and I have tried to avoid jargon.

Previews Most chapters begin with a chapter preview, which includes a brief discussion of chapter objectives and content.

Important Statements and Equations Most important statements and definitions are set in bold print for added emphasis and ease of review. Important equations are highlighted with a tan screen for review or reference.

Problem-Solving Strategies and Hints I have included general strategies for solving the types of problems featured in both the examples and in the end-of-chapter problems. This feature will help students identify necessary steps in solving problems and eliminate any uncertainty they might have. Problem-solving strategies are highlighted by a light color screen for emphasis and ease of location.

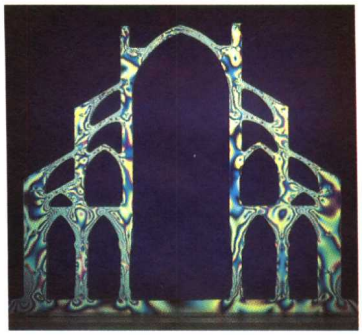
Marginal Notes Comments and marginal notes are used to locate important statements, equations, and concepts in the text.

Illustrations The readability and effectiveness of the text material and worked examples are enhanced by the large number of figures, diagrams, photographs, and tables. Full color

is used to add clarity to the artwork and to make it as realistic as possible. For example, vectors are color-coded, and curves in *xy*-plots are drawn in color. Three-dimensional effects are produced with the use of color airbrushed areas, where appropriate. The color photographs have been carefully selected, and their accompanying captions have been written to serve as an added instructional tool. Several chapter-opening photographs, particularly in the chapters on mechanics, include color-coded vector overlays that illustrate and present physical principles more clearly and apply them to real-world situations.

Mathematical Level Calculus is introduced gradually, keeping in mind that a course in calculus is often taken concurrently. Most steps are shown when basic equations are developed, and reference is often made to mathematical appendices at the end of the text. Vector products are introduced later in the text where they are needed in physical applications. The dot product is introduced in Chapter 7, "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 as an aid in understanding concepts. In many cases, these examples serve as models for solving the end-of-chapter problems. The examples are set off in a box, and the solution answers are highlighted with a light blue screen. Most examples are given titles to describe their content.



(Peter Aprahamian/Science Photo Library)

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

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.

Biographical Sketches Throughout the text I have included short biographies of important scientists to add more historical emphasis and show the human side of the lives of scientists.

Optional Topics Many chapters include special topic sections which are intended to expose the student to various practical and interesting applications of physical principles. These optional sections are labeled with an asterisk (*).

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

Thought Questions Questions requiring verbal answers are provided at the end of each chapter. Some questions provide the student with a means of self-testing the concepts presented in the chapter. Others could serve as a basis for initiating classroom discussions.

Problems An extensive set of problems is included at the end of each chapter. Answers to odd-numbered problems are given at the end of the book; these 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. In my opinion, assignments should consist mainly of the keyed problems to help build self-confidence in students.

Usually, the problems within a given section are presented so that the straightforward problems (numbered in black print) are first, followed by problems of increasing difficulty.

For ease in identifying the intermediate-level problems, the problem number is printed in blue. I have also included a small number of challenging problems, which are indicated by a problem number printed in magenta.

Appendices and Endpapers Several appendices are provided at the end of the text, including the new appendix with instructions for problem-solving with spreadsheets. Most of the appendix material represents a review of mathematical 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 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 chart. Other useful information, including fundamental constants and physical data, planetary data, a list of standard prefixes, mathematical symbols, the Greek alphabet, and a table of standard abbreviations and symbols of units appears on the endpapers.

ANCILLARIES

The ancillary package has been updated and expanded in response to suggestions from users of the third edition. The most essential changes are an expansive set of interactive software, an updated test bank with greater emphasis on conceptual questions and open-ended problems, a new Student Solutions Manual and Study Guide with complete solutions to 25 percent of the text problems, a student's Pocket Guide, and a new spreadsheet supplement.

Interactive Software

Interactive Homework System

The World Wide Web (WWW) is the platform for an interactive homework system developed out of the University of Texas at Austin. This system, developed to coordinate with *Physics for Scientists and Engineers,* uses WWW, telnet, telephone, and Scantron submission of student work. The system has been class-tested at the University of Texas with over 1800 students participating each semester. Over 100,000 questions are answered electronically per month. Instructors at any university using Serway's *Physics for Scientists and Engineers* may establish access to this system by providing a class roster and making problem selections. Over 2000 algorithm-based problems are available; problem parameters vary from student to student, so that each student must do original work. All grading is done by computer, with results automatically posted on WWW. Students receive immediate right/wrong feedback, with multiple tries allowed for incorrect answers. When students answer incorrectly, they are automatically linked into text from the appropriate section of the fourth edition of Serway's *Physics for Scientists and Engineers with Modern Physics.*

A demo using the WWW interface is available at the URL **http://hw.ph.utexas.edu:80** by clicking on the demo link. Further information for instructors interested in importing the system to their institutions is available from **see@physics.utexas.edu**. The fourth edition of *Physics for Scientists and Engineers* will be linked into the system by January 1996.

SD2000 Interactive Software

This learning environment of physics simulations and demonstrations has been developed by Future Graph, Inc., exclusively to accompany this textbook. Its applications span all of the basic topics treated in the textbook. SD2000 is available on computer disk or CD-ROM in Macintosh and IBM Windows formats. The icon identifies examples and sections for which a simulation or demonstration exists.

Simulations A collection of 10 powerful simulators allows students to model and bring to life an infinite number of physics problems. Students can model systems that include Kinetic motion, Collisions, Geometric optics, and Electric and magnetic fields, as well as laboratory tools such as Fourier synthesizers, Wave form generators, and Oscilloscopes. SD2000 boxes throughout the text identify how these simulators can be used to reinforce the concepts presented in the text. In modeling individualized simulations, students may investigate how varying the components of a situation will affect the outcome.

- Chapter 4: Motion, Section 4.4
- Chapter 9: Collisions, Section 9.5
- Chapter 16: Wave Motion, Section 16.4
- Chapter 18: Complex Waves—The Fourier Synthesizer, Section 18.8
- Chapter 21: Systems of Particles, Section 21.1
- Chapter 23: Motion in an Electric Field, Section 23.7
- Chapter 25: Mapping the Electric Field, Section 25.5
- Chapter 29: Motion of Charged Particles in Electric and Magnetic Fields, Section 29.5
- Chapter 33: The Oscilloscope, Section 33.5
- Chapter 36: Optical Instruments, Section 36.10

Demonstrations Lessons derived from worked examples in the text of *Physics for Scientists and Engineers* allow students to investigate the results of changing parameters within the context of the example. Students can interactively explore physics through equations, calculations, graphs, tables, animations, and simulations. A complete list of demonstrations follows:

Chapter 2
Section 2.4
Example 2.3
Example 2.15

Chapter 3
Example 3.8

Chapter 4
Section 4.2
Section 4.3

Chapter 5
Example 5.6
Example 5.9
Example 5.15

Chapter 6
Example 6.4
Example 6.5
Example 6.9
Example 6.10

Chapter 7
Example 7.3
Example 7.5
Example 7.18

Chapter 8
Example 8.10

Chapter 9
Example 9.11
Example 9.16
Example 9.23

Chapter 10
Example 10.4

Chapter 11
Example 11.13

Chapter 13
Section 13.4
Section 13.6
Section 13.7

Chapter 14
Example 14.2
Example 14.4
Example 14.6
Example 14.7
Example 14.11

Chapter 16
Example 16.1
Example 16.3
Example 16.5

Chapter 18
Example 18.2
Example 18.3

Chapter 20
Example 20.6

Chapter 21
Example 21.1
Example 21.3
Section 21.6

Chapter 22
Example 22.4
Example 22.12

Interactive-Physics Simulations

Approximately 100 simulations by Ray Serway and Knowledge Revolution are available on computer disk in either Macintosh or IBM format to be used in conjunction with the highly acclaimed program *Interactive Physics II* from Knowledge Revolution. Most of these simulations are keyed to appropriate worked-example problems and to selected end-of-chapter problems. The remainder are demonstrations that complement concepts or applications discussed in the text. Simulations can be used in the classroom or laboratory to help students understand physics concepts by developing better visualization skills. The simulation is started by simply clicking the RUN button. The simulation engine calculates the motion of the defined system and displays it in smooth animation. The results can be displayed in

graphical, digital, tabular, and bar-graph formats. The acquired data can also be exported to a spreadsheet of your choice for other types of analyses. The Interactive Physics Icon  identifies the examples, problems, and figures for which a simulation exists. A complete list follows.

List of Interactive Physics Simulations

Chapter 2
Example 2.10
Example 2.12
Example 2.14
Example 2.15
Problem 2.46
Problem 2.49
Problem 2.72
Problem 2.76
Problem 2.80
Problem 2.81

Chapter 3
Example 3.8
Problem 3.50

Chapter 4
Example 4.2
Example 4.5
Example 4.6
Example 4.7
Example 4.11
Figure 4.5
Problem 4.17
Problem 4.55
Problem 4.58
Problem 4.66
Problem 4.82
Problem 4.84

Chapter 5
Example 5.8
Example 5.9
Example 5.12
Example 5.13
Example 5.14
Problem 5.18
Problem 5.37
Problem 5.38
Problem 5.42
Problem 5.47
Problem 5.55
Problem 5.70
Problem 5.73
Problem 5.74
Problem 5.76
Problem 5.83
Problem 5.84
Problem 5.87
Problem 5.88

Chapter 6
Example 6.1
Example 6.3
Problem 6.5
Problem 6.21
Problem 6.30

Chapter 7
Example 7.7
Example 7.8
Example 7.12
Figure 7.8
Problem 7.37
Problem 7.43
Problem 7.44
Problem 7.82
Problem 7.89

Chapter 8
Example 8.1
Example 8.3
Example 8.6
Example 8.8
Example 8.9
Problem 8.10
Problem 8.11
Problem 8.17
Problem 8.19
Problem 8.33
Problem 8.35
Problem 8.59
Problem 8.64
Problem 8.67

Chapter 9
Example 9.7
Example 9.11
Example 9.13
Example 9.14
Problem 9.66
Problem 9.72
Problem 9.83
Problem 9.87

Chapter 10
Example 10.11
Example 10.12
Example 10.15
Problem 10.51

Chapter 11
Problem 11.51
Problem 11.65

Chapter 12
Example 12.1
Example 12.3
Example 12.4
Problem 12.36
Problem 12.40
Problem 12.51

Chapter 13
Example 13.4
Example 13.5
Example 13.8
Figure 13.9
Problem 13.18
Problem 13.57
Problem 13.63

f(g) Scholar — Spreadsheet/Graphing, Calculator/Graphing Software

f(g) Scholar is a powerful, scientific/engineering spreadsheet software program with over 300 built-in math functions, developed by Future Graph, Inc. It uniquely integrates graphing calculator, spreadsheet, and graphing applications into one, and allows for quick and easy movement between the applications. Students will find many uses for f(g) Scholar across their science, math and engineering courses, including working through their laboratories from start to finished reports. Other features include a programming language for defining math functions, curve fitting, three-dimensional graphing and equation displaying. When bookstores order f(g) Scholar through Saunders College Publishing they can pass on our exclusive low price to the student.

Student Ancillaries

Student Solutions Manual and Study Guide by John R. Gordon, Ralph McGrew, Steve Van Wyk, and Ray Serway The manual features detailed solutions to 25 percent of the end-of-chapter problems from the text. These are indicated with boxed problem numbers. The manual also features a skills section that reviews mathematical concepts and important notes from key sections of the text and provides a list of important equations and concepts.

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

Discovery Exercises for Interactive Physics by Jon Staib This workbook is designed to be used in conjunction with the Interactive Physics simulations previously described. The workbook consists of a set of exercises in which the student is required to fill in blanks, answer questions, construct graphs, predict results, and perform simple calculations. Each exercise is designed to teach at least one physical principle and/or to develop student's physical intuition. The workbook and templates can be used either as stand-alone tutorials, or in a laboratory setting.

Spreadsheet Templates The Spreadsheet Template Disk contains spreadsheet files designed to be used with the end-of-chapter problems entitled Spreadsheet Problems. The files have been developed in Lotus 1-2-3 using the WK1 format. These can be used with most spreadsheet programs including all the recent versions of Lotus 1-2-3, Excel for Windows and Macintosh, Quattro Pro, and f(g) scholar. Over 30 templates are provided for the student.

(© Duomo/Steven E. Sutton, 1994)

Spreadsheet Investigations in Physics by Lawrence B. Golden and James R. Klein This workbook with the accompanying disk illustrates how spreadsheets can be used for solving many physics problems and when spreadsheet analysis is useful. The workbook is divided into two parts. The first part consists of spreadsheet tutorials, while the second part is a short introduction to numerical methods. The tutorials include basic spreadsheet techniques emphasizing navigating the spreadsheet, entering data, constructing formulas, and graphing. The numerical methods include differentiation, integration, interpolation, and the solution of differential equations. Many examples and exercises are provided. Step-by-step instructions are given for constructing numerical models of selected physics problems. The exercises and examples used to illustrate the numerical methods are chosen from introductory physics and mathematics. The spreadsheet material is presented using Lotus 1-2-3 Release 2.x features, with specific sections devoted to features of other spreadsheet programs, including recent versions of Lotus 1-2-3 for Windows, Excel for Windows and the Macintosh, Quattro Pro, and f(g) Scholar.

Mathematical Methods for Introductory Physics with Calculus by Ronald C. Davidson, Princeton University This brief book is designed for students who find themselves unable to keep pace in their physics class because of a lack of familiarity with the necessary mathematical tools. *Mathematical Methods* provides a brief overview of all the various types of mathematical topics that may be needed in an introductory-level physics course through the use of many worked examples and exercises.

So You Want to Take Physics: A Preparation for Scientists and Engineers by Rodney Cole This text is useful to those students who need additional preparation before or during a course in physics. The book includes typical problems with worked-out solutions, and a review of techniques in mathematics and physics. The friendly, straightforward style makes it easier to understand how mathematics is used in the context of physics.

Practice Problems with Solutions This collection of more than 500 level-1 problems taken from the third edition of *Physics for Scientists and Engineers* is available with full solutions. These problems can be used for homework assignments or student practice and drill exercises.

Challenging Problems in Physics by Boris Korsunsky This set of 600 thought-provoking problems is meant to test the student's understanding of basic concepts and help them develop general approaches to solving physics problems.

Life Science Applications for Physics This supplement, compiled by Jerry Faughn, 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 having a significant number of pre-med students.

Physics Laboratory Manual by David Loyd To supplement the learning of basic physical principles while introducing laboratory procedures and equipment, each chapter of the laboratory manual includes a pre-laboratory assignment, objectives, an equipment list, the theory behind the experiment, experimental procedure, calculations, graphs, and questions. In addition, a laboratory report is provided for each experiment so the student can record data, calculations, and experimental results.

(Ken Sakomoto, Black Star)

Instructor's Ancillaries

Instructor's Manual with Solutions by Ralph McGrew and Steve Van Wyk This manual consists of complete, worked-out solutions to all the problems in the text and answers to even-numbered problems. The solutions to the new problems in the fourth edition are marked so the instructor can identify them. All solutions have been carefully reviewed for accuracy.

Computerized Test Bank by Jorge Cossio Available for the IBM PC and Macintosh computers, this test bank contains over 2300 multiple-choice and open-ended problems and questions, representing every chapter of the text. The test bank enables the instructor to customize tests by rearranging, editing, and adding new questions. The software program prints each answer on a separate grading key. All questions have been reviewed for accuracy.

Printed Test Bank This test bank is the printed version of the computerized test bank; it contains all of the multiple-choice questions and open-ended problems and questions from the software disk. Answers are also provided.

Interactive Physics Demonstrations by Ray Serway A set of physics computer simulations that use the Interactive Physics II program is available for use in classroom presentations. These simulations are very useful to show animations of motion, and most are keyed to specific sections or examples in the textbook.

Saunders Physics Videodisc Contains animations derived from SD2000 software and Interactive Physics II software, video clips demonstrating real-world applications of physics, and still images from the text of *Physics for Scientists and Engineer with Modern Physics*, fourth edition. The still images include most of the line art from the text with enlarged labels for better classroom viewing.

Physics Demonstration Videotape by J. C. Sprott of the University of Wisconsin, Madison A unique two-hour video-cassette divided into 12 primary topics. Each topic contains between four and nine demonstrations for a total of 70 physics demonstrations.

Selected Solutions Transparency Masters Selected worked-out solutions are identical to those included in the Student Solutions Manual and Study Guide. These can be used in the classroom when transferred to acetates.

Overhead Transparency Acetates This collection of transparencies consists of more than 200 full-color figures from the text and features large print for easy viewing in the classroom.

Instructor's Manual to Accompany Challenging Problems for Physics by Boris Korsunsky This book contains the answers and solutions to all 600 problems that appear in *Challenging Problems for Physics.* All problems are restated for convenience, along with the necessary diagrams.

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. A list of the suppliers of scientific equipment and a summary of the equipment needed for all the laboratory experiments in the manual are also included.

TEACHING OPTIONS

This book is structured in the following sequence of topics: Volume I includes classical mechanics, matter waves, and heat and thermodynamics, Volume II includes electricity and magnetism, light waves, optics, relativity, and modern physics. This presentation is a more traditional sequence, with the subject of matter waves presented before electricity and magnetism. Some instructors may prefer to cover this material after completing electricity and magnetism (after Chapter 34). The chapter on relativity was placed at the end of the text because this topic is often treated as an introduction to the era of "modern physics." If time permits, instructors may choose to cover Chapter 39 in Volume II after completing Chapter 14, which concludes the material on Newtonian mechanics.

For those instructors teaching a two-semester sequence, some sections and chapters could be deleted without any loss in continuity. I have labeled these with asterisks (*) in the Table of Contents and in the appropriate sections of the text. For student enrichment, some of these sections or chapters could be given as extra reading assignments.

ACKNOWLEDGMENTS

In preparing the fourth edition of this textbook, I have been guided by the expertise of the many people who reviewed part or all of the manuscript. Robert Bauman was instrumental in the reviewing process, checking the entire text for accuracy and offering numerous suggestions to improve clarity. I appreciate the assistance of Irene Nunes for skillfully editing and refining the language in the text. In addition, I would like to acknowledge the following scholars and express my sincere appreciation for their helpful suggestions, criticisms, and encouragement:

Edward Adelson, Ohio State University
Joel Berlinghieri, The Citadel
Ronald E. Brown, California Polytechnic State University–San Luis Obispo
Lt. Commander Charles Edmonson, U.S. Naval Academy
Phil Fraundorf, University of Missouri–St. Louis
Ken Ganeger, California State University–Dominiquez Hills
Alfonso Diaz-Jimínez, ADJOIN Research Center, Colombia
George Kottowar, Texas A & M
Raymond L. Kozub, Tennessee Technological University
Tom Moon, Montana Tech
Edward Mooney, Youngstown State University
Marvin Payne, Georgia Southern University
Sama'an Salem, California State University–Long Beach
John Sheldon, Florida International University
J. C. Sprott, University of Wisconsin–Madison
Larry Sudduth, Georgia Institute of Technology
David Taylor, Northwestern University
George Williams, University of Utah

I would also like to thank the following professors for their suggestions during the development of the prior editions of this textbook:

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James Walker, Washington State University
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George Williams, University of Utah
William W. Wood
Edward Zimmerman, University of Nebraska, Lincoln
Earl Zwicker, Illinois Institute of Technology

I would like to thank Michael Carchidi for coordinating and contributing to the end-of-chapter problems in the fourth edition. I am very grateful to the following individuals for contributing many creative and interesting new problems to the text: Barry Gilbert, Rhode Island College; Boris Korsunsky, Northfield Mound Hermon School; Bo Lou, Ferris State University; and Roger Ludin, California Polytechnic State University–San Luis Obispo.

I appreciate the assistance of Steve Van Wyk and Ralph McGrew for their careful review of all new end-of-chapter problems and for the preparation of the answer section in the text and the Instructor's Manual. I am indebted to my colleague and friend John R. Gordon for his many contributions during the development of this text, for his continued encouragement and support, and for his expertise in preparing the Student Solutions Manual and Study Guide with the assistance of Ralph McGrew and Steve Van Wyk. Linda Miller is to be thanked for assisting in the preparation of the manuscript and for typesetting and proofreading the Student Solutions Manual and Study Guide. My thanks to Michael Rudmin for the contribution of illustrations to the Student Solutions Manual and Study Guide. Thanks to Sue Howard for locating many excellent photographs and to Jim Lehman and the late Henry Leap for providing numerous photographs of physics demonstrations.

My thanks to Larry Golden and James Klein for their development of end-of-chapter spreadsheet problems and the accompanying templates, as well as the supplement, Numerical Analysis: Spreadsheet Investigations in Physics.

The support package is becoming an ever more essential component of a textbook. I would like to thank the following individuals for authoring the ancillaries that accompany this text: Jorge Cossio for thoroughly reviewing and updating the test bank; Jon Staib for developing the Discovery Exercises workbook that accompanies the Interactive Physics simulations and for reviewing and fine tuning many of the simulations; Evelyn Patterson of the U.S. Air Force Academy for her insightful review and improvements to the Interactive Physics simulations; John Minnerly for converting the Interactive Physics files into an IBM Windows format; Bob Blitshtein and the staff at Future Graph, Inc., for their creation of the SD2000 software package to accompany this text; V. Gordon Lind for concepting and authoring the Pocket Guide; David Loyd for preparing the lab manual and accompanying instructor's manual; Boris Korsunsky for preparing a supplement of Challenging Problems for Physics; Jerry Faughn for compiling *Life Science Applications for Physics;* Ron Davidson for authoring *Mathematical Methods for Introductory Physics with Calculus;* and Rodney Cole for preparing the preparatory manual for physics, *So You Want to Take Physics.*

During the development of this textbook, I benefited from valuable discussions and communications with many people including Subash Antani, Gabe Anton, Randall Caton, Don Chodrow, Jerry Faughn, John R. Gordon, Herb Helbig, Lawrence Hmurcik, William Ingham, David Kaup, Len Ketelsen, Alfonso Diaz-Jimínez, Henry Leap, H. Kent Moore, Charles McFarland, Frank Moore, Clem Moses, Curt Moyer, William Parks, Dorn Peterson, Joe Rudmin, Joe Scaturro, Alex Serway, John Serway, Georgio Vianson, and Harold Zimmerman. Special recognition is due to my mentor and friend, Sam Marshall, a gifted teacher and scientist who helped me sharpen my writing skills while I was a graduate student.

Special thanks and recognition go to the professional staff at Saunders College Publishing for their fine work during the development and production of this text, especially Laura Maier, Developmental Editor; Sally Kusch, Senior Project Editor; Charlene Squibb, Production Manager; and Carol Bleistine, Manager of Art and Design. Thanks also to Tim Frelick, VP/Director of Editorial, Design, and Production, and to Margie Waldron, VP/Marketing, for their continued support of this project. I thank John Vondeling, Vice

President / Publisher, for his great enthusiasm for the project, his friendship, and his confidence in me as an author. I am most appreciative of the intelligent copyediting by Charlotte Nelson, the excellent artwork by Rolin Graphics, Inc., and the attractive design by Rebecca Lemna.

A special note of appreciation goes to the hundreds of students at Clarkson University who used the first edition of this text in manuscript form during its development. I also wish to thank the many users of the second and third editions who submitted suggestions and pointed out errors. With the help of such cooperative efforts, I hope to have achieved my main objective; that is, to provide an effective textbook for the student.

And last, I thank my wonderful family for continuing to support and understand my commitment to physics education.

Raymond A. Serway
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June 1995

To The Student

I feel it is appropriate to offer some words of advice which should be of benefit to you, the student. Before doing so, I will 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 I would like to offer some suggestions based on my own experiences in learning and teaching over the years.

First and foremost, maintain a positive attitude towards 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 be 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. This is best accomplished through a careful reading of the textbook before attending your lecture on that material. In the process, it is useful to jot down certain points which are not clear to you. Take careful notes in class, and then ask questions pertaining to those ideas that require clarification. Keep in mind that few people are able to absorb the full meaning of scientific material after one reading. Several readings of the text and notes may be necessary. Your lectures and laboratory work should supplement the text and clarify some of the more difficult material. You should reduce memorization of material to a minimum. Memorizing passages from a text, equations, and derivations does not necessarily mean you understand the material. Your understanding of the material will be enhanced through a combination of efficient study habits, discussions with other students and instructors, and your ability to solve the problems in the text. Ask questions whenever you feel it is necessary.

STUDY SCHEDULE

It is important to set up a regular study schedule, preferably on a daily basis. Make sure 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 the lecture. As a general rule, you should devote about two hours of study time for every hour in class. If you are having trouble with the course, seek the advice of the instructor or students who have taken the course. You may find it necessary to seek further instruction from experienced students. Very often, instructors will 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 will lead to disastrous results. Rather than staying up for an all-night session, it is better to review the basic concepts and equations briefly, followed by a good night's rest. If you feel in need of additional help in