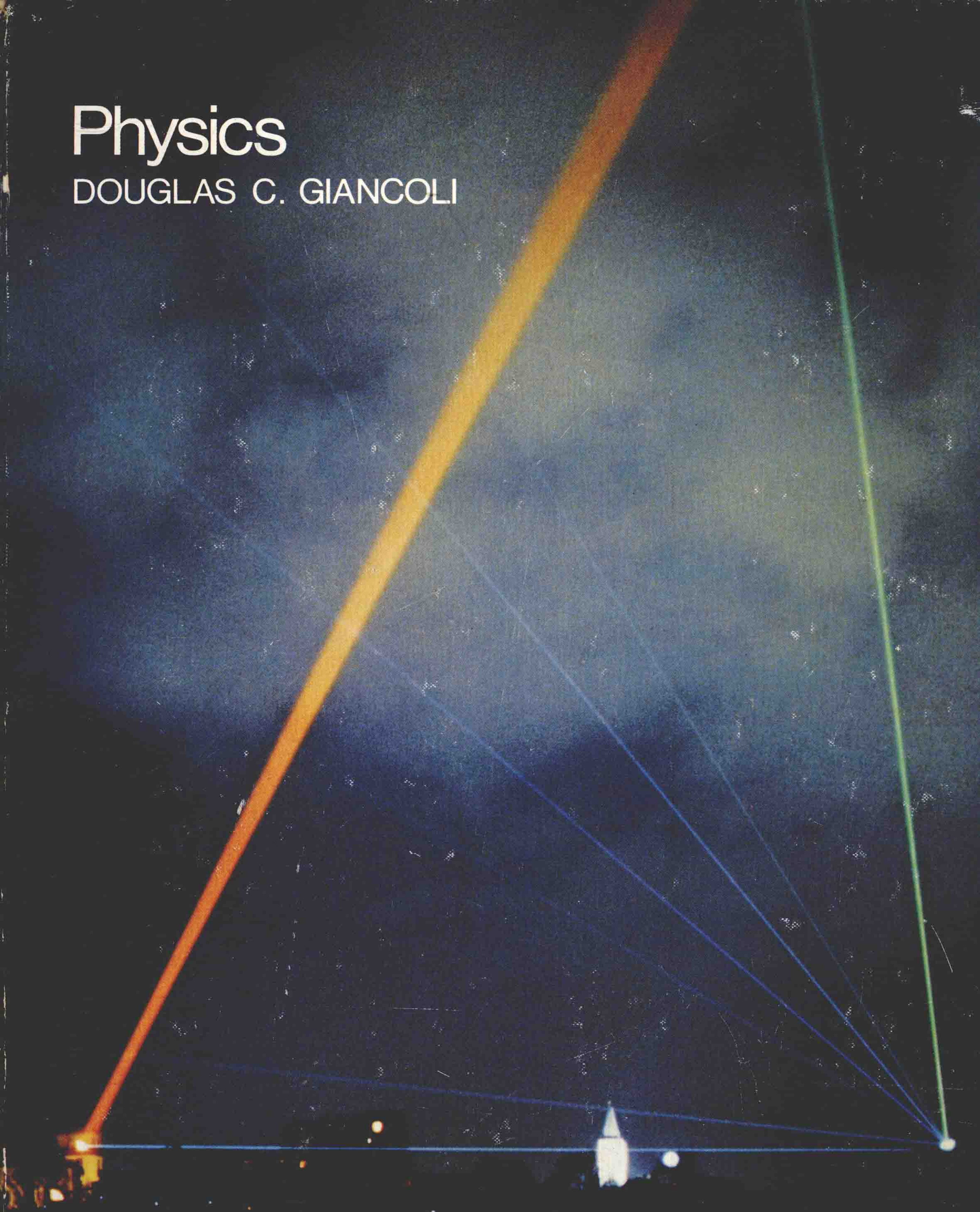
Physics

DOUGLAS C. GIANCOLI



Physics
Principles with applications

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COVER PHOTOGRAPH

Laser beams (see Chapter 27) illuminate the evening sky over Kassel, Germany, in celebration of a modern-art exhibition. (Courtesy of Horst H. Baumann and Spectra-Physics, Inc.)

For Andrea, Francesca, and Mary Teresa

Preface

Two intentions motivated the writing of this introductory physics textbook: to give students a thorough understanding of the basic concepts of physics and, by means of many interesting applications, to prepare them to use physics in their own lives and professions. The book is thus appropriate for the introductory one-year physics courses commonly taken by students majoring in the life sciences, premedicine, architecture, technology, environmental sciences, and other disciplines. It may also be suitable for use in colleges that offer only one introductory physics course. It makes use of algebra and elementary trigonometry, but not calculus.

What this book offers, above all, is an in-depth presentation of physics. In developing the concepts, I have tried to avoid the dogmatic approach of giving general principles and then deriving conclusions—an approach that makes physics seem like a collection of facts. Instead, I have attempted to motivate students by opening a topic with observations (including ones that they can make themselves) and then going on to generalizations and/or development of physical theories. This procedure is closer to the way science is practiced and thus gives students a more honest picture of science; it also gives them, I believe, a better understanding of the fundamentals because the students can relate them to their own experience. In addition, where possible, I have endeavored to present the basic concepts in their historical and philosophical context. I have also attempted to bring each topic to a natural conclusion by discussing why it is important; topics are not left hanging, with students asking, "Why did we study that?" (One example is statics: this subject has practical importance because real materials are elastic and can fracture; therefore elasticity and fracture are included in Chapter 4 on statics.)

The second important feature of this book is the inclusion of a wide range of examples from, and applications to, other fields: biology, medicine, architecture, technology, earth sciences, the environment, and daily living. These serve not only to enliven the book but also to show how physics is important in our lives and in other disciplines and professions. Some applications serve only as examples of physical principles. Many other applications, however, are treated in depth, with whole sections or subsections devoted to them (among these are the study of the nervous system, constructing arches and domes, effects of radiation, and feedback). Yet the applications do not dominate the text (that is, after all, a physics book!). They have been carefully chosen and integrated into the text so as not to interfere with the development of the physics but rather to illuminate it.

A great deal of attention is given to problem solving. Methods of attacking problems are discussed in several places (for example, Section 2-8). Some 250 Examples are fully worked out in the text; these help students to fix ideas in their minds, to demonstrate interesting applications, and to help students develop problem-solving skills. Many examples are taken from everyday life and aim at being realistic. There are over 2000 end-of-chapter exercises, including no fewer than 500 Questions that require verbal answers based on an understanding of the concepts and more than 1500 Problems involving mathematical calculation. The wide range of Problems relates directly to the physics as well as the applications. They are arranged by sections, and they are graded according to difficulty: (I) simple problems requiring an understanding of basic definitions and concepts and typically the use of a single equation; (II) problems requiring more thought and often the combination of two different concepts; (III) the most difficult, often requiring synthesis of three or more concepts or perhaps dealing with more advanced material. I suggest that instructors assign a significant number of the type I and type II Problems and only a small number of type III; although most type I may seem easy, they help to build self-confidence—an important part of learning, especially in physics.

Throughout the text *Système international* (SI) units are used. Other metric and British units are defined for informational purposes.

Topics are presented in more or less traditional order, beginning with mechanics and ending with modern physics; nearly all topics customarily taught in introductory physics courses are included here (including those listed in the *New MCAT Student Manual*). The tradition of beginning with mechanics is sensible, I believe, since it was developed first, historically, and since so much else in physics depends on it. Within mechanics there is a variety of ways to order the topics. Although this book allows for flexibility, my reasons for the order as it stands may be of interest. I have placed statics (Chapter 4) after dynamics partly because many students seem to have trouble with the concept of force. (They tend to associate force with motion, and it seems to help if they understand the nature of this connection before dealing with forces without motion.) This order also allows full development of the concept of torque before it is used in statics. Moreover, statics is a special case of dynamics—we study statics so that we can prevent structures from becoming dynamic (falling down)—and that sense of being at the limit of dynamics is intuitively helpful. Also in mechanics I have treated rotational motion before energy because angular variables and torque follow the pattern of kinematics and Newton's laws already discussed for translational motion. The conservation laws—energy, momentum, and angular momentum—offer an entirely different approach to mechanics. It therefore seems easier for students if we treat these two approaches separately in a unified way. The chapters are written, nonetheless, so that most of Chapter 5, on momentum and energy, can be treated right after Chapter 2, on Newton's laws, with the appropriate sections on rotational kinetic energy and angular momentum following Chapter 3. Another option is whether light should follow electricity and magnetism or instead precede it by coming directly after waves and sound. The former is more traditional, and it is the order I have used. The material on light (Chapters 21 to 23), however, is so treated that it can be taught immediately after sound (Chapter 12).

The book contains more material than can be covered in most one-year courses. This was done to give instructors flexibility in choice of topics. The wide range of subjects also means that students can learn about many topics even though there is not class time for them. This aspect makes the book more valuable to students as a resource and as a reference book. Many sections and subsections are marked with a star (asterisk) to indicate they are *optional.* These sections contain slightly more advanced physics material (often material not usually covered in typical courses) and/or interesting applications. They contain no material needed in later chapters (except, perhaps, in later optional sections). This is not to imply that all nonstarred sections must be covered; there still remains considerable flexibility in the choice of material to suit the needs of students and instructors.

As is only too well known, mathematics can be an obstacle to student understanding. To avoid frightening students with an initial chapter on mathematics, I have instead used an appendix for review of algebra, geometry, accuracy and significant figures, exponents, powers of ten, proportions, and equations. Other appendixes cover order-of-magnitude estimating and dimensional analysis. Other important mathematical tools, such as addition of vectors and trigonometry, are dealt with in text where first needed.

Difficult language too can hinder understanding; and to put students at their ease, I have tried to write in a relaxed, colloquial style, avoiding jargon. New or unusual terms are carefully defined when first used.

An extremely important aspect of the text is the more than 800 line drawings and photographs, which illustrate the physical principles as well as the applications and exercises. They are an integral part of the material, and it may be helpful to point out to students how valuable they are for understanding physics.

I wish to thank the Rutherford High Energy Laboratory, Didcot, England, and the University of California at Berkeley, who were so hospitable to me during parts of the writing process, and to express my gratitude to the Physics Department at California State Polytechnic University, Pomona, for continual support and encouragement.

I also wish to thank the many people who contributed in various ways to making this a better book. The professors who read part or all of the manuscript and offered many excellent comments include Isaac Bass, Paul A. Bender, Joseph Boyle, Peter Brancazio, William Klink, William Eidson, David J. Ernst, Laurent Hodges, Gordon Jones, Robert Messina, Kwangjai Park, D. Lee Rutledge, William Riley, Paul Urone, Jearl Walker, Gareth Williams, and Peter Zimmerman. Special thanks go to Logan Campbell, physics editor at Prentice-Hall, who coordinated the project in an effective and humanistic manner, to Keith Brown, who worked out all the solutions to the Problems (and made me delete a few that could not be done), to Isaac Bass, who allowed me to use some of his interesting problems, to Bob Messina, who checked the examples for correctness, and to Donna Botash, who typed nearly all the manuscript. The responsibility for errors, of course, lies with me, and I welcome corrections and comments.

D. C. G.

Notes to students and instructors on the format

1 Sections and subsections marked with a star (*) are considered optional (see the Preface).

2 The customary conventions are used: Symbols for quantities are italicized (such as *m* for mass), whereas units are not italicized (m for meter); boldface (**F**) is used for vectors, and this is discussed in the text.

3 Important terms are italicized where they are introduced, and the most important are in boldface (such as *coefficient of friction* and **acceleration**).

4 The most basic laws and equations are set off and preceded by a colored rectangle (▮).

5 Worked-out Examples and their Solutions in the text are set off with a rectangle (▮) at the beginning and two rectangles (▮▮) at the end.

6 Each chapter ends with a Summary, giving a brief review of important concepts and terms (the most important ones are italicized here).

7 Following the Summary in each chapter are sets of Questions that students should attempt to answer (to themselves at least) and Problems arranged according to section and difficulty (see the Preface). Questions and Problems that relate to optional sections are starred.

8 Each chapter contains a bibliography for further reading.

9 The appendixes contain useful tables and other valuable material, such as a mathematic review and discussions of order-of-magnitude estimating and dimensional analysis. Frequently used tables are located inside the front and back covers.

10 The extensive Index can be a useful tool. For example, it can be used to look up concepts or words whose meanings have been forgotten.

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