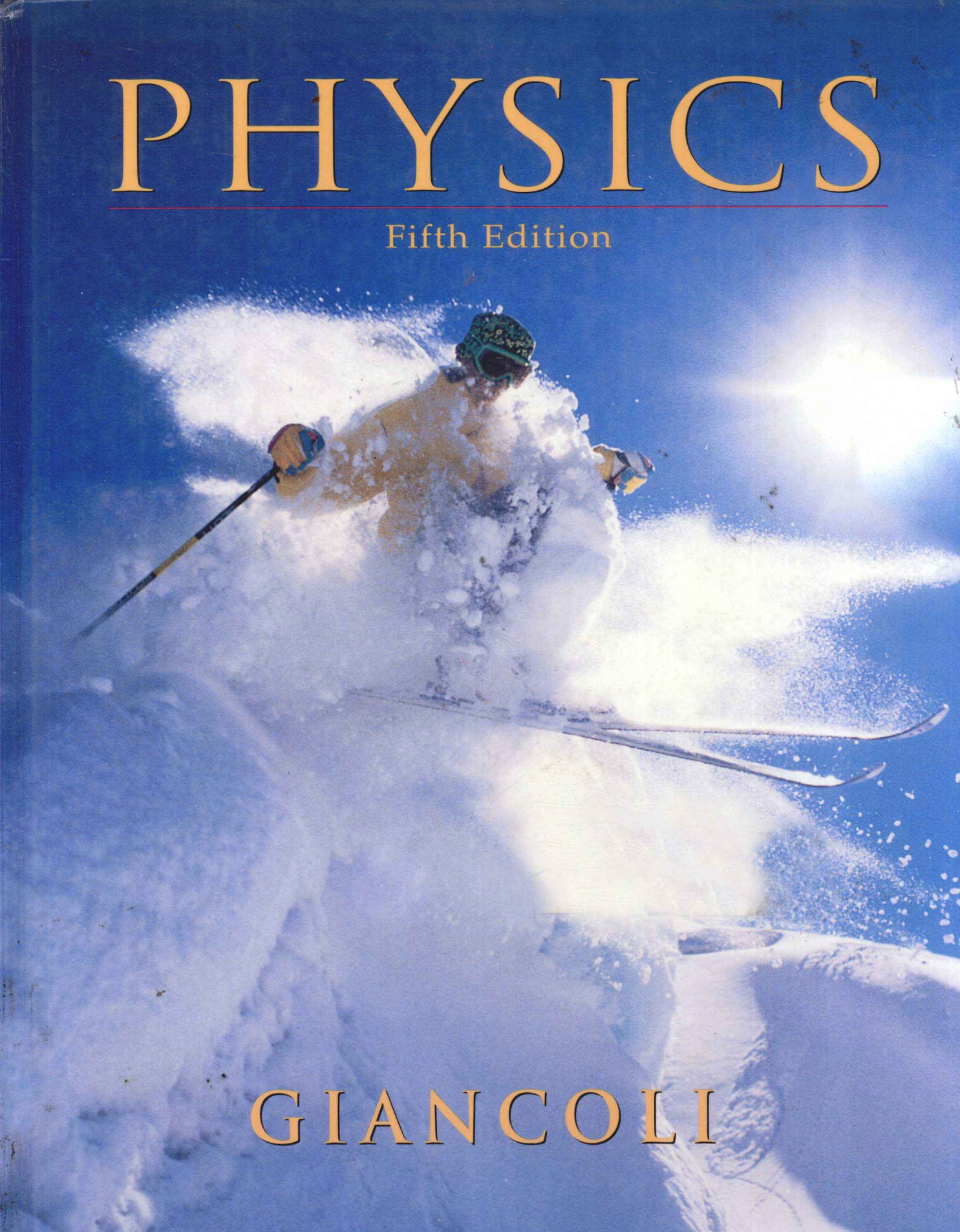
PHYSICS

Fifth Edition



GIANCOLI

PHYSICS

PRINCIPLES WITH APPLICATIONS

Fifth Edition

Douglas C. Giancoli

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PREFACE

A Fifth Edition?

By the fifth edition of an algebra-based physics text, one might expect that the author has at last gotten it right.

I hope the earlier editions weren't all that wrong. The idea of a new edition is to improve, to bring in material, and perhaps to delete material that makes the book longer but isn't all that useful. All these things have been done:

Physics. Physics itself may not change all that rapidly, but over the span of a few years, there may be some new discoveries to include, such as

- planets revolving around distant stars
- information gathered by the Hubble Space Telescope
- updates in particle physics and cosmology (e.g., age of universe).

Pedagogy. One aspect of physics that is changing fairly rapidly is research on how students learn. As a result, this new edition contains some new elements:

Conceptual Examples, an average of 2 or 3 per chapter, are each a sort of brief Socratic question and answer. It is intended that readers will be stimulated by the questions to think, or reflect, and come up with a response—before reading the Response given. Here are a few:

- Velocity vs. acceleration (Chapter 2)
- What exerts the force on a car? (Chapter 4)
- Apple and the wagon (reference frames and projectile motion, Chapter 3)
- Which object rolls down a plane faster? (Chapter 8)
- Finger on a full straw (Chapter 10)
- Suction (Chapter 10)
- Boiling pasta (Chapter 14)
- Electric shielding/safety from lightning (Chapter 16)
- Which part of the photo is the reflection? (Chapter 23).

Estimating Examples, also a new feature of this edition, are intended to show how to make order-of-magnitude estimates even when the data are scarce, even when you might never have guessed that any result was possible at all.

Problem Solving has not been slighted in the least. There are many new worked-out Examples and here are some highlights:

- Air bags (2-10)
- Bungee jumper (6-14)
- Computer hard drive (8-4)
- Loudspeaker (11-7)
- Photocopier (16-5)
- Age of archeological bone (30-10).

Some of the new Examples have replaced older less useful ones. Many other Examples have been improved by more detailed reasoning, by

displaying more mathematical steps, and by improving the ambience to make them more real-world and so more inviting and interesting.

New problems have been added and many of the old ones have undergone change.

Example Titles. Examples of all three types (including Conceptual and Estimating) now have titles (for fun and for easy reference).

Emphasized Equations. The great laws of physics are emphasized not only by setting them off, but also by giving them a marginal note in capitals and in a box. The equations that express the great laws, as well as the major equations that one just can't do without, are emphasized with a tan screen.

New Topics in this fifth edition include (these are only a few)

- Rolling motion (Chapter 8)
- Work in rotational motion ($W = \tau\theta$) (Chapter 8)
- v and a for simple harmonic motion (Chapter 11)
- Highway mirages (Chapter 24)
- Hubble Space Telescope (several places)
- Higgs Boson, Symmetry (explained), Supersymmetry (Chapter 32).

Diagrams. There are many more diagrams (over 200 new ones, for an increase of 20 percent), a lot of them to go with Examples and with Problems. Many of the old diagrams have been improved with more realistic backgrounds and figures, and more detail, and the use of photorealistic art.

Photographs. Many of the chapter opening photos now have vectors or other analysis superimposed on them—to give students a richer feeling for the physics. These are visual images of physics that will be fixed in the students' minds.

Many new and interesting photos have been added in the text to bring home the usefulness of physics, a few of which are: diffusion, images in spherical mirrors, depth of field with a camera lens, Hubble Space Telescope, and DNA X-ray diffraction.

Applications. Relevant applications of physics to everyday life and to biology, medicine, architecture, geology, and other fields has always been a strong feature of this book, and continues to be. Among other things, they answer the students' question, "Why study physics?" New applications have been added (and a few older ones dropped), some of which are

- Elevator and counterweight (Chapter 4)
- Shielding (Chapters 16 and 20)
- Dry cell (Chapter 18)
- Aurora borealis (Chapter 20)
- Induction stove (Chapter 21)
- TV and radio antennas (Chapter 22)
- CD player, laser and disk (Chapter 28)
- Smoke detectors (Chapter 29)

and some already mentioned earlier such as airbags, bungee jumping, photocopiers, highway mirages, and computer hard drives.

Revised Physics. No topic, no paragraph in this book was overlooked in the search to improve the clarity of the presentation. Many changes and clarifications have been made, both small and not so small. Here are just a few of the more important ones:

- New tables of typical lengths, times, masses (Chapter 1) and voltages (Chapter 17)
- Chapter 2: rearranged presentation of displacement, velocity, and reference frames
- New diagrams to aid understanding of velocity and acceleration (Chapter 2)
- Unit conversion moved to Chapter 1
- Relative velocity moved to end of Chapter 3
- Simplified introduction to Newton's second law (Chapter 4)
- Simple machines: pulley (Chapter 4), lever (Chapter 9), hydraulic lift (Chapter 10)
- New Section: "Car rounding a curve" (Chapter 5)
- Period and frequency introduced earlier (Chapter 5)
- Work and energy reworked in general, and potential energy especially dealt with in more detail (Chapter 6)
- Angular momentum simplified a bit, especially vector aspects (Chapter 8)
- More formulas for moment of inertia (Fig. 8-20)
- Rotating reference frames, inertial forces, and Coriolis removed from Chapter 8 to an Appendix.
- Greatly simplified vertical spring derivation (Chapter 11)
- Energy transported by waves simplified, with more difficult parts in optional Sections (Chapters 11 and 12)
- Speed of light measurement moved from Chapter 23 on Optics to Chapter 22 on EM waves
- Magnifying glass reworked (Chapter 23)
- Relativistic momentum reworked and in more detail (Chapter 26)
- New energy state diagrams for complex atoms (Chapter 28)
- New results in elementary particle physics and cosmology (Chapters 32 and 33).

Page Layout: Complete Derivations. Serious attention has been paid to how each page was formatted, especially for page turns. Great effort has been made to keep important derivations and arguments on facing pages. Thus readers don't have to turn back to check. More importantly, throughout the book, readers see before them, on two facing pages, an important slice of phyics. On rare occasions when an argument related to a particular figure requires a page turn, that figure is repeated after the page turn so readers won't have to look back.

Deletions. With all of these additions, something had to go to keep the book from getting too long. Some new Examples simply replaced less interesting old ones. The treatment of quite a few topics was shortened and some were simply dropped. Here are some of the deletions: derived vs. base units; operational definitions (general details); section on "Laws or Definitions" dropped (kept a tiny bit earlier in Chapter 4); vector nature of angular quantities (greatly shortened); Reynolds number, sedimentation, Stokes' equation; flow in tubes (halved); Olber's paradox.

Scope of this Book

This book is written for students. The two motivating factors are to give students a thorough understanding of the basic concepts of physics and, by means of interesting applications, to prepare them to use physics in their own lives and professions. In particular, this book is written for students who are taking a one-year introductory course in physics that uses algebra and trigonometry but not calculus. Many of these students have as their main interest biology, (pre)medicine, architecture, technology, or

the earth and environmental sciences. This book contains a wide range of applications to these and other fields, as well as to everyday life. These applications answer that common student query, "Why must I study physics?" The answer, of course, is that physics comes into play in all these fields very importantly, and here they can see how. Physics is all about us. Indeed, it is the goal of this book to help students see the world through eyes that know physics.

Before the applications must come the physics. And this new edition, even more than previous editions, aims to explain physics in a readable and interesting manner that is accessible and clear. It aims to teach students by anticipating their needs and difficulties, but without oversimplifying.

General Approach

This book offers an in-depth presentation of physics, and retains the basic approach of the earlier editions. Rather than using the common, dry, dogmatic approach of treating topics formally and abstractly first, and only later relating the material to the students' own experience, my approach is to recognize that physics is a description of reality and thus to start each topic with concrete observations and experiences that students can directly relate to. Then we move on to the generalizations. Not only does this make the material more interesting and easier to understand, but it is closer to the way physics is actually practiced.

I have sought, where possible, to present the basic concepts of physics in their historical and philosophic context.

As mentioned above, this book includes of a wide range of examples and applications from other fields: biology, medicine, architecture, technology, earth sciences, the environment, and daily life. Some applications serve only as examples of physical principles. Others are treated in depth, with whole Sections devoted to them (among these are the study of medical imaging systems, constructing arches and domes, and the effects of radiation). But applications do not dominate the text—this 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 illuminate it. You won't find essay sidebars here. The applications are integrated right into the physics. Even when an application gets a separate Section all to itself, it is directly tied to the physics just studied. To make it easy to spot these applications, a new *Physics Applied* marginal note has been added.

Mathematics can be an obstacle to student understanding. To avoid frightening students with an initial chapter on mathematics, I have instead incorporated many important mathematical tools, such as addition of vectors and trigonometry, directly in the text where first needed. In addition, the appendices contain a review of many mathematical topics such as algebra and geometry, as well as dimensional analysis. A few advanced topics are also given an Appendix: Rotating frames of reference, Inertial forces, Coriolis effect; Gauss's law; Galilean and Lorentz transformations.

It is necessary, I feel, to pay careful attention to detail, especially when deriving an important result. I have aimed at including all steps in a derivation, and have tried to make clear which equations are general, and which are not, by explicitly stating the limitations of important equations in brackets next to the equation, such as

$$x = x_0 + v_0 t + \frac{1}{2} a t^2. \qquad \text{[constant acceleration]}$$

Difficult language, too, can hinder understanding: and I have tried to write in a relaxed style, avoiding jargon, and often talking directly to the students. New or unusual terms are carefully defined when first used.

Color is used pedagogically to bring out the physics. Different types of vectors are given different colors (see the chart on page xxiii). There are many new diagrams to illustrate new Examples (and old ones too) and to enrich the text and problems. The fifth edition features new and revised art—including new photorealistic art, more illustrations to accompany the in-text Examples and end-of-chapter problems, and dozens of new photos.

Problem Solving

Strong attention is given to problem solving. Learning how to approach and solve problems is a basic part of a physics course, and is a highly useful skill in itself. Solving problems is also important because the process brings understanding of the physics. Scattered throughout the book are special Sections and special Boxes devoted to how to approach the solving of problems. Many are found in the early chapters, where students first begin wrestling with problem solving; but many are also found later in the book, throughout mechanics, and in electricity, for example, where problem solving is an emphasized issue, as well as in thermodynamics and in optics. These Problem Solving Boxes provide a summary of how to approach problem solving. They do *not* provide a prescription to be followed. Hence they are often placed *after* a few Examples have been done, as a sort of summary of how we have been approaching Problems.

Over 400 Examples are fully worked out in the text. In this new edition, there are three types of Examples: regular worked Examples, Estimating Examples, and Conceptual Examples. The regular Examples are fully worked out in the text, and most are accompanied by analytical drawings. These Examples are designed to help students develop problem-solving skills and range from simple to fairly complicated. Estimating Examples encourage student analysis and understanding by using "back of the envelope" estimations as a problem-solving technique; they increase awareness of the power of analytical thinking. Conceptual Examples, in contrast to numerical problem solving and the application of formulas, challenge students to explore the basic concepts that are fundamental to understanding physics. Many Examples are taken from everyday life and aim at being realistic applications of physics principles.

There are over 3100 end-of-chapter exercises, including more than 700 questions that require verbal answers based on an understanding of the concepts, and about 2400 problems involving mathematical calculation.

Each chapter contains a large group of problems arranged by Section and graded according to difficulty: level I problems are simple, usually plug-in types, designed to give students confidence; level II are normal problems, requiring more thought and often the combination of two different concepts; level III are the most difficult and serve as a challenge to superior students. The arrangement by Section number means only that those problems depend on material up to and including that Section: ear-

lier material may also be relied upon. The ranking of problems by difficulty (I, II, III) is intended only as a guide.

I suggest that instructors assign a significant number of the level I and level II problems, and reserve level III problems to stimulate the best students. Although most level I problems may seem easy, they help to build self-confidence—an important part of learning, especially in physics.

Each chapter also contains a group of "General Problems" which are unranked and not arranged by Section number.

Answers to odd-numbered problems are given at the back of the book. Throughout the text, *Système International* (SI) units are used. Other metric and British units are defined for informational purposes.

Organization

The general outline of this new edition retains a traditional order of topics: mechanics (Chapters 1 to 12), including vibrations, waves, and sound, followed by kinetic theory and thermodynamics (Chapters 13 to 15), electricity and magnetism (Chapters 16 to 22), light (Chapters 23 to 25), and modern physics (Chapters 26 to 33). Nearly all topics customarily taught in introductory physics courses are included here.

The tradition of beginning with mechanics is sensible, I believe, because it was developed first, historically, and because so much else in physics depends on it. Within mechanics, there are various ways to order topics, and this book allows for considerable flexibility. I prefer, for example, to cover statics after dynamics, partly because many students have trouble with the concept of force without motion. Besides, 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. Nonetheless statics (Chapter 9) can be covered earlier, if desired, before dynamics, after a brief introduction to vectors. Another option is light, which I have placed after electricity and magnetism and EM waves. But light could be treated immediately after the chapters on waves (Chapter 11 and 12). Special relativity (Chapter 26), which is located along with the other chapters on modern physics, could instead be treated along with mechanics—say, after Chapter 7.

Not every chapter need be given equal weight. Whereas Chapter 4 or Chapter 21 might require $1\frac{1}{2}$ to 2 weeks of coverage, Chapter 12 or 22 may need only $\frac{1}{2}$ week.

The book contains more material than can be covered in most one-year courses, so instructors have flexibility in choice of topics. Sections marked with a star (asterisk) are considered optional (if not covered in class, they can be a resource for later study). 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 does not imply that all nonstarred sections must be covered: there still remains considerable flexibility in the choice of material. For a brief course, all optional material could be dropped as well as major parts of Chapters 10, 12, 19, 22, 28, 29, 32, and 33, as well as selected parts of Chapters 7, 8, 9, 15, 21, 24, 25, and 31.

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Douglas C. Giancoli

Supplements

For the Instructor

Instructor's Solutions Manual by Irvin A. Miller *Print version* (0-13-627985-6); *Electronic Versions:* Windows (0-13-627993-7); Macintosh (0-13-628009-9)
Contains detailed, worked solutions to every problem in the text by Irv Miller of Drexel University.

Answers to Questions
Prepared by Michelle Rallis and Kurt Reibel of The Ohio State University, Columbus and Gordon Aubrecht of The Ohio State University, Marion, this supplement contains answers to all end-of-chapter questions.

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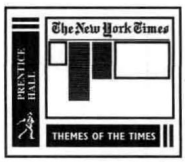
For the Student

Student Study Guide by Joseph Boyle (0-13-627944-9)
Complements the strong pedagogy in Giancoli's text with overviews, topic summaries and exercises, key phrases and terms, self-study exams, and questions for review of each chapter.

MCAT Study Guide by Joseph Boone (0-13-627951-1)
A thoroughly revised study resource that references all of the physics topics on the MCAT to the appropriate sections in the text. Additional review, review questions, and problems are provided.

Physics on the Internet: A Student's Guide
by Andrew Stull and Carl Adler (0-13-890153-8)
The perfect tool to help students take advantage of the *Physics: Principles and Applications, Fifth Edition* Web page. This useful resource gives clear steps to access Prentice Hall's regularly updated physics resources, along with an overview of general navigation strategies. Available FREE for students when purchased in a special package with Giancoli's text.



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Media Supplements

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An easy way to use *Interactive Physics* in your courses, this highly interactive workbook/disk package contains 40 simulation projects of varying degrees of difficulty. Each contains a physics review, simulation details, hints, explanation of results, math help, and a self test.

Physics Explorer Runtime Version by LOGAL,
Windows (0-13-627969-4); Macintosh (0-13-627977-5)
Tailored for use with Giancoli's text, *Physics Explorer Runtime Version* contains simulations of over 100 problems and examples directly from Giancoli's text. Students can conduct experiments, interactively record results on a spreadsheet, and generate graphs using each of ten independent learning models:
Particle Mechanics—One Body, Two Body, Gravity, and Harmonic Motion
Wave Mechanics—Waves, Ripple Tank, Diffraction
Electricity and Magnetism—One Body Electrodynamics, AC/DC Circuits, Electrostatics.

Presentation Manager CD-Rom
This CD-ROM contains all the text art and videos from the Physics You Can See video tape as well as additional lab and demonstration videos and animations from the *Interactive Journey through Physics* CD-ROM.

Physics: Principles and Applications Web Site
http://www.prenhall.com/giancoli
Features include practice tests with on-line feedback/grading keyed to the text.

Physics You Can See *Videos* (0-205-12393-7)
Each two- to five-minute segment demonstrates a classical physics experiment. Includes 11 segments such as "Coin and Feather" (acceleration due to gravity); "Monkey & Gun" (projectile motion); "Swivel Hips" (force pairs); and "Collapse a Can" (atmospheric pressure).

NOTES TO STUDENTS AND INSTRUCTORS ON THE FORMAT

1. Sections marked with a star (*) are considered optional. They can be omitted without interrupting the main flow of topics. No later material depends on them except possibly later starred sections. They may be fun to read though.
2. The customary conventions are used: symbols for quantities (such as m for mass) are italicized, whereas units (such as m for meter) are not italicized. Boldface (**F**) is used for vectors.
3. Few equations are valid in all situations. Where practical, the limitations of important equations are stated in square brackets next to the equation. The equations that represent the great laws of physics are displayed with a tan background, as are a few other equations that are so useful that they are indispensable.
4. The number of significant figures (see Section 1–4) should not be assumed to be greater than given: if a number is stated as (say) 6, with its units, it is meant to be 6 and not 6.0 or 6.00.
5. At the end of each chapter is a set of questions that students should attempt to answer (to themselves at least). These are followed by problems which are ranked as level I, II, or III, according to estimated difficulty, with level I problems being easiest. These problems are arranged by Section, but problems for a given Section may depend on earlier material as well. There follows a group of General Problems, which are not arranged by Section nor ranked as to difficulty. Questions and problems that relate to optional Sections are starred.
6. Being able to solve problems is a crucial part of learning physics, and provides a powerful means for understanding the concepts and principles of physics. This book contains many aids to problem solving: (a) worked-out Examples and their solutions in the text, which are set off with a vertical blue line in the margin, and should be studied as an integral part of the text; (b) special "Problem-solving boxes" placed throughout the text to suggest ways to approach problem solving for a particular topic—but don't get the idea that every topic has its own "techniques," because the basics remain the same; (c) special problem-solving Sections (marked in blue in the Table of Contents); (d) marginal notes (see below), many of which refer to hints for solving problems, in which case they are so indicated; (e) problems themselves at the end of each chapter (see point 5 above); (f) some of the worked-out Examples are Estimation Examples, which show how rough or approximate results can be obtained even if the given data are sparse (see Section 1–7).
7. Conceptual Examples look like ordinary Examples but are conceptual rather than numerical. Each proposes a question or two, which hopefully starts you to think and come up with a response. Give yourself a little time to come up with your own response before reading the Response given.
8. Marginal notes: brief notes in the margin of almost every page are printed in blue and are of four types: (a) ordinary notes (the majority) that serve as a sort of outline of the text and can help you later locate important concepts and equations; (b) notes that refer to the great laws and principles of physics, and these are in capital letters and in a box for emphasis; (c) notes that refer to a problem-solving hint or technique treated in the text, and these say "Problem Solving"; (d) notes that refer to a physics application in the text or an Example, and these say "Physics Applied."
9. This book is printed in full color. But not simply to make it more attractive. The color is used above all in the figures, to give them greater clarity for our analysis, and to provide easier learning of the physical principles involved. The table on the next page is a summary of how color is used in the figures, and shows which colors are used for the different kinds of vectors, for field lines, and for other symbols and objects. These colors are used consistently throughout the book.

NOTES ON USE OF COLOR

Vectors

A general vector

resultant vector (sum) is slightly thicker

components of any vector are dashed

Displacement (**D, r**)

Velocity (**v**)

Acceleration (**a**)

Force (**F**)

Force on second or third object in same figure

Momentum (**p** or $m\mathbf{v}$)

Angular momentum (**L**)

Angular velocity (ω)

Torque (τ)

Electric field (**E**)

Magnetic field (**B**)

Electricity and magnetism

Electric field lines

Equipotential lines

Magnetic field lines

Electric charge (+) or +

Electric charge (–) or –

Electric circuit symbols

Wire

Resistor

Capacitor

Inductor

Battery

Optics

Light rays

Object

Real image (dashed)

Virtual image (dashed and paler)

Other

Energy level (atom, etc.)

Measurement lines 1.0 m

Path of a moving object

Direction of motion or current

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