INTERNATIONAL EDITION

PHYSICS
for Scientists and Engineers
with Modern Physics

THIRD EDITION

FISHBANE | GASIOROWICZ | THORNTON

PHYSICS

FOR SCIENTISTS AND ENGINEERS
WITH MODERN PHYSICS

THIRD EDITION

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SOME FUNDAMENTAL PHYSICAL CONSTANTS

Constant	*Symbol*	*Value*
speed of light in a vacuum	c	3.00×10^{8} m/s
gravitational constant	G	6.67×10^{-11} $m^3/kg \cdot s^2$
Avogadro's number	N_A	6.02×10^{23} mol^{-1}
universal gas constant	R	8.31 J/mol·K
Boltzmann's constant	k	1.38×10^{-23} J/K
elementary charge	e	1.60×10^{-19} C
permittivity of free space	ϵ_0	8.85×10^{-12} $C^2/N \cdot m^2$
	$1/(4\pi\epsilon_0)$	8.99×10^{9} $kg \cdot m^3 \cdot s^{-2} \cdot C^{-2}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$ T·m/A
electron mass	m_e	9.11×10^{-31} kg
proton mass	m_p	1.67×10^{-27} kg
neutron mass	m_n	1.67×10^{-27} kg
Planck's constant	h	6.63×10^{-34} J·s
$h/2\pi$	$\hbar$	1.05×10^{-34} J·s
		$= 6.58 \times 10^{-22}$ MeV·s
	$\hbar c$	197 MeV·fm
electron charge-to-mass ratio	$-e/m_e$	-1.76×10^{11} C/kg
proton-electron mass ratio	m_p/m_e	1840
molar volume of ideal gas at STP		22400 cm^3/mol
Bohr magneton	μ_B	9.27×10^{-24} J/T
magnetic flux quantum	$\Phi_0 = h/2e$	2.07×10^{-15} Wb
Bohr radius	a_0	0.529×10^{-10} m
Rydberg constant	R_∞	1.10×10^{7} m^{-1}

SOME ASTRONOMICAL CONSTANTS

Constant	*Symbol*	*Value*
standard gravity at Earth's surface	g	9.80665 m/s^2
equatorial radius of Earth	R_e	6.374×10^{6} m
mass of Earth	M_e	5.976×10^{24} kg
mass of Moon		7.350×10^{22} kg $= 0.0123$ M_e
mean radius of Moon's orbit around Earth		3.844×10^{8} m
mass of Sun	$M_\odot$	1.989×10^{30} kg
mean radius of Earth's orbit around Sun	AU	1.496×10^{11} m
period of Earth's orbit around Sun	yr	3.156×10^{7} s
diameter of our galaxy		7.5×10^{20} m
mass of our galaxy		2.7×10^{41} kg $= (1.4 \times 10^{11})$ $M_\odot$
Hubble parameter	H	2.1×10^{-18} s^{-1}

SOME SI BASE UNITS

Physical Quantity	Name of Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol

SOME SI DERIVED UNITS

Physical Quantity	Name of Unit	Symbol	SI Unit
frequency	hertz	Hz	s^{-1}
energy	joule	J	$kg\cdot m^2/s^2$
force	newton	N	$kg\cdot m/s^2$
pressure	pascal	Pa	$kg/m\cdot s^2$
power	watt	W	$kg\cdot m^2/s^3$
electric charge	coulomb	C	$A\cdot s$
electric potential	volt	V	$kg\cdot m^2/A\cdot s^3$
electric resistance	ohm	Ω	$kg\cdot m^2/A^2\cdot s^3$
capacitance	farad	F	$A^2\cdot s^4/kg\cdot m^2$
inductance	henry	H	$kg\cdot m^2/A^2\cdot s^2$
magnetic flux	weber	Wb	$kg\cdot m^2/A\cdot s^2$
magnetic flux density	tesla	T	$kg/A\cdot s^2$

SI UNITS OF SOME OTHER PHYSICAL QUANTITIES

Physical Quantity	SI Unit
speed	m/s
acceleration	m/s^2
angular speed	rad/s
angular acceleration	rad/s^2
torque	$kg\cdot m^2/s^2$, or $N\cdot m$
heat flow	J, or $kg\cdot m^2/s^2$, or $N\cdot m$
entropy	J/K, or $kg\cdot m^2/K\cdot s^2$, or $N\cdot m/K$
thermal conductivity	$W/m\cdot K$

SOME CONVERSIONS OF NON-SI UNITS TO SI UNITS

Energy:

1 electron-volt (eV) = 1.6022×10^{-19} J
1 erg = 10^{-7} J
1 British thermal unit (BTU) = 1055 J
1 calorie (cal) = 4.186 J
1 kilowatt-hour (kWh) = 3.6×10^6 J

Mass:

1 gram (g) = 10^{-3} kg
1 atomic mass unit (u) = $931.5\ MeV/c^2$
= 1.661×10^{-27} kg
1 MeV/c^2 = 1.783×10^{-30} kg

Force:

1 dyne = 10^{-5} N
1 pound (lb or #) = 4.448 N

Length:

1 centimeter (cm) = 10^{-2} m
1 kilometer (km) = 10^3 m
1 fermi = 10^{-15} m
1 Angstrom (Å) = 10^{-10} m
1 inch (in or ″) = 0.0254 m
1 foot (ft) = 0.3048 m
1 mile (mi) = 1609.3 m
1 astronomical unit (AU) = 1.496×10^{11} m
1 light-year (ly) = 9.46×10^{15} m
1 parsec (ps) = 3.09×10^{16} m

Angle:

1 degree (°) = 1.745×10^{-2} rad
1 min (′) = 2.909×10^{-4} rad
1 second (″) = 4.848×10^{-6} rad

Volume:

1 liter (L) = 10^{-3} m^3

Power:

1 kilowatt (kW) = 10^3 W
1 horsepower (hp) = 745.7 W

Pressure:

1 bar = 10^5 Pa
1 atmosphere (atm) = 1.013×10^5 Pa
1 pound per square inch (lb/in^2) = 6.895×10^3 Pa

Time:

1 year (yr) = 3.156×10^7 s
1 day (d) = 8.640×10^4 s
1 hour (h) = 3600 s
1 minute (min) = 60 s

Speed:

1 mile per hour (mi/h) = 0.447 m/s

Magnetic field:

1 gauss = 10^{-4} T

PHYSICS

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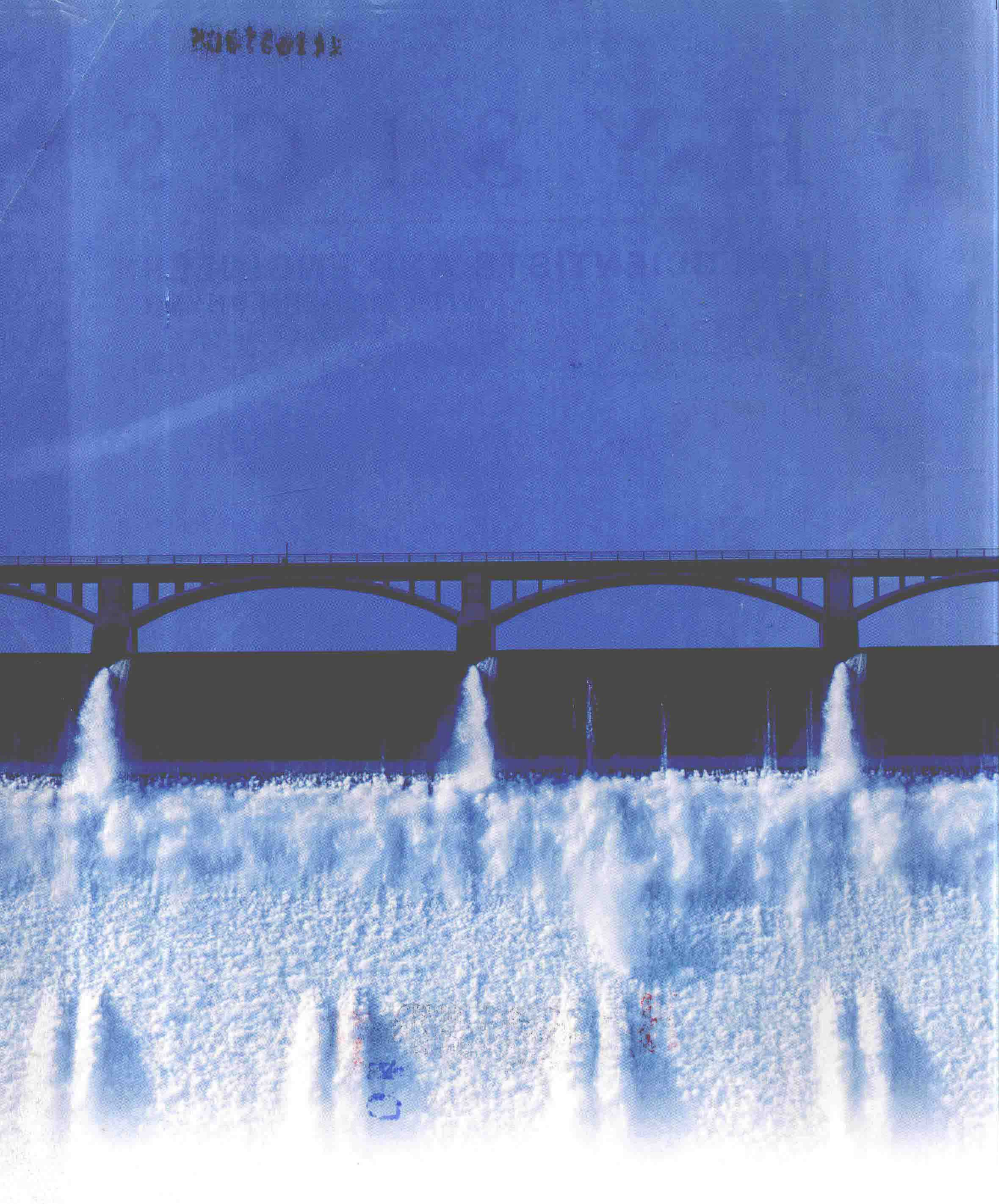


Dedication

To our students, the most important element in the making of this book

Preface

This text is designed for a calculus-based physics course at the beginning university and college level. It is written with the expectation that students either have taken or are currently taking a beginning course in calculus. Students taking a physics course based on this book should leave with a solid conceptual understanding of the fundamental physical laws, how these laws can be applied to solve many problems, and how physics is relevant to the world around them.

"Understanding" encompasses our three overriding goals for this book:

Doing Things Correctly. First, we want a book that is fundamentally *right*. This is sometimes taken to mean "rigorous," but we want to emphasize that we do not feel "rigorous" is a synonym for "difficult." Rather, we associate "right" with showing all the evidence, with using the evidence correctly to support the point being made, and with making the point in a way that will allow the student to say, "I see where that comes from." We try to avoid the phrase "It can be shown that . . . " and the attitude that "It is true because we say it is."

Conceptual Emphasis. Second, we want students to understand the material at as deep a conceptual level as possible. We are aware that there is a large gap between being able to get the right answer to a physics problem and comprehending the physical concepts that lie behind it. We want students to be able to answer the *why* as well as the *how*. The student who has a conceptual understanding can not only do problems for which he or she has models, but can also approach a new problem with confidence. Many of the changes to the third edition are designed to address this issue, including the addition of Conceptual Examples, a "What Do You Think" step at the end of most Examples, and a substantial increase in the number of end-of-chapter qualitative questions.

Modern Physics Integrated. Third, without sacrificing the essential aspects of classical physics, we have included modern notions throughout the book. Classical topics have lost none of their importance and must form the basis of any first course. However, what is traditionally called "modern" physics—the topics centered on relativity and quantum physics—began about a century ago. It hardly seems possible to ignore these topics in view of their importance for today's technology and, more critically, for understanding today's world. Many of the ideas of modern physics are not mathematically difficult. However, they can be nonintuitive, and we think it is important that students begin to develop intuition about this material as early as possible. Although much of this material appears in optional sections (marked with an asterisk), in many cases it is intertwined with the classical material. The uncertainty principle and its role in both classical and quantum physics, information on atomic structure and spectra, information on band structure or on blackbody radiation, and the nature and role of fundamental forces are a few of the topics that are included in this way. We conclude the text in what has become the traditional way, with chapters on modern physics. We think the preparation we laid down for this material in earlier chapters will make it more easily assimilated.

A few words about mathematics: The idea of getting it *right* applies to mathematical derivation as well as to qualitative aspects. Our approach is to introduce the mathematics that students need to know the first time they need to know it, in the context of the physics being presented. We try to make that material self-contained so that the student can understand the material without having to go elsewhere for mathematical help. In this way, the mathematics appears in progressive degrees of difficulty. We believe that this approach fosters better understanding and less reliance on formula memorization. We also feel that the ability to make quantitative estimates is one of the most important skills that a scientist or engineer can have. We have made the development of that ability an important part of our approach, both in the text and in the problems. Finally, as in real-world problems, we vary the number of significant figures in examples and in problems. We feel students should maintain an awareness of significant figures and not end up thinking all problems involve the same number of significant figures.

The Third Edition

With the help of reviewers and users of the second edition, we have made a thorough review of content and organization, with some material moved both within and among chapters to enhance the logical progression and structure of the material. We have rewritten much of the material with clarity in mind.

Organizational Changes.

Changes to the third edition include:

- Redistribution of the material in the 2nd-edition chapter "Properties of Solids"—for example, the material on heat conduction in solids now appears in the appropriate chapter on thermal physics, while material on stress and strain now appears in the chapter on statics.
- Redistribution of the material on waves between Chapters 14 and 15 to create a more logical division between single waves, and the superposition of several.
- Consolidation of some material that we feel does not affect the basic understanding of the subject—for example, both the "physical optics" and "magnetism in matter" chapters are more compact.

Conceptual Examples. We have added a new type of Example, designed to help the student think about the material in a way that emphasizes conceptual understanding of the content. These may have some modest algebraic content, such as a simple estimate or reasoning involving inequalities. There are two or more of these per chapter.

CONCEPTUAL EXAMPLE 17–4 We learn by experience that we can loosen a metal lid that is stuck on a glass jar by pouring hot water over the lid. Why does this work?

Answer As the lid's temperature rises, it expands. Movement occurs where the glass and metal are stuck and the lid releases (Fig. 17–11). In fact, you could dip the entire system (lid and glass container) in hot water, and the different expansions of the metal and the glass will lead to the same result. Note that the same difference in the thermal expansion is used in making a good seal: lids are placed on jars when the contents are hot.

▶ **FIGURE 17–11** By pouring hot water over this lid, you can take advantage of thermal expansion to free it from the jar.

Think About This. The primary purpose of these sections is to pose and answer questions about a new idea or the application of the material discussed. When writing these sections, we ask the kinds of questions a good student might be asking on his or her own, and which the majority of students will find intriguing.

Worked Examples. We have introduced a new structure into the Worked Examples to serve as a model and to build problem-solving skills. The goal of this new structure is to emphasize visualization and the identification of the knowns, unknowns, and concepts to be used. We avoid using a stiff and uncompromising framework, but most examples are broken down into a series of steps:

- ***Setting It Up.*** In most cases this step begins with a sketch and, for mechanics problems, the preparation of a free-body diagram. The figures accompanying most Examples are in a student sketch style that the student can realistically be expected to emulate. To reinforce this first step, all the figures in the end-of-chapter Problems are also drawn in this style. Because a sketch represents a first step in problem solving, the sketches in the end-of-chapter problems sometimes provide a crucial hint to the student. This step also includes some reasoning on how to determine what is being asked when it may not be completely obvious.
- ***Strategy.*** Here the concepts used to solve the problem are outlined and applied to the situation; it is where we "talk it through." This is the heart of the solution, the part where most students will succeed or fail.
- ***Working It Out.*** The strategy outlined in the preceding part is carried through in a series of well-defined steps. This part should be straightforward if the previous steps have been done properly.
- ***What Do You Think?*** The final step in solving a problem is to confirm that the answer makes sense. This section of the solution reinforces the example by asking the student a thought-provoking conceptual question associated with the problem just solved. These questions should confirm that the student has understood the concepts or send them looking for checks to the answers. Answers to "What Do You Think?" questions are provided at the end of the book.

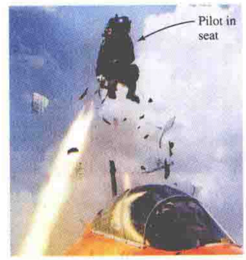
Vectors. These are now represented with an arrow over the letter rather than in boldface (for example, $\vec{F} = m\vec{a}$) to be more consistent with the way professors write them in lecture and the way students write them in homework and exams.

Questions. The end-of-chapter material includes qualitative questions under the heading "Understanding the Concepts." We have increased the number of these conceptual questions by nearly 50 percent.

THINK ABOUT THIS . . .

HOW DOES AN AIR BAG PROTECT YOU IN A CRASH?

Large forces imply large accelerations. A car accident or a fall from a great height may be deadly because of the rapid deceleration, the result of large forces that your body may not be equipped to withstand. For protection it is necessary to find a way to bring you to a stop by providing a smaller deceleration over a larger time. Air bags in automobiles work on this principle; when a collision stops a car very suddenly, a passenger would suffer a very sudden deceleration in a subsequent collision with the steering wheel or the windshield. This is mitigated by the very rapid release of an air bag, which is deep enough and "soft" enough to allow the passenger to slow down over a longer period of time. Firefighters similarly use large elastic safety nets to catch people who have to jump from burning buildings. When the deceleration is for fun, the same principle applies. Bungee cords are made of a very elastic material, and there are no bungee *chains*, which would have the unfortunate effect of stopping you "on a dime." Still another application is provided by airplane ejection seats, which in the past were powered by explosives beneath the seat. The rapid acceleration of these mechanisms often led to serious damage to the pilot. Today ejection seats are powered by small rockets that can supply a smaller acceleration over a longer period of time, rather than a large acceleration over a very short period of time and hence a safer ejection (Fig. 4–12). One other example comes to mind: You may have seen drawings in which Superman catches Lois Lane just before she hits the ground. That very action would imply a rapid deceleration that would be just as bad for Lois as hitting the ground. Superman would do better not to wait for the last instant and instead slow Lois down over a longer period of time.



▲ **FIGURE 4–12** Test ejection of a pilot from an AMX jet fighter. The jet plumes below the seat are due to the ejection rocket.

EXAMPLE 4–3 You need to deliver a box of bowling balls to a bowling alley. The balls will be placed in a box that is initially at rest but that you want to push into the bowling alley. The box itself has a mass that is very small compared to even one bowling ball. You start with one ball in the box, exert a given force of given strength upon the box for a time period Δt, and at the end of that time the box moves at a speed of 3.2 m/s. You then repeat the procedure with more bowling balls in the box; you exert the same amount of force on the box for the same period of time (Δt) and find the box to have a final speed of 0.4 m/s. How many balls are in the box now?

Setting It Up The two cases are shown in Figs. 4–11a and b at the particular time, after an interval Δt, when the speeds are v_1 and v_2, respectively. You know that an identical force of constant magnitude F acts on two different masses m_1 and m_2 for identical time periods Δt, where $m_2 = nm_1$. Here m_1 is the mass of one bowling ball and n is the number of balls in the box, which is the quantity we want to find. The resulting speeds after time Δt are v_1 and v_2, respectively, and are given.

Strategy In the two cases described the box containing the bowling ball(s) is subject to the same force. Moreover, we can ignore the mass of the box. Using Newton's second law, we can find the accelerations a_1 and a_2 during the period Δt when the force operates. These accelerations are

$$a_1 = \frac{F}{m_1} \quad \text{and} \quad a_2 = \frac{F}{m_2} = \frac{F}{nm_1}.$$

Although we do not know the numerical values of the two accelerations, we do know the speeds v_1 and v_2 after a fixed period of acceleration. Further, we learned in Chapter 2 that an object that starts at rest and undergoes a fixed acceleration $\vec{a}$ for a given period of time Δt has the velocity $\Delta\vec{v} = \vec{v} = \vec{a}\,\Delta t$. In our one-dimensional case, then, we have

$$v_1 = a_1\,\Delta t = \frac{F\,\Delta t}{m_1} \quad \text{and} \quad v_2 = a_2\,\Delta t = \frac{F\,\Delta t}{nm_1}.$$

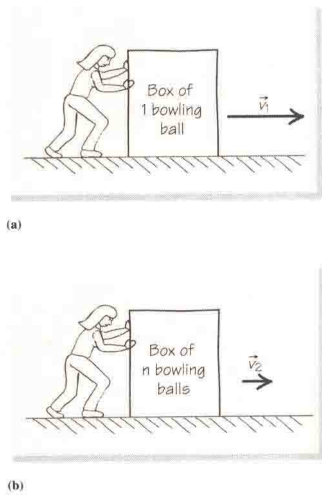
We now have enough information to solve for the unknown, n.

Working It Out We can solve for the ratio F/m in terms of v_1 and Δt and substitute it into the equation for v_2, which we can then solve for n. Alternatively, we can simply take the ratio of the two speeds:

$$\frac{v_1}{v_2} = \frac{(F\,\Delta t/m_1)}{(F\,\Delta t/nm_1)} = n.$$

Numerical substitution gives $n = (3.2\ \text{m/s})/(0.4\ \text{m/s}) = 8$ bowlin[g] balls.

What Do You Think? Suppose the mass of the box is not neg[-]ligible. What would be the effect?



▲ **FIGURE 4–11** Delivering bowling balls to an alley. In (a) the box has one ball, and in (b) there is an unknown number of balls.

Problems. Approximately 40 percent of the end-of-chapter Problems are new or revised. We have separated the Problems into two categories. The first group of Problems is organized by section. The second group, called General Problems, resembles the situations that are met in real-life science and engineering. They also help to develop the student's appreciation of the links that exist throughout physics as well as how to approach problems for which the clues may be more obscure. All Problems are labeled I, II, or III. Level I Problems are the least difficult. These Problems develop student recognition of particular physics concepts and build confidence. Level II Problems typically have more than one step and require an increased understanding of the material; the General Problems carry this requirement a step further. Level III Problems are especially challenging, in some cases demanding significant synthesis of concepts in the text. The gradations in problem range and difficulty allow you to tailor the Problems you assign to the capabilities of your class and to the subjects that interest you the most.

Versions of the Text

The third edition is available in two hardback versions, Extended with Modern Physics (Chapters 1–45) and Standard (Chapters 1–40), as well as in three softcover volumes: Volume I (Chapters 1–20), Volume II (Chapters 21–38), and Volume III (Chapters 39–45).

Supplements

Instructor Supplements

Instructor's Resource Center on CD-ROM (0-13-039150-6) This CD-ROM set includes virtually every electronic asset you'll need in and out of the classroom. Though you can navigate freely through the CDs to find the resources you want, the included software allows you to browse and search through the catalog of assets. The CD-ROMs are organized by chapter and include all text illustrations and tables from *Physics for Scientists and Engineers, Third Edition*, in JPEG, Microsoft PowerPoint, and Adobe PDF formats. Instructors can preview, sequence, and play back images, as well as perform keyword searches, add lecture notes, and incorporate their own digital resources. The IRC/CDs also contain TestGen, a powerful dual-platform, fully networkable software program for creating tests ranging from short quizzes to long exams. Questions from the third edition *Test Item File*, including algorithmic versions, are supplied, and professors can use the Question Editor to modify existing questions or create new questions. The CD-ROMs also contain additional Powerpoint Presentations, electronic versions of the *Test Item File*, the *Instructor's Solutions Manual*, the *Instructor's Resource Manual*, and the end-of-chapter Understanding the Concepts questions and problems from *Physics for Scientists and Engineers, Third Edition.*

Instructor's Solutions Manual (Vol. I: 0-13-039157-3; Vol. II: 0-13-144741-6) Authored by *Jerry Shi (Pasadena City College)*, the ISM contains detailed, worked solutions to every problem from the text, as well as answers to the "Understanding the Concepts" questions.

Instructor's Resource Manual (0-13-141738-X) By *Prabha Ramakrishnan (North Carolina State University)*. This IRM contains lecture outlines, notes, demonstration suggestions, and other teaching resources.

Test Item File (0-13-039158-1) This test bank contains approximately 3000 multiple choice, short answer, and true/false questions, many conceptual in nature. All are referenced to the corresponding text section and ranked by level of difficulty.

Transparency Pack (0-13-039166-2) Includes approximately 400 full-color transparencies of images from the text.

PH GradeAssist Instructor's Quick Start Guide (0-13-141740-1) This guide will help adopting instructors register for and use PH GradeAssist, Prentice Hall's own online homework system. It also contains the access code necessary to create their accounts and access the course material.

Peer Instruction: A User's Manual (0-13-565441-6)
Eric Mazur (Harvard University)
A manual with ready-to-use resources for an innovative new approach to teaching introductory physics, developed by a well-known physicist and leader in physics education.

Just-in-Time Teaching: Blending Active Learning with Web Technology (0-13-085034-9)
Gregor Novak (Air Force Academy), Andrew Gavrin (IUPUI), Wolfgang Christian (Davidson College), and Evelyn Patterson (Air Force Academy)
In this resource book for educators, the four authors fully discuss just what *Just-in-Time Teaching* is. *Just-in-Time Teaching (JiTT)* is a teaching and learning methodology designed to engage students by using feedback from pre-class Web assignments to adjust classroom lessons. This allows students to receive rapid response to the specific questions and problems they are having instead of more generic lectures that may or may not address what students actually need help with. Many teachers have found that this process also encourages students to take more control of the learning process and become active and interested learners.

Physlets®: Teaching Physics with Interactive Curricular Material (0-13-029341-5)
Wolfgang Christian and Mario Belloni (Davidson College)
This manual/CD package shows physics instructors—both Web novices and Java-savvy programmers alike—how to author their own interactive curricular material using Physlets—Java applets written for physics pedagogy that can be embedded directly into HTML documents and that can interact with the user. It demonstrates the use of Physlets in conjunction with JavaScript to deliver a wide variety of Web-based interactive physics activities. It also provides examples of Physlets created for classroom demonstrations, traditional and Just-in-Time Teaching homework problems, pre- and post-laboratory exercises, and Interactive Engagement activities. More than just a technical how-to book, the manual gives instructors some ideas about the new possibilities that Physlets offer and is designed to make the transition to using Physlets quick and easy.

Student Supplements

Student Study Guide with Selected Solutions (Vol. I: 0-13-100070-5; Vol. II: 0-13-146500-7)
David Reid (Eastern Michigan University)
The print study guide provides the following for each chapter:

- Objectives
- Chapter Review with Examples and integrated quizzes
- Reference Tools & Resources (equation summaries, important tips, and tools)
- Practice Problems by *Carl Adler (East Carolina University)*
- Selected Solutions for several end-of-chapter problems

PH GradeAssist Student Quick Start Guide (0-13-141741-X) This guide contains information on how to register and use PH GradeAssist. It also contains the access code necessary for students to create their accounts and access the course.

Ranking Task Exercises in Physics: Student Edition (0-13-144851-X)
Thomas L. O'Kuma (Lee College), David P. Maloney (Indiana University–Purdue University at Fort Wayne), and Curtis J. Hieggelke (Joliet Junior College)
Ranking Task Exercises are a unique resource for physics instructors who are looking for tools to incorporate more conceptual analysis in their course. This supplement contains 218 Ranking Task Exercises that cover all classical physics topics. Ranking Tasks are an innovative type of conceptual exercise that ask students to make comparative judgments about a set of variations on a particular physical situation.

Physlet® Physics (0-13-101969-4)
Wolfgang Christian and Mario Belloni (Davidson College)
This text and CD-ROM package provides ready-to-run interactive Physlet-based curricular material for both teachers and students. Physlets, award-winning Java applets written by Christian and Belloni, have been widely adopted by the physics teaching community. This book provides the first class-tested collection of ready-to-run Physlet-based material that is easy to assign (like an end-of-chapter problem of a textbook) and easy to use (material is on a CD and in the book). Neither a Web server nor an Internet connection is required.

Interactive Physics Workbook, Second Edition (0-13-067108-8)
Cindy Schwarz (Vassar College), John Ertel (Naval Academy), MSC Software
This interactive workbook and hybrid CD-ROM package is designed to help students visualize and work with specific physics problems through simulations created with Interactive Physics files. Forty problems of varying degrees of difficulty require students to make predictions, change variables, run, and visualize motion on the computer. The workbook/study guide provides instructions, physics review, hints, and questions. The accompanying hybrid CD-ROM contains everything students need to run the simulations.

Tutorials in Introductory Physics and Homework Package (0-13-097069-7)
Lillian C. McDermott, Peter S. Shaffer, and the Physics Education Group (all of the University of Washington)
This landmark book presents a series of physics tutorials designed by a leading physics education research group. Emphasizing the development of concepts and scientific reasoning skills, the tutorials focus on the specific conceptual and reasoning difficulties that students tend to encounter. The tutorials cover a range of topics in Mechanics, Electricity and Magnetism, and Waves & Optics.

The Portable TA: A Physics Problem-Solving Guide, Second Edition (Vol. I: 0-13-231713-3; Vol. II: 0-13-231721-4)
Andrew Elby
This two-volume set contains a collection of problems with carefully detailed strategies and solutions that provide students with additional problem-solving techniques.

MCAT Physics Study Guide (0-13-627951-1)
Joseph Boone (California Polytechnic State University-San Luis Obispo)
Since most MCAT questions require more thought and reasoning than simply plugging numbers into an equation, this study guide is designed to refresh students' memories about the topics they've covered in class. Additional review, practice problems, and review questions are included.

Mathematics for Physics with Calculus (0-13-191336-0)
Biman Das (SUNY Potsdam)
Designed for concurrent self-study or remedial math work for students in introductory courses, this text is ideal for students who find themselves unable to keep pace because of a lack of familiarity with necessary mathematical tools. It not only shows them clearly how mathematics is directly applied to physics, but discusses math anxiety in general and how to overcome it.

Media Resources

Course Management Options

Course management systems offer you a robust architecture for communicating with your students and letting them communicate with each other, allowing you and your students to post course-related documents, managing your roster and gradebook, and providing on-line assessment. For schools with a local WebCT or Blackboard license, we offer a complete downloadable content cartridge that will give you a rapid start to your on-line course materials. Adapt and customize our materials to your needs, using the tools of these systems. For instructors without the benefit of a local course management system, we also offer OneKey, Pearson Education's own nationally hosted course management system, powered by Blackboard. OneKey combines the power of a full-featured course management system with a quick, easy-to-use interface.

The content cartridge for *Physics for Scientists and Engineers, Third Edition*, includes all the material from the Companion Website, selected resources from the Instructor's Resource Center on CD-ROMs, and all of the questions from the TestGenerator test bank, plus additional materials designed specifically to work in concert with innovative teaching methods. The latter include several activities for *Just-in-Time Teaching*, by *Gregor Novak* and *Andrew Gavrin*; and conceptual, quantitative, and MCAT practice problem sets for on-line assessment.

On-line Assessment Options

You may not need the full capabilities of a course management system (such as posting documents or managing a bulletin board) but may prefer to use an on-line assessment system. On-line assessment provides students instantaneous feedback and repeated practice, and it offers instructors relief from hours of grading and managing a gradebook. On-line assessment systems feature algorithmically-generated questions and quizzes, allow you to create and modify assignments and question pools, and provide tools for analyzing your gradebook entries. Prentice Hall has a powerful new entry in the on-line assessment space: PH GradeAssist. Ask your PH representative about getting a PHGA demonstration and an Instructor's Quick Start Guide. In addition, Prentice Hall partners with other systems, such as WebAssign, to provide an ample selection of book-specific questions to include in your assignments.

PH GradeAssist

This nationally hosted system includes assessment banks associated with Just-in-Time Teaching materials, and other conceptual and quantitative questions. In addition, most of the even-numbered end-of-chapter Problems and questions for *Physics for Scientists and Engineers, Third Edition*, have been converted for use in PHGA, and the majority of them have an algorithmically-generated variant. You select which questions to assign, and you may edit them or create new questions. You also control various important parameters, such as how much questions are worth and when a student can take a quiz.

WebAssign

WebAssign's nationally hosted homework delivery service harnesses the power of the Internet and puts it to work for you by collecting and grading homework. You can create assignments from a database of end-of-chapter questions and problems from the third edition of *Physics for Scientists and Engineers*, or write and customize your own. You have complete control over the homework your students receive, including due date, content, feedback, and question formats.

Companion Website (*http://physics.prenhall.com/fishbane*)

The Companion Website is a quick, interactive resource that allows students to check their understanding with practice quizzes and to explore the material of each chapter further by mining the World Wide Web.

- Reference Tools and Resources by *David Reid (Eastern Michigan University)*
- Practice Questions by *Carl Adler (East Carolina University)*
- Algorithmically generated Practice Problems by *Carl Adler*
- On-line Destinations (links to related sites) by *Carl Adler*
- Applications, with links to related Internet sites, by *Gregor Novak* and *Andrew Gavrin (Indiana University–Purdue University, Indianapolis)*

All quiz modules are scored by the computer; results can be automatically e-mailed to the student's professor or teaching assistant.

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