As requested by instructors, here is a new edition of the textbook originated by David Halliday and Robert Resnick in 1963 and that I used as a first-year student at MIT. (Gosh, time has flown by.) Constructing this new edition allowed me to discover many delightful new examples and revisit a few favorites from my earlier eight editions. Here below are some highlights of this 12th edition.

Figure 10.39 What tension was required by the Achilles tendons in Michael Jackson in his gravity-defying 45° lean during his video *Smooth Criminals*?

Figure 10.7.2 What is the increase in the tension of the Achilles tendons when high heels are worn?

Figure 9.65 Falling is a chronic and serious condition among skateboarders, in-line skaters, elderly people, people with seizures, and many others. Often, they fall onto one outstretched hand, fracturing the wrist. What fall height can result in such fracture?

Figure 34.5.4 In functional near infrared spectroscopy (fNIRS), a person wears a close-fitting cap with LEDs emitting in the near infrared range. The light can penetrate into the outer layer of the brain and reveal when that portion is activated by a given activity, from playing baseball to flying an airplane.

Figure 28.5.2 Fast-neutron therapy is a promising weapon against salivary gland malignancies. But how can electrically neutral particles be accelerated to high speeds?

Figure 29.63 Parkinson's disease and other brain disorders have been treated with transcranial magnetic stimulation in which pulsed magnetic fields force neurons several centimeters deep to discharge.
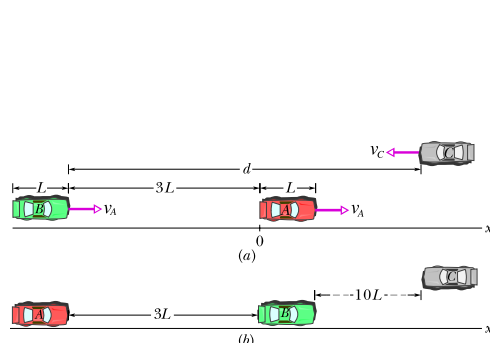

Figure 2.37 How should autonomous car B be programmed so that it can safely pass car A without being in danger from oncoming car C?
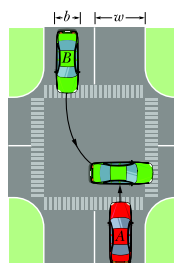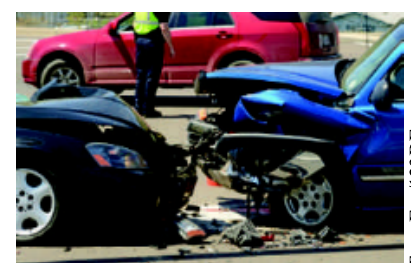

Figure 4.39 In a Pittsburgh left, a driver in the opposite lane anticipates the onset of the green light and rapidly pulls in front of your car during the red light. In a crash reconstruction, how soon before the green did the other driver start the turn?

Figure 9.6.4 The most dangerous car crash is a head-on crash. In a head-on crash of cars of identical mass, by how much does the probability of a fatality of a driver decrease if the driver has a passenger in the car?

In addition, there are problems dealing with

- remote detection of the fall of an elderly person,
- the illusion of a rising fastball,
- hitting a fastball in spite of momentary vision loss,
- ship squat in which a ship rides lower in the water in a channel,
- the common danger of a bicyclist disappearing from view at an intersection,
- measurement of thunderstorm potentials with muons,

and more.

WHAT'S IN THE BOOK

- Checkpoints, one for every module
- Sample problems
- Review and summary at the end of each chapter
- Nearly 300 new end-of-chapter problems

In constructing this new edition, I focused on several areas of research that intrigue me and wrote new text discussions and many new homework problems. Here are a few research areas:

We take a look at the first image of a black hole (for which I have waited my entire life), and then we examine gravitational waves (something I discussed with Rainer Weiss at MIT when I worked in his lab several years before he came up with the idea of using an interferometer as a wave detector).

I wrote a new sample problem and several homework problems on autonomous cars where a computer system must calculate safe driving procedures, such as passing a slow car with an oncoming car in the passing lane.

I explored cancer radiation therapy, including the use of Augur-Meitner electrons that were first understood by Lise Meitner.

I combed through many thousands of medical, engineering, and physics research articles to find clever ways of looking inside the human body without major invasive surgery. Some are listed in the index under "medical procedures and equipment." Here are three examples:

(1) Robotic surgery using single-port incisions and optical fibers now allows surgeons to access internal organs, with patient recovery times of only hours instead of days or weeks as with previous surgery techniques.

(2) Transcranial magnetic stimulation is being used to treat chronic depression, Parkinson's disease, and other brain malfunctions by applying pulsed magnetic fields from coils near the scalp to force neurons several centimeters deep to discharge.

(3) Magnetoencephalography (MEG) is being used to monitor a person's brain as the person performs a task such as reading. The task causes weak electrical pulses to be sent along conducting paths between brain cells, and each pulse produces a weak magnetic field that is detected by extremely sensitive SQUIDs.
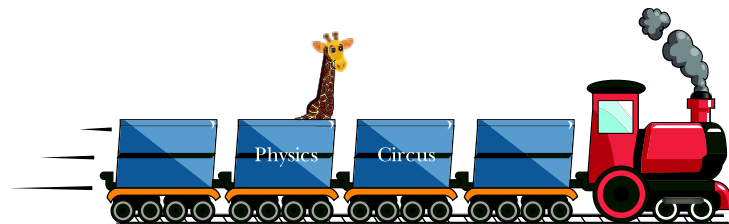
WileyPLUS THE *WILEYPLUS* ADVANTAGE

WileyPLUS is a research-based online environment for effective teaching and learning. The customization features, quality question banks, interactive eTextbook, and analytical tools allow you to quickly create a customized course that tracks student learning trends. Your students can stay engaged and on track with the use of intuitive tools like the syncing calendar and the student mobile app. Wiley is committed to providing accessible resources to instructors and students. As such, all Wiley educational products and services are born accessible, designed for users of all abilities.

Links Between Homework Problems and Learning Objectives In *WileyPLUS*, every question and problem at the end of the chapter is linked to a learning objective, to answer the (usually unspoken) questions, "Why am I working this problem? What am I supposed to learn from it?" By being explicit about a problem's purpose, I believe that a student might better transfer the learning objective to other problems with a different wording but the same key idea. Such transference would help defeat the common trouble that a student learns to work a particular problem but cannot then apply its key idea to a problem in a different setting.

Animations of one of the key figures in each chapter. Here in the book, those figures are flagged with the swirling icon. In the online chapter in *WileyPLUS*, a mouse click begins the animation. I have chosen the figures that are rich in information so that a student can see the physics in action and played out over a minute or two instead of just being flat on a printed page. Not only does this give life to the physics, but the animation can be repeated as many times as a student wants.

Video Illustrations David Maiullo of Rutgers University has created video versions of approximately 30 of the photographs and figures from the chapters. Much of physics is the study of things that move, and video can often provide better representation than a static photo or figure.

Videos I have made well over 1500 instructional videos, with more coming. Students can watch me draw or type on the screen as they hear me talk about a solution, tutorial, sample problem, or review, very much as they would experience were they sitting next to me in my office while I worked out something on a notepad. An instructor's lectures and tutoring will always be the most valuable learning tools, but my videos are available 24 hours a day, 7 days a week, and can be repeated indefinitely.
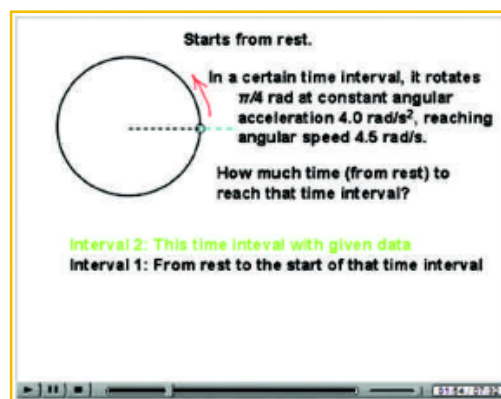
- **Video tutorials on subjects in the chapters.** I chose the subjects that challenge the students the most, the ones that my students scratch their heads about.

- **Video reviews of high school math**, such as basic algebraic manipulations, trig functions, and simultaneous equations.

- **Video introductions to math**, such as vector multiplication, that will be new to the students.

- **Video presentations of sample problems.** My intent is to work out the physics, starting with the key ideas instead of just grabbing a formula. However, I also want to demonstrate how to read a sample problem, that is, how to read technical material to learn problem-solving procedures that can be transferred to other types of problems.

- **Video solutions to 20% of the end-of chapter problems.** The availability and timing of these solutions are controlled by the instructor. For example, they might be available after a homework deadline or a quiz. Each solution is not simply a plug-and-chug recipe. Rather I build a solution from the key ideas to the first step of reasoning and to a final solution. The student learns not just how to solve a particular problem but how to tackle any problem, even those that require *physics courage.*

- **Video examples of how to read data from graphs** (more than simply reading off a number with no comprehension of the physics).

- Many of the sample problems in the textbook are available online in both reading and video formats.

Problem-Solving Help   I have written a large number of resources for *WileyPLUS* designed to help build the students' problem-solving skills.

• **Hundreds of additional sample problems.** These are available as stand-alone resources but (at the discretion of the instructor) they are also linked out of the homework problems. So, if a homework problem deals with, say, forces on a block on a ramp, a link to a related sample problem is provided. However, the sample problem is not just a replica of the homework problem and thus does not provide a solution that can be merely duplicated without comprehension.

• **GO Tutorials** for 15% of the end-of-chapter homework problems. In multiple steps, I lead a student through a homework problem, starting with the key ideas and giving hints when wrong answers are submitted. However, I purposely leave the last step (for the final answer) to the students so that they are responsible at the end. Some online tutorial systems trap a student when wrong answers are given, which can generate a lot of frustration. My GO Tutorials are not traps, because at any step along the way, a student can return to the main problem.

• **Hints on every end-of-chapter homework problem** are available (at the discretion of the instructor). I wrote these as true hints about the main ideas and the general procedure for a solution, not as recipes that provide an answer without any comprehension.

• **Pre-lecture videos.** At an instructor's discretion, a pre-lecture video is available for every module. Also, assignable questions are available to accompany these videos. The videos were produced by Melanie Good of the University of Pittsburgh.

Evaluation Materials

• **Pre-lecture reading questions are available in *WileyPLUS* for each chapter section.** I wrote these so that they do not require analysis or any deep understanding; rather they simply test whether a student has read the section. When a student opens up a section, a randomly chosen reading question (from a bank of questions) appears at the end. The instructor can decide whether the question is part of the grading for that section or whether it is just for the benefit of the student.

• **Checkpoints are available within each chapter module.** I wrote these so that they require analysis and decisions about the physics in the section. Answers are provided in the back of the book.

• **All end-of-chapter homework problems** (and many more problems) are available in *WileyPLUS*. The instructor can construct a homework assignment and control how it is graded when the answers are submitted online. For example, the instructor controls the deadline for submission and how many attempts a student is allowed on an answer. The instructor also controls which, if any, learning aids are available with each homework problem. Such links can include hints, sample problems, in-chapter reading materials, video tutorials, video math reviews, and even video solutions (which can be made available to the students after, say, a homework deadline).

• **Symbolic notation problems** that require algebraic answers are available in every chapter.

• **All end-of-chapter homework questions** are available for assignment in *WileyPLUS*. These questions (in a multiple-choice format) are designed to evaluate the students' conceptual understanding.

• **Interactive Exercises and Simulations** by Brad Trees of Ohio Wesleyan University. How do we help students understand challenging concepts in physics? How do we motivate students to engage with core content in a meaningful way? The simulations are intended to address these key questions. Each module in the Etext is linked to one or more simulations that convey concepts visually. A simulation depicts a physical situation in which time dependent phenomena are animated and information is presented in multiple representations including a visual representation of the physical system as well as a plot of related variables. Often, adjustable parameters allow the user to change a property of the system and to see the effects of that change on the subsequent behavior. For visual learners, the simulations provide an opportunity to "see" the physics in action. Each simulation is also linked to a set of interactive exercises, which guide the student through a deeper interaction with the physics underlying the simulation. The exercises consist of a series of practice questions with feedback and detailed solutions. Instructors may choose to assign the exercises for practice, to recommend the exercises to students as additional practice, and to show individual simulations during class time to demonstrate a concept and to motivate class discussion.
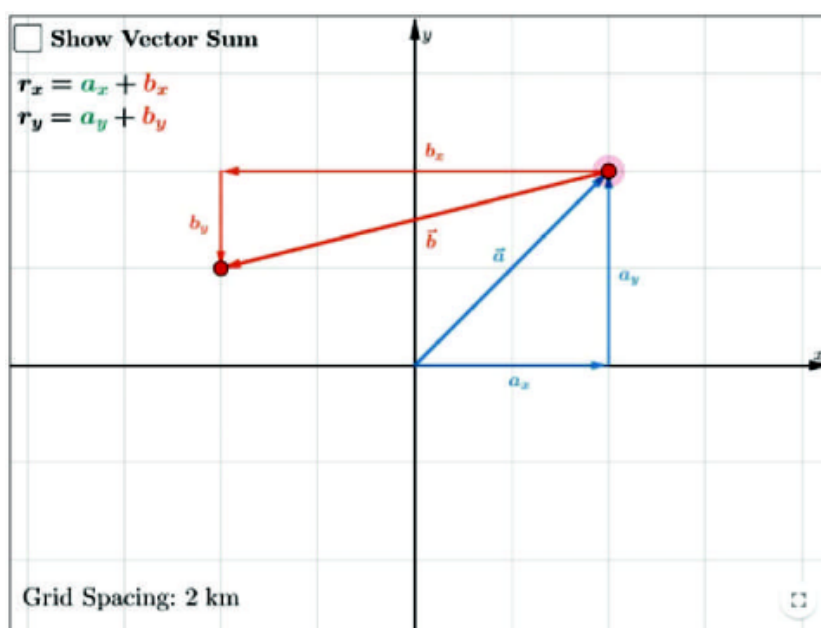
Icons for Additional Help   When worked-out solutions are provided either in print or electronically for certain of the odd-numbered problems, the statements for those problems include an icon to alert both student and instructor. There are also icons indicating which problems have a GO Tutorial or a link to the *The Flying Circus of Physics,* which require calculus, and which involve a biomedical application. An icon guide is provided here and at the beginning of each set of problems.

GO Tutoring problem available (at instructor's discretion) in *WileyPLUS*		
SSM Worked-out solution available in Student Solutions Manual	**CALC**	Requires calculus
E Easy **M** Medium **H** Hard	**BIO**	Biomedical application
FCP Additional information available in *The Flying Circus of Physics* and at flyingcircusofphysics.com		

FUNDAMENTALS OF PHYSICS—FORMAT OPTIONS

Fundamentals of Physics was designed to optimize students' online learning experience. We highly recommend that students use the digital course within *WileyPLUS* as their primary course material. Here are students' purchase options:

• 12th Edition *WileyPLUS* course
• *Fundamentals of Physics* Looseleaf Print Companion bundled with *WileyPLUS*

- *Fundamentals of Physics* volume 1 bundled with *WileyPLUS*
- *Fundamentals of Physics* volume 2 bundled with *WileyPLUS*
- *Fundamentals of Physics* Vitalsource Etext

SUPPLEMENTARY MATERIALS AND ADDITIONAL RESOURCES

Supplements for the instructor can be obtained online through *WileyPLUS* or by contacting your Wiley representative. The following supplementary materials are available for this edition:

Instructor's Solutions Manual by Sen-Ben Liao, Lawrence Livermore National Laboratory. This manual provides worked-out solutions for all problems found at the end of each chapter. It is available in both MSWord and PDF.

- **Instructor's Manual** This resource contains lecture notes outlining the most important topics of each chapter; demonstration experiments; laboratory and computer projects; film and video sources; answers to all questions, exercises, problems, and checkpoints; and a correlation guide to the questions, exercises, and problems in the previous edition. It also contains a complete list of all problems for which solutions are available to students.

- **Classroom Response Systems ("Clicker") Questions** by David Marx, Illinois State University. There are two sets of questions available: Reading Quiz questions and Interactive Lecture questions. The Reading Quiz questions are intended to be relatively straightforward for any student who reads the assigned material. The Interactive Lecture questions are intended for use in an interactive lecture setting.

- **Wiley Physics Simulations** by Andrew Duffy, Boston University and John Gastineau, Vernier Software. This is a collection of 50 interactive simulations (Java applets) that can be used for classroom demonstrations.

- **Wiley Physics Demonstrations** by David Maiullo, Rutgers University. This is a collection of digital videos of 80 standard physics demonstrations. They can be shown in class or accessed from *WileyPLUS*. There is an accompanying Instructor's Guide that includes "clicker" questions.

- **Test Bank** by Suzanne Willis, Northern Illinois University. The Test Bank includes nearly 3,000 multiple-choice questions. These items are also available in the Computerized Test Bank, which provides full editing features to help you customize tests (available in both IBM and Macintosh versions).

- **All text illustrations** suitable for both classroom projection and printing.

- **Lecture PowerPoint Slides** These PowerPoint slides serve as a helpful starter pack for instructors, outlining key concepts and incorporating figures and equations from the text.

STUDENT SUPPLEMENTS

Student Solutions Manual (ISBN 9781119455127) by Sen-Ben Liao, Lawrence Livermore National Laboratory. This manual provides students with complete worked-out solutions to 15 percent of the problems found at the end of each chapter within the text. The Student Solutions Manual for the 12th edition is written using an innovative approach called TEAL, which stands for Think, Express, Analyze, and Learn. This learning strategy was originally developed at the Massachusetts Institute of Technology and has proven to be an effective learning tool for students. These problems with TEAL solutions are indicated with an SSM icon in the text.

Introductory Physics with Calculus as a Second Language (ISBN 9780471739104) *Mastering Problem Solving* by Thomas Barrett of Ohio State University. This brief paperback teaches the student how to approach problems more efficiently and effectively. The student will learn how to recognize common patterns in physics problems, break problems down into manageable steps, and apply appropriate techniques. The book takes the student step by step through the solutions to numerous examples.