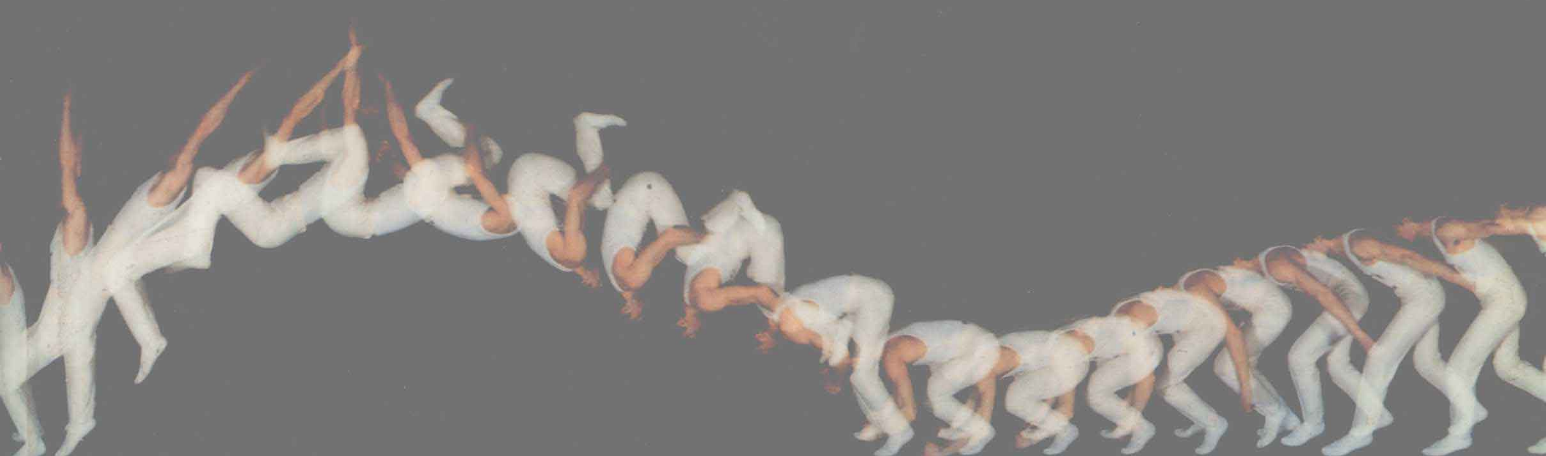
KANE & STERNHEIM

PHYSICS

THIRD EDITION



PHYSICS

THIRD EDITION

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SUPPLEMENTS

Student Study Guide and Solutions Manual for Physics 3rd Edition. (0-471-85220-1)

Morton M. Sternheim, University of Massachusetts, Amherst
Joseph W. Kane, Digital Equipment Corporation

Developed for student use with this text, including objectives, reviews, examples, new concepts and terms, quizes and exams, as well as solutions for approximately 25% of the problems in the text.

Experiments in Physics—A Laboratory Manual (0-471-88548-7)

Daryl W. Preston, California State University at Hayward
Morton M. Sternheim, University of Massachusetts, Amherst
Joseph W. Kane, Digital Equipment Corporation

A laboratory manual designed to be used in the introductory physics course. The experiments follow the order of topics in traditional texts. Optional material is provided as well as flexibility in the choice of experiments.

Essential Mathematics for College Physics with Calculus, A Self-Study Guide (0-471-80876-8)

Michael Ram, SUNY Buffalo

Math supplement for both noncalculus and calculus courses, covering the mathematics used in physics. Uses the tutorial approach. Chapters independent and nonsequential. Emphasis on key points and stumbling blocks, test strategies, memorization tricks, etc.

Concentrated Physics Concepts Part 1, Mechanics (0-471-82562-X)

David Alexander, Wichita State University
Richard Cornelius, Wichita State University

Interactive computer-aided instruction to help teach problem-solving techniques. Exposes students to a wide range of physics topics such as conversion of units, vectors, significant figures, particle dynamics, rotational dynamics, and many more.

For The Instructor
Instructor's Manual for *Physics, 3rd Edition includes solutions to all exercises and problems* and *Transparency Masters.*

PREFACE

Physics is intended for students with diverse backgrounds. It is based on our experience with a course taken by many students majoring in basic and applied life science areas as well as by students in a variety of other fields. Most of these students were sophomores or juniors, and had already taken other college-level science courses; few had studied physics in high school. Many had been exposed to calculus, but few had confidence in their ability to use it seriously.

This book differs in several ways from many other physics texts. First, the specific needs of science majors, including those in the life sciences, have influenced which physics topics are included or emphasized. Thus we cover some topics no longer of great current interest to many physicists, such as geometric optics, the mechanics of fluids, and acoustics, and minimize historical material and contemporary physics areas with little impact on other sciences. Second, we make extensive use of examples involving biological and chemical systems and alternative energy sources. Finally, we devote entire sections and chapters to applications of physics, covering subjects such as nerve conduction, ionizing radiation, and nuclear magnetic resonance. These features help to motivate students while demonstrating the widespread utility of physics and the unity of science.

Physics contains 31 chapters, grouped into nine units. To accommodate varying needs and tastes, there is more material than can usually be covered in a two-semester or three-quarter course. Chapters that may be treated lightly or omitted entirely include Chapter Eight, Elastic Properties of Materials; Chapter Eighteen, Nerve Conduction; Chapter Twenty-five, Special Relativity; Chapter Twenty-nine, The Structure of Matter; and Chapter Thirty-one, Ionizing Radiation. Most of the chapters end with Supplementary Topics sections containing either applications of physics or traditional topics that can be omitted without loss of continuity. This arrangement assists the instructor in selecting what to include or emphasize and also helps the student to distinguish the basic principles of physics from more peripheral material.

Each chapter has a checklist of terms to define or explain and exercises keyed to the sections. There are also problems, which are unkeyed; occasional more difficult ones are preceded by an asterisk. Exercises and problems are provided for the Supplementary Topics so that they may be fully integrated into the course.

Our general approach is to use the minimum amount of formal mathematics consistent with a precise treatment of the physics under consideration. This means we use algebra rather freely and some geometry. Because some students are relatively weak in these skills when they begin studying physics, we proceed fairly slowly in the first few chapters. We also provide a mathematical review in Appendix B. Differentiation is introduced in Chapter One, and it is used subsequently in definitions. The few derivations requiring differentiation are placed at the ends of the chapters where they do not interrupt the flow of the text material. Integration is never used, and no calculus is required for any of the examples, exercises, or problems.

In preparing the third edition of *Physics*, we have had two main objectives. We wanted to strengthen the pedagogic aspects wherever possible by clarifying our developments and adding examples, exercises, and problems. We also sought to keep the book up to date and to increase its appeal for students with a wide range of interests. This meant revising or adding many sections and subsections devoted to topics in basic physics and to applications of the fundamental principles in science and technology. Much of this new material is based on very recent developments or events. We think that both students and teachers will find it very stimulating.

In improving the pedagogy, we looked carefully at each section to make sure that there were varied examples, exercises, and problems at different levels of difficulty. We have added over 50 examples and nearly 300 exercises and problems and have revised some of the older items. We also rewrote sections and paragraphs scattered throughout the book where we thought we could improve the discussion or could clarify topics that are difficult for students.

Clearly physics underlies much of what is happening today in other sciences and in technology. In keeping with our basic philosophy, the additions are aimed at making the book interesting and useful for students majoring in all areas of the biological and physical sciences. Some additions discuss traditional topics that were requested by teachers using earlier editions. These include the parallel axis theorem (Chapter Four), spherical mirrors (Chapter Twenty-four), the twin paradox (Chapter Twenty-five), and blackbody radiation (Chapter Twenty-six). We have expanded and updated some earlier discussions of applications such as tomography and NMR and PET scans (Chapters Twenty-three, Twenty-nine, Thirty-one) and of nuclear safety and accidents (Chapter Thirty). Completely new materials include Coriolis forces and wind patterns (Chapter Seven); large-scale atmospheric motions and monsoons (Chapter Twelve); models for the earth's crust (Chapter Thirteen); hysteresis and magnetic disk storage (Chapter Twenty); auditory localization by barn owls (Chapter Twenty-two); reflectance, rainbows (Chapter Twenty-three); direct observations of quantum jumps, barrier penetration and tunneling, scanning tunneling electron microscope (Chapter Twenty-eight); superconductivity (Chapters Seventeen, Twenty-nine); superstrings (Chapter Thirty); and radon in the home (Chapter Thirty-one).

This edition of *Physics* uses only S.I. units and units approved for use with that system. However, we do show how to convert to and from other kinds of units. We also include an appendix which discusses other systems of units and a fairly extensive list of conversion factors.

We thank the many students and faculty colleagues who have helped us in so many ways. We are also indebted to the competent and cooperative editorial and production staffs at John Wiley & Sons for their valuable assistance, to our reviewers for their useful suggestions, and to Margaret Silbar, a talented science writer, who provided the material on superstrings. Most of all, we thank our families for their ongoing patience, help, and encouragement.

JOSEPH W. KANE

MORTON M. STERNHEIM

PROLOGUE
PHYSICS AND THE SCIENCE STUDENT

"Why should I study physics?" Sometimes asked with emotional overtones ranging from anguish to anger, this is one of the questions most frequently heard by physics teachers. It seems appropriate therefore to begin this book by attempting an answer.

One reason this question is asked so often is that many people who have not studied physics—and some who have—lack a clear notion of what physics is. Dictionaries are not much help. A typical short dictionary definition says that physics is the branch of science that deals with matter, energy, and their interactions. This is vague and general enough to include what is usually considered to be chemistry; in any case, it does not give any real feeling for what is involved. Longer dictionary entries usually expand the definition by noting that physics includes subfields such as mechanics, heat, electricity, and so forth. They give no clues as to why some subfields of science are included and others are not.

A better approach to defining physics is to ask what physicists are concerned about. Physicists attempt to understand the basic rules or *laws* that govern the operation of the natural world in which we live. Since their activities and interests evolve with time, the basic science called physics also changes with time. Many of the most active contemporary subfields of physics were undreamed of a generation or two ago. On the other hand, some parts of what are now considered to be chemistry or engineering were once considered to be physics. This is because physicists sometimes gradually abandon a field once the basic principles are known, leaving further developments and practical applications to others.

The fact that physics deals with the basic rules governing how the world works lets us see why people with varied interests may find the study of physics interesting and useful. For example, a historian who wants to understand the origins of our contemporary society will find significance in the story of the development of physics and its relationship to other human activities. Similarly, a philosopher concerned about concepts of space and time will profit greatly from understanding the revolutionary twentieth-century advances in physics. However, since we have written this book primarily for students majoring in the sciences, we have not stressed the historical or philosophical aspects of physics. Instead, we have tried to make clear in every chapter the connection between physics and the other biological and physical sciences.

Perhaps the most obvious impact of physics on science is at the level of instrumentation. A knowledge of physics helps in the intelligent use of everything from light microscopes and centrifuges to electron microscopes and elaborate radiation detection systems used in nuclear medicine. Physics also enters in more fundamental ways. The physical laws governing the behavior of molecules, atoms, and atomic nuclei are the basis for all of chemistry and biochemistry. Physiology offers many examples of physical processes and principles: diffusion within cells, the regulation of the body temperature, the motion of fluids in the circulatory system, and electrical signals in nerve fibers are just a few. In comparative anatomy, the physics associated with an anatomical feature often helps to clarify the evolutionary process. Athletic activities ranging from running and jumping to karate can be studied and sometimes optimized with the aid of physical principles. Physical principles explain the motion of the atmosphere, and the structure of astronomical objects. In the course of developing and illustrating the basic principles of physics, we discuss all these applications and many others.

A few remarks about how one studies physics may be helpful. More than any other science, physics is a logical and deductive discipline. In any subfield of physics, there are just a few fundamental concepts or laws derived from experimental measurements. Once one has mastered these basic ideas, the applications are usually straightforward conceptually, even though the details may sometimes become complicated. Consequently, it is important to focus one's attention on the basic principles and to avoid memorizing a mass of facts and formulas.

Most of the basic laws of physics can be expressed rather concisely in the form of mathematical equations. This is a great convenience, since a tremendous amount of information is implicitly contained in a single equation. However, this also means that any serious attempt to learn or apply physics necessitates a willingness to use a certain amount of mathematics. High school algebra plus a bit of geometry is adequate for everything covered in this book, but a reasonable level of facility is required. A student who has become rusty at these mathematical skills may want to begin with the Mathematical Review in Appendix B. One post–high school mathematical technique, differentiation, is introduced in the first chapter. However, except in definitions, its use is restricted to a few derivations located in the Supplementary Topics. None of the exercises or problems requires this mathematical tool.

In summary, we believe the student will benefit in two major ways from studying physics. The student will gain an understanding of the basic laws that govern everything in our world from the subatomic to the cosmic scale and will also learn much that will be important in his or her work in the sciences. The study of physics as a basic science is not particularly easy, but we believe it is rewarding, particularly for students planning further training in related sciences. We hope that all who use this book will agree.

J. W. K
M. M. S

UNIT ONE

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