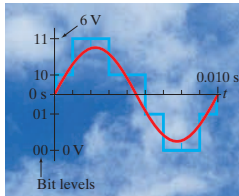


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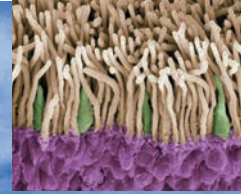
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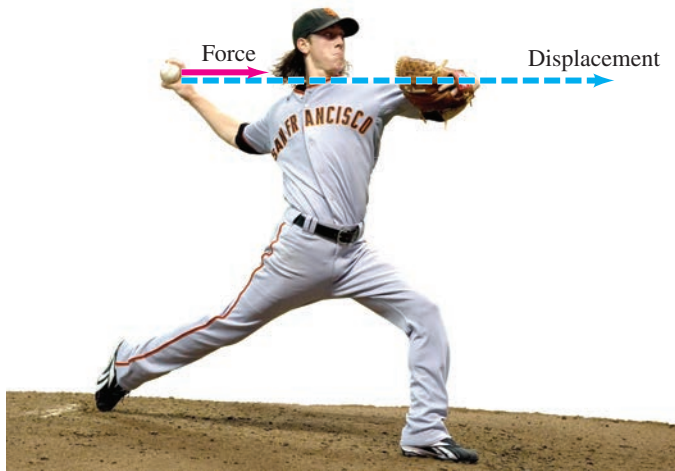
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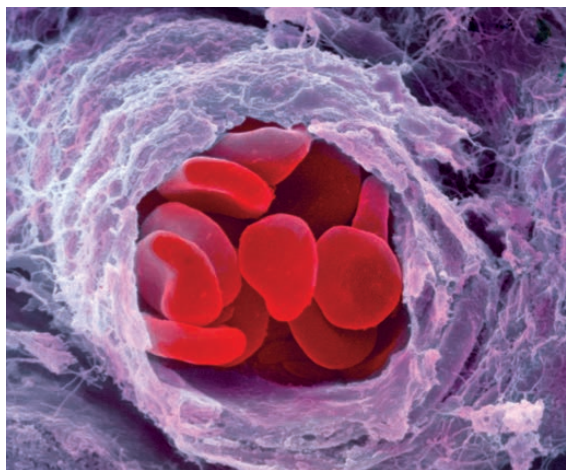
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## Student Supplements

-  **MasteringPhysics™** ([www.masteringphysics.com](http://www.masteringphysics.com)) is a homework, tutorial, and assessment system based on years of research into how students work physics problems and precisely where they need help. Studies show that students who use MasteringPhysics significantly increase their final scores compared to hand-written homework. MasteringPhysics achieves this improvement by providing students with instantaneous feedback specific to their wrong answers, simpler sub-problems upon request when they get stuck, and partial credit for their method(s) used. This individualized, 24/7 Socratic tutoring is recommended by nine out of ten students to their peers as the most effective and time-efficient way to study.
- **Pearson eText** is available through MasteringPhysics. Allowing students access to the text wherever they have access to the Internet, Pearson eText comprises the full text, including figures that can be enlarged for better viewing. Within eText, students are also able to pop up definitions and terms to help with vocabulary and the reading of the material. Students can also take notes in eText using the annotation feature at the top of each page.
- **ActivPhysics OnLine™** (accessed through the Self Study area within [www.masteringphysics.com](http://www.masteringphysics.com)) provides students with a group of highly regarded applet-based tutorials.

# Preface

## What's New?

Lots! Much is new and unseen before. Here are the big four:

1. **Multiple-choice Questions** added to the end of each Chapter. They are not the usual type. These are called **MisConceptual Questions** because the responses ( $a$ ,  $b$ ,  $c$ ,  $d$ , etc.) are intended to include common student misconceptions. Thus they are as much, or more, a learning experience than simply a testing experience.
2. **Search and Learn Problems** at the very end of each Chapter, after the other Problems. Some are pretty hard, others are fairly easy. They are intended to encourage students to go back and reread some part or parts of the text, and in this search for an answer they will hopefully learn more—if only because they have to read some material again.
3. **Chapter-Opening Questions (COQ)** that start each Chapter, a sort of “stimulant.” Each is multiple choice, with responses including common misconceptions—to get preconceived notions out on the table right at the start. Where the relevant material is covered in the text, students find an Exercise asking them to return to the COQ to rethink and answer again.
4. **Digital.** Biggest of all. Crucial new applications. Today we are surrounded by digital electronics. How does it work? If you try to find out, say on the Internet, you won't find much physics: you may find shallow hand-waving with no real content, or some heavy jargon whose basis might take months or years to understand. So, for the first time, I have tried to explain
  - The basis of digital in bits and bytes, how analog gets transformed into digital, sampling rate, bit depth, quantization error, compression, noise (Section 17–10).
  - How digital TV works, including how each pixel is addressed for each frame, data stream, refresh rate (Section 17–11).
  - Semiconductor computer memory, DRAM, and flash (Section 21–8).
  - Digital cameras and sensors—revised and expanded Section 25–1.
  - New semiconductor physics, some of which is used in digital devices, including LED and OLED—how they work and what their uses are—plus more on transistors (MOSFET), chips, and technology generation as in 22-nm technology (Sections 29–9, 10, 11).

Besides those above, this new seventh edition includes

**5. *New topics, new applications, principal revisions.***

- You can measure the Earth's radius (Section 1–7).
- Improved graphical analysis of linear motion (Section 2–8).
- Planets (how first seen), heliocentric, geocentric (Section 5–8).
- The Moon's orbit around the Earth: its phases and periods with diagram (Section 5–9).
- Explanation of lake level change when large rock thrown from boat (Example 10–11).



- Biology and medicine, including:
    - Blood measurements (flow, sugar)—Chapters 10, 12, 14, 19, 20, 21;
    - Trees help offset CO<sub>2</sub> buildup—Chapter 15;
    - Pulse oximeter—Chapter 29;
    - Proton therapy—Chapter 31;
    - Radon exposure calculation—Chapter 31;
    - Cell phone use and brain—Chapter 31.
  - Colors as seen underwater (Section 24–4).
  - Soap film sequence of colors explained (Section 24–8).
  - Solar sails (Section 22–6).
  - Lots on sports.
  - Symmetry—more emphasis and using italics or boldface to make visible.
  - Flat screens (Sections 17–11, 24–11).
  - Free-electron theory of metals, Fermi gas, Fermi level. New Section 29–6.
  - Semiconductor devices—new details on diodes, LEDs, OLEDs, solar cells, compound semiconductors, diode lasers, MOSFET transistors, chips, 22-nm technology (Sections 29–9, 10, 11).
  - Cross section (Chapter 31).
  - Length of an object is a script  $\ell$  rather than normal  $l$ , which looks like 1 or  $I$  (moment of inertia, current), as in  $F = \ell B$ . Capital  $L$  is for angular momentum, latent heat, inductance, dimensions of length [ $L$ ].
6. **New photographs** taken by students and instructors (we asked).
  7. **Page layout:** More than in previous editions, serious attention to how each page is formatted. Important derivations and Examples are on facing pages: no turning a page back in the middle of a derivation or Example. Throughout, readers see, on two facing pages, an important slice of physics.
  8. **Greater clarity:** No topic, no paragraph in this book was overlooked in the search to improve the clarity and conciseness of the presentation. Phrases and sentences that may slow down the principal argument have been eliminated: keep to the essentials at first, give the elaborations later.
  9. Much use has been made of physics education research. See the new powerful pedagogic features listed first.
  10. **Examples modified:** More math steps are spelled out, and many new Examples added. About 10% of all Examples are Estimation Examples.
  11. **This Book is Shorter** than other complete full-service books at this level. Shorter explanations are easier to understand and more likely to be read.
  12. **Cosmological Revolution:** With generous help from top experts in the field, readers have the latest results.

## See the World through Eyes that Know Physics

I was motivated from the beginning to write a textbook different from the others which present physics as a sequence of facts, like a catalog: “Here are the facts and you better learn them.” Instead of beginning formally and dogmatically, I have sought to begin each topic with concrete observations and experiences students can relate to: start with specifics, and after go to the great generalizations and the more formal aspects of a topic, showing *why* we believe what we believe. This approach reflects how science is actually practiced.

The ultimate aim is to give students a thorough understanding of the basic concepts of physics in all its aspects, from mechanics to modern physics. A second objective is to show students how useful physics is in their own everyday lives and in their future professions by means of interesting applications to biology, medicine, architecture, and more.

Also, much effort has gone into techniques and approaches for solving problems: worked-out Examples, Problem Solving sections (Sections 2–6, 3–6, 4–7, 4–8, 6–7, 6–9, 8–6, 9–2, 13–7, 14–4, and 16–6), and Problem Solving Strategies (pages 30, 57, 60, 88, 115, 141, 158, 184, 211, 234, 399, 436, 456, 534, 568, 594, 655, 666, and 697).

This textbook is especially suited for students taking a one-year introductory course in physics that uses algebra and trigonometry but not calculus.<sup>†</sup> Many of these students are majoring in biology or premed, as well as architecture, technology, and the earth and environmental sciences. Many applications to these fields are intended to answer that common student query: “Why must I study physics?” The answer is that physics is fundamental to a full understanding of these fields, and here they can see how. Physics is everywhere around us in the everyday world. It is the goal of this book to help students “see the world through eyes that know physics.”

A major effort has been made to not throw too much material at students reading the first few chapters. The basics have to be learned first. Many aspects can come later, when students are less overloaded and more prepared. If we don’t overwhelm students with too much detail, especially at the start, maybe they can find physics interesting, fun, and helpful—and those who were afraid may lose their fear.

Chapter 1 is *not* a throwaway. It is fundamental to physics to realize that every measurement has an *uncertainty*, and how significant figures are used. Converting units and being able to make rapid *estimates* are also basic.

*Mathematics* can be an obstacle to students. I have aimed at including all steps in a derivation. Important mathematical tools, such as addition of vectors and trigonometry, are incorporated in the text where first needed, so they come with a context rather than in a scary introductory Chapter. Appendices contain a review of algebra and geometry (plus a few advanced topics).

*Color* is used pedagogically to bring out the physics. Different types of vectors are given different colors (see the chart on page xix).

Sections marked with a star \* are considered optional. These contain slightly more advanced physics material, or 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).

For a brief course, all optional material could be dropped as well as significant parts of Chapters 1, 10, 12, 22, 28, 29, 32, and selected parts of Chapters 7, 8, 9, 15, 21, 24, 25, 31. Topics not covered in class can be a valuable resource for later study by students. Indeed, this text can serve as a useful reference for years because of its wide range of coverage.

<sup>†</sup>It is fine to take a calculus course. But mixing calculus with physics for these students may often mean not learning the physics because of stumbling over the calculus.

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Hsiao-Ling Zhou, Georgia State University  
Michael Ziegler, The Ohio State University  
Ulrich Zurcher, Cleveland State University



New photographs were offered by Professors Vickie Frohne (Holy Cross Coll.), Guillermo Gonzales (Grove City Coll.), Martin Hackworth (Idaho State U.), Walter H. G. Lewin (MIT), Nicholas Murgu (NEIT), Melissa Vigil (Marquette U.), Brian Woodahl (Indiana U. at Indianapolis), and Gary Wysin (Kansas State U.). New photographs shot by students are from the AAPT photo contest: Matt Buck, (John Burroughs School), Matthew Claspill (Helias H. S.), Greg Gentile (West Forsyth H. S.), Shilpa Hampole (Notre Dame H. S.), Sarah Lampen (John Burroughs School), Mrinalini Modak (Fayetteville–Manlius H. S.), Joey Moro (Ithaca H. S.), and Anna Russell and Annacy Wilson (both Tamalpais H. S.).

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## About the Author

Douglas C. Giancoli obtained his BA in physics (summa cum laude) from UC Berkeley, his MS in physics at MIT, and his PhD in elementary particle physics back at UC Berkeley. He spent 2 years as a post-doctoral fellow at UC Berkeley's Virus lab developing skills in molecular biology and biophysics. His mentors include Nobel winners Emilio Segrè and Donald Glaser.

He has taught a wide range of undergraduate courses, traditional as well as innovative ones, and continues to update his textbooks meticulously, seeking ways to better provide an understanding of physics for students.

Doug's favorite spare-time activity is the outdoors, especially climbing peaks. He says climbing peaks is like learning physics: it takes effort and the rewards are great.



## To Students

### HOW TO STUDY
















1. Read the Chapter. Learn new vocabulary and notation. Try to respond to questions and exercises as they occur.
2. Attend all class meetings. Listen. Take notes, especially about aspects you do not remember seeing in the book. Ask questions (everyone wants to, but maybe you will have the courage). You will get more out of class if you read the Chapter first.
3. Read the Chapter again, paying attention to details. Follow derivations and worked-out Examples. Absorb their logic. Answer Exercises and as many of the end-of-Chapter Questions as you can, and all MisConceptual Questions.
4. Solve at least 10 to 20 end of Chapter Problems, especially those assigned. In doing Problems you find out what you learned and what you didn't. Discuss them with other students. Problem solving is one of the great learning tools. Don't just look for a formula—it might be the wrong one.

### NOTES ON THE FORMAT AND PROBLEM SOLVING








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. Symbols for vectors are shown in boldface with a small arrow above:  $\vec{F}$ .
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 indispensable equations.
4. At the end of each Chapter is a set of **Questions** you should try to answer. Attempt all the multiple-choice **MisConceptual Questions**. Most important are **Problems** which are ranked as Level I, II, or III, according to estimated difficulty. Level I Problems are easiest, Level II are standard Problems, and Level III are “challenge problems.” These ranked Problems are arranged by Section, but Problems for a given Section may depend on earlier material too. There follows a group of **General Problems**, not arranged by Section or ranked. Problems that relate to optional Sections are starred (\*). Answers to odd-numbered Problems are given at the end of the book. **Search and Learn Problems** at the end are meant to encourage you to return to parts of the text to find needed detail, and at the same time help you to learn.
5. Being able to solve **Problems** is a crucial part of learning physics, and provides a powerful means for understanding the concepts and principles. This book contains many aids to problem solving: (a) worked-out **Examples**, including an Approach and Solution, which should be studied as an integral part of the text; (b) 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); (c) **Problem Solving Strategies** placed throughout the text to suggest a step-by-step approach to problem solving for a particular topic—but remember that the basics remain the same; most of these “Strategies” are followed by an Example that is solved by explicitly following the suggested steps; (d) special problem-solving Sections; (e) “Problem Solving” marginal notes which refer to hints within the text for solving Problems; (f) **Exercises** within the text that you should work out immediately, and then check your response against the answer given at the bottom of the last page of that Chapter; (g) the Problems themselves at the end of each Chapter (point 4 above).
6. **Conceptual Examples** pose a question 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.
7. **Math** review, plus additional topics, are found in Appendices. Useful **data**, **conversion factors**, and math **formulas** are found inside the front and back covers.

## USE OF COLOR







### Vectors

A general vector	
resultant vector (sum) is slightly thicker	
components of any vector are dashed	
Displacement ( $\vec{D}$ , $\vec{r}$ )	
Velocity ( $\vec{v}$ )	
Acceleration ( $\vec{a}$ )	
Force ( $\vec{F}$ )	
Force on second object	
or third object in same figure	
Momentum ( $\vec{p}$ or $m\vec{v}$ )	
Angular momentum ( $\vec{L}$ )	
Angular velocity ( $\vec{\omega}$ )	
Torque ( $\vec{\tau}$ )	
Electric field ( $\vec{E}$ )	
Magnetic field ( $\vec{B}$ )	





### Electricity and magnetism

Electric field lines	
Equipotential lines	
Magnetic field lines	
Electric charge (+)	 or 
Electric charge (-)	 or 


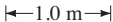


### Electric circuit symbols

Wire, with switch S	
Resistor	
Capacitor	
Inductor	
Battery	
Ground	

### Optics

Light rays	
Object	
Real image (dashed)	
Virtual image (dashed and paler)	

### Other

Energy level (atom, etc.)	
Measurement lines	
Path of a moving object	
Direction of motion or current	



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