COLLEGE PHYSICS

RAYMOND A. SERWAY
James Madison University
JERRY S. FAUGHN
Eastern Kentucky University

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PREFACE

This textbook is appropriate for a one-year course in introductory physics commonly taken by students majoring in the biological, environmental, earth, and social sciences, as well as other disciplines such as industrial technology and architecture. The mathematical techniques used in the book include algebra and trigonometry, but not calculus.

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, we have attempted to motivate the student through practical examples which demonstrate the role of physics in other disciplines.

Coverage

The material covered in this book is concerned with standard topics in classical physics and modern physics. The book is divided into six parts: Part I (Chapters 1–9) deals with the fundamentals of Newtonian mechanics and the physics of fluids; Part II (Chapters 11–13) is concerned with heat and thermodynamics; Part III (Chapters 14–15) covers wave motion and sound; Part IV (Chapters 16–23) is concerned with electricity and magnetism; Part V (Chapters 24–27) treats the properties of light and the field of geometric and wave optics; and Part VI (Chapters 28–32) represents an introduction to the theory of relativity and modern physics.

Features

Most instructors would agree that the textbook assigned in a course should be the student's major "guide" for understanding and learning the subject matter. With this in mind, we 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 We have attempted to write the book in a style that is clear, relaxed, and pleasing to the reader. New terms are carefully defined, and we have tried to avoid jargon.

Organization The book is divided into six parts: mechanics, thermodynamics, vibrations and wave motion, electricity and magnetism, light and optics, and modern physics. Each part includes an overview of the subject matter to be covered in that part and some historical perspectives.

Introductory Chapter An introductory chapter is included to "set the stage" for the text and to discuss the units of physical quantities, order-of-magnitude calculations, dimensional analysis, significant figures, mathematical notation, and the techniques of treating vector quantities.

Units The international system of units (SI) is used throughout the book. The

British engineering system of units (conventional system) is used only to a limited extent in the early chapters on mechanics.

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

Equations Important equations are enclosed in a color screened box, and marginal notes are often used to describe their meaning.

Worked Examples A large number of worked examples (276) are presented as an aid in understanding concepts. In many cases, these examples will serve as models for solving end-of-chapter problems. The examples are set off from the text with a vertical bar for ease of location, and most examples are given titles to describe their content.

Worked Example Exercises Many of the worked examples are followed immediately by exercises (set in color) with answers (a total of 105). These exercises are intended to make the textbook more interactive with the student, and to test the student's understanding of problem-solving techniques.

Special Topics Many chapters include special topic sections which are intended to expose the student to various practical and interesting applications of physical principles. Many of these are considered optional, and as such are labeled with an asterisk (*).

Guest Essays As an added feature, we have included 12 essays written by guest authors. The topics covered in these essays are arch structures, the circulatory system, the nervous system, heat engines, applications of lasers in medicine, exponential growth, general relativity, superconductivity, atmospheric physics, the perception of musical sound, fiber optic communications, and semiconductor technology. These essays are intended as supplemental reading for the student and do not include problem sets.

Important Statements Many important statements and definitions are set in color for added emphasis and ease of review.

Illustrations The readability and effectiveness of the textual material and worked examples are enhanced by the large number of figures, diagrams, photographs, and tables. A second color is used to add clarity to the artwork. For example, vectors are color-coded, and curves in *xy*-plots are drawn in color. Three-dimensional effects are produced with the use of air-brushed areas, where appropriate.

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

Readings Each chapter contains a set of suggested additional readings. These have been selected on the basis of their level and the degree to which they supplement the text.

Thought Questions A list of questions requiring verbal answers is given at the end of each chapter (440 total). 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. Answers to selected questions are included in the Student Study Guide With Computer Exercises that accompanies the test.

Problems An extensive set of problems is included at the end of each chapter. (The text contains more than 1600 problems.) Answers to odd-numbered problems are given at the end of the book in a section which is shaded at the edges for ease of location. For the convenience of both the student and instructor, most problems are keyed to specific sections of the chapter. About one third of the problems, labeled "Additional Problems," are not keyed to specific sections. In general, there are three categories of problems in each chapter, corresponding to three levels of difficulty. Problems that are straightforward in nature are presented first and are unmarked. These are followed by problems of intermediate difficulty, marked with one dot (•). Finally, we include a small number of more challenging problems, marked with two dots (••). In our opinion, assignments should mainly consist of problems from the first two categories so as to help build self-confidence in students.

Appendices Several appendices are provided at the end of the text. Most of the appendix material represents a review of mathematical techniques used in the text, including scientific notation, algebra, geometry, and trigonometry. Reference to these appendices is made throughout the text. Most mathematic review sections include worked examples and exercises with answers. The last few appendices supplement textual information. The endpapers at the back of the text contain useful conversion factors and a Trigonometric Table.

Ancillaries

The ancillaries that are available with this text include an Instructor's Manual with Selected Solutions, a Printed Test Bank containing over 1200 multiple choice problem-solving and descriptive questions, a Computerized Test Bank for the Apple II family of computers, a Classroom Lesson Disk (Apple II format) containing demonstrations for use in lecture situations, a Student Study Guide With Computer Exercises (described below), and a Courseware Disk (Apple II format) containing programs to be used with the computer exercises.

The Student Study Guide With Computer Exercises is a unique student aid in that it combines the value of a problem-solving oriented study guide with a group of integrated and interactive computer exercises. Each chapter of the study guide contains a list of objectives, a review and summary of important concepts, a few worked examples, answers to selected questions from the text, and further drill on problem-solving methodology through the use of programmed exercises. The study guide also includes the option of using a number of computer programs (presented in special computer modules) which are interactive in nature. That is, the student's input will have direct and immediate effect on the output. This feature will enable students to work through many challenging numerical problems, and experience the power of the computer in scientific work. The computer exercises direct the student's use of the programs contained on the Courseware Disk. This disk is available upon adoption of the study guide.

Teaching Options

As is often the case, the book contains more than enough material for a one-year course in introductory physics. This gives the instructor more flexibility in choosing topics for a specific course. On the average, it should be possible to cover about one chapter each week. Many special topic sections containing interesting applications are considered optional and are therefore marked with an asterisk (*). For shorter courses, instructors may also elect to omit several chapters without any loss in continuity. The chapters we would suggest as being optional are Chapter 8 (Rotational Motion), Chapter 22 (Alternating Current Circuits), Chapter 23 (Electromagnetic Waves), Chapter 27 (Optical Instruments), and Chapter 32 (Nuclear Physics Applications and Elementary Particles).

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Raymond A. Serway
James Madison University
Harrisonburg, Virginia

Jerry Faughn
Eastern Kentucky University
Richmond, Kentucky

TO THE STUDENT

We feel it is appropriate to offer some words of advice which should be of benefit to you, the student. Before doing so, we 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 we 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 based on our 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. If you are reluctant to ask questions in class, seek private consultation. Many individuals are able to speed up the learning process when the subject is discussed on a one-to-one basis.

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 an all night study session, it is better to briefly review the basic concepts and equations, followed by a good night's rest. If you feel in need of additional help in understanding the concepts, preparing for exams, or in problem-solving, we suggest that you acquire a copy of the student study guide which accompanies the text, which 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, while important statements and definitions are highlighted in color. Many useful tables are contained in appendices, but most are incorporated in the text where they are used most often. Appendix A is a convenient review of mathematical techniques. Answers to odd-numbered problems are given at the end of the text, and answers to end-of-chapter questions are provided in the study guide. Exercises (with answers), which follow some worked examples, represent extensions of those examples, and in most cases you are expected to perform a simple calculation. Their purpose is to test your problem-solving skills as you read through the text. An overview of the entire text is given in the table of contents, while the index will enable you to locate specific material quickly. Footnotes are sometimes used to supplement the discussion or to cite other references on the subject. A list of suggested additional readings is given at the end of each chapter.

After reading a chapter, you should be able to define any new quantities introduced in that chapter, and discuss the principles and assumptions that were used to arrive at certain key relations. The chapter summaries and the review sections of the study guide should help you in this regard. In some cases, it will be necessary to refer to the index of the text to locate certain topics. You should be able to correctly associate with each physical quantity a 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.

Problem Solving

R. P. Feynman, Nobel laureate in physics, once said, "You do not know anything until you have practiced." In keeping with this statement, we strongly advise that you develop the skills necessary to solve a wide range of problems. Your ability to solve problems will be one of the main tests of your knowledge of physics, and therefore you should try to solve as many problems as possible. It is essential that you understand basic concepts and principles before attempting to solve problems. It is good practice to try to find alternate solutions to the same problem. For example, problems in mechanics can be solved using Newton's laws, but very often an alternative method using energy considerations is more direct. You should not deceive yourself into thinking you understand the problem after seeing its solution in class. You must be able to solve the problem and similar problems on your own.

The method of solving problems should be carefully planned. A systematic plan is especially important when a problem involves several concepts. First, read the problem several times until you are confident you understand what is being asked. Look for any key words that will help you interpret the problem, and perhaps allow you to make certain assumptions. Your ability to interpret the question properly is an integral part of problem solving. You should acquire the habit of writing down the information given in a problem, and decide what quantities need to be found. You might want to construct a table listing quantities given, and quantities to be found. This procedure is sometimes used in the worked examples of the text. After you have decided on the method you feel is appropriate for the situation, proceed with your solution.

We often find that students fail to recognize the limitations of certain formulas or physical laws in a particular situation. It is very important that you understand and remember the assumptions which underlie a particular theory or formalism. For example, certain equations in kinematics apply only to a particle moving with constant acceleration. These equations are not valid for situations in which the acceleration is not constant, such as the motion of an object connected to a spring, or the motion of an object through a fluid.

Experiments

Physics is a science based upon experimental observations. In view of this fact, we recommend that you try to supplement the text through various types of "hands-on" experiments, either at home or in the laboratory. These can be used to test ideas and models discussed in class or in the text. For example, the common "Slinky" toy is excellent for studying traveling waves; a ball swinging on the end of a long string can be used to investigate pendulum motion; various masses attached to the end of a vertical spring or rubber band can be used to determine their elastic nature; an old pair of Polaroid sunglasses and some discarded lenses and magnifying glass are the components of various experiments in optics; you can get an approximate measure of the acceleration of gravity by dropping a ball from a known height by simply measuring the time of its fall with a stopwatch. The list is endless. When physical models are not available, be imaginative and try to develop models of your own.

Scientific Method

All that we have said can be summarized in an approach called the scientific method. The scientific method, which is used in all branches of science, consists of five steps:

1. Recognize the problem.
2. Hypothesize an answer.
3. Predict a result based upon the hypothesis.
4. Devise and perform an experiment to check the hypothesis.
5. Develop a theory which links the confirmed hypothesis to previously existing knowledge.

Someone once said that there are only two professions in which people truly enjoy what they are doing: professional sports and physics. The authors suspect that this is an exaggeration, but it is true that both fields are exciting and stretch your skills to the limit. It is our sincere hope that you too will find physics an exciting and enjoyable experience, and that you will profit from this experience, regardless of your chosen profession.

Welcome to the exciting world of physics.

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