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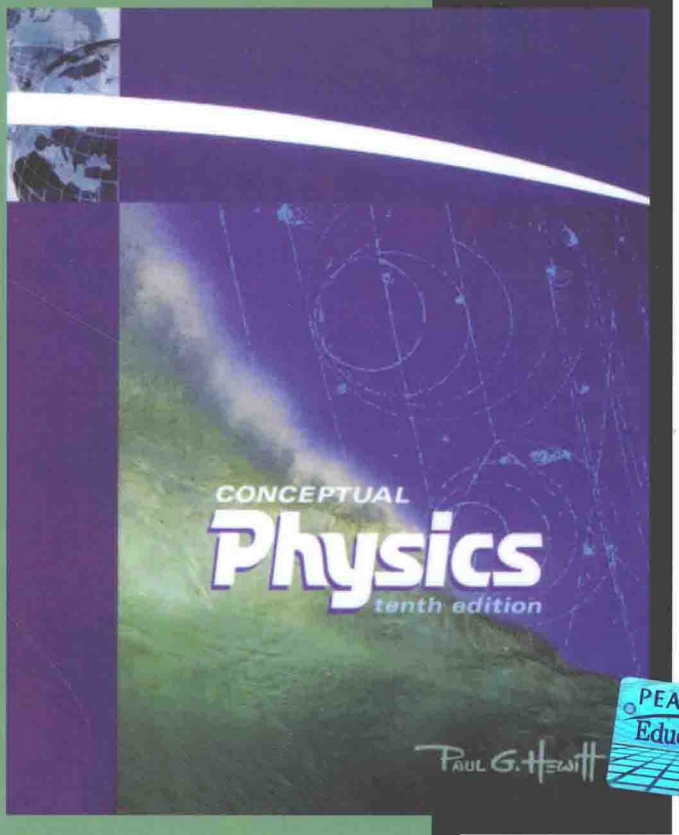
国际著名物理图书——影印版系列

Paul G. Hewitt

概念物理

（第10版）



清华大学出版社

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Conceptual Physics (Tenth Edition)

Paul G. Hewitt

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北京

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一本引人入胜的物理教材（代影印版序）

Paul G. Hewitt 这本物理教材具有以下特点：

一、联系实际广泛。从人们体重的测定到地热的开发，从背越式跳高到潮汐的形成，从人造卫星到大风揭走房顶，从彩色电视到致密光盘，从北极光到眼睛的欺骗，从放射性到原子弹、氢弹……内容五花八门，应有尽有，和日常生活、实用技术、自然风光紧密相联，阅读起来兴趣盎然。

二、涉及现代物理新发展。相对论（包括广义相对论）、核反应、二象性、混沌、激光、全息都有介绍。21 世纪这几年的宇宙学的成就，如宇宙整体上是平展的，暗物质、暗能量也都有触及。阅读之后，让人眼界大为开阔。

三、内容涵盖一般物理学的全部基本内容，系统也基本上是传统的，但也很恰当地嵌入了现代内容，有的讲得还相当深入。如力学中引力一章就较仔细地讲解了潮汐，简述了爱因斯坦的引力理论；热学中讲了能量的退降和熵的概念等。

四、在正文中只写了几个非常基本的，不写不行的公式，如 $F = Gm_1m_2/r^2$；$F = kq_1q_2/r^2$，$E = F/q$，$E = mc^2$ 等。其他方程、公式一概没有，也没有一个用公式计算的例题，因此学习起来不需要微积分。

五、尽管不用数学公式，但道理讲得通俗易懂。如对动量守恒定律没有用公式，而是借助牛顿第三定律的概念就说得很明白。又如对光在透明介质中的速度慢于在真空中的速度，用光激发原子振动而后原子又再发射因此滞后来说明，也很容易理解。引力定律用图形和曲线也讲得很明白等。

六、每章后均列有 50 个问答题和少量计算题，大多是从实际出发提出问题，帮助读者更深入全面地但也是定性的理解本题的本质。

七、书的表现形式也很令人喜欢。用了许多作者的亲人，如妻、子、弟、侄女、孙子的照片来说明物理原理，也画了许多卡通人物或动物来解说问题，使人读起书来感到很亲切，有兴趣。书中不断出现的“亮牌”，写的是各处的要点，对掌握书的内容很有帮助。

八、本书还附有一本书面的练习册。其中一部分是为各章设计的选择题和填空题，另一部分是本书的问答题和计算题的全部解答，是很好的学习辅助工具。

概括起来，我认为 Hewitt 的这部教材是一本“高级科普式的十万个为什么”。解说了一个现代文化人应该具有的物理知识，讲解清楚、正确、易懂。本书不但可以作为一本很好的大学物理教材，尤其是文科物理教材，其他的人如中学、大学物理教师或学生能够阅读一遍也会受益匪浅的。

张三慧

2007 年 8 月于清华园

The Conceptual Physics Photo Album

Conceptual Physics is a very personal book, reflected in the many photographs of family and friends that grace its pages. Foremost to providing suggestions and feedback to this and previous editions is Ken Ford, former CEO of the American Institute of Physics, to whom the Eighth Edition was dedicated. Ken's hobby of gliding is appropriately shown on page 391, and his dedication to teaching Germantown Academy high-school students in Pennsylvania is seen on page 686. The First Edition of *Conceptual Physical Science* was dedicated to resourceful Charlie Spiegel, shown on page 503. Although Charlie passed away in 1996, his personal touch carries over to this book. Assisting in the production of this edition is my wife Lillian, to whom this book is dedicated. She is shown on pages 2, 143, 316, and 382. Lillian holds our colorful pet conure, Sneezlee, on page 521. Her dad Wai Tsan Lee is on page 461, and her niece and nephew, Allison and Erik Wong, demonstrate thermodynamics on page 353.

Part openers with the cartoon style blurbs about physics are of family and close friends. The book opener on page 1 is of my great nephew Evan Suchocki (pronounced Su-hock'-ee, with silent c) holding a pet chickie while sitting on my lap. Part 1 on page 21 shows Debbie and Natalie Limogan, children of my dear San Francisco friends, Hideko and Herman Limogan. The little boy in the middle is Genichiro Nakada. Part 2 on page 209 is Andres Riveros Mendoza, son of David Riveros, my co-author of a physics textbook in Spanish, *Fisica 1 & 2: Las Reglas de la Naturaleza*, published in Mexico City, Mexico. Part 3 opens on page 289 with Terrence Jones, son of my niece Corine Jones, who is now grown up and created the computer font for the *Next-Time Questions*. Part 4, page 361, is my grandson Alexander Hewitt, and Part 5, page 409, is my granddaughter Megan, daughter of Leslie and Bob Abrams. Part 6, page 495, is Lillian's nephew, Christopher Lee. Grandchildren Alexander and Grace Hewitt open Part 7 on page 619. Grace alone begins Part 8 on page 685.

To celebrate this Tenth Edition, chapter-opening photographs are of teacher friends and colleagues, mostly in their classrooms demonstrating physics typical of the chapter material. Their names appear with their photos.

City College of San Francisco friends and colleagues open Chapters 3, 4, 7, 13, 21, and 23. On page 101 we see Will Maynez with the air track he designed and built, and again burning a peanut on page 324. Dave Wall is on page 595.

Physics teacher friends from high schools include Chicago's finest, close friend Marshall Ellenstein, who swings the water-filled bucket on page 146 and walks barefoot on broken glass on page 265. Marshall, a longtime contributor to *Conceptual Physics*, has recently converted videos made of my lectures in 1982 to a 3-disc DVD set, *Conceptual Physics Alive!—The San Francisco Years* (which predate the DVDs of 34 lectures in Hawaii). Page 122 shows dear friend and dedicated San Mateo physics teacher, Pablo Robinson, who risks his body for science sandwiched between beds of nails. Pablo, shown again on page 515, is the author of the lab manual that accompanies this book. An old black and white photo of Pablo's children, David and Kristin, is shown on page 159. Pablo's wife Ellyn, author of *Biotechnology: Science for the New Millennium*, EMC-Paradigm Publishing, 2006, is on page 290. Dean Baird, co-author of the *Conceptual Physical Science* lab manuals, is on page 325.

Family photos begin with the touching photo on page 81 of son Paul and his daughter Grace. Another photo on page 88 linking touching to Newton's third law is of my brother Steve with his daughter Gretchen at their coffee farm in Costa Rica. Gretchen is shown again, grown up, on page 319. Steve's son Travis is seen on page 155, and his oldest daughter Stephanie on page 232. My son Paul is again shown on pages 309 and 346. His lovely wife, Ludmila, holds crossed Polaroids on page 573, and their dog Hanz pants on page 326. The endearing girl on page 217 is my daughter Leslie, now a mom, teacher, and earth-science co-author of our *Conceptual Physical Science* textbooks. This photo of Leslie, now colorized, has been a trademark of *Conceptual Physics* since the Third Edition. A more recent photo of her with husband Bob is on page 595. Their children, Megan and Emily, along with son Paul's children, make up the colorful set of photos on page 520. Photos of my late son James are on pages 151, 400, and 550. He left me my first grandson, Manuel, seen on pages 238 and 388. Manuel's grandmom, my wife

Millie, before passing away in early 2004, bravely holds her hand above the active pressure cooker on page 309. Brother Dave (no, not a twin) and his wife Barbara demonstrate atmospheric pressure on page 272. Their son Dave is on page 451, and grandson John Perry Hewitt is on page 282. Sister Marjorie Hewitt Suchocki, an author and theologian at Claremont School of Theology, illustrates reflection on page 533. Marjorie's son, John Suchocki, author of the third edition (2007) of *Conceptual Chemistry*, Benjamin Cummings, and my chemistry co-author of the *Conceptual Physical Science* textbooks, walks fearlessly across hot coals on page 306 (for emphasis, David Willey does the same on page 337). Nephew John is also a talented vocalist and guitarist known as John Andrew in his popular CDs, seen with his guitar on page 480. The group listening to music on page 404 are part of John's and Tracy's wedding party; from left to right, Butch Orr, my niece Cathy Candler, bride and groom, niece Joan Lucas, sister Marjorie, Tracy's parents Sharon and David Hopwood, teacher friends Kellie Dippel and Mark Werkmeister, and myself.

Personal friends who were my former students begin with Tenny Lim, who draws her bow on page 114 as she has been doing since the Sixth Edition. Tenny is now a "rocket scientist" at Jet Propulsion Lab in Pasadena. Another rocket-scientist friend is Helen Yan, who develops satellites for Lockheed Martin in Sunnyvale in addition to stints at part-time physics teaching. Her hand lettering, now in computer font, adorns the Next-Time Questions for this edition. On page 315 Helen poses with the box she first posed with for the Fifth Edition when she was my teaching assistant. Another former student is Alexei Cogan, who demonstrates center of gravity on page 143. The karate gal on page 96 is former CCSF student Cassy Cosme. This is a colorized black and white photo that graced three editions of this book before it went full color in the Seventh Edition. On page 151 student Cliff Braun is at the far left of my son James in Figure 8.51, with nephew Robert Baruffaldi at the far right.

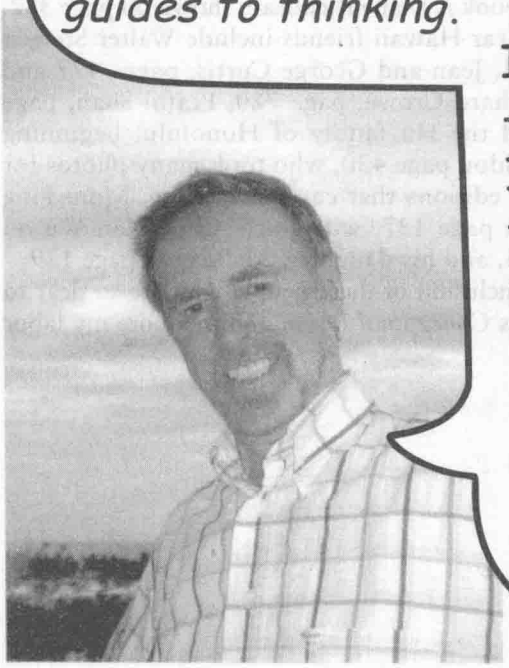
Two dear friends who go back to my own school days are Howie Brand on page 91 and Dan Johnson on page 285. Other cherished friends are Paul Ryan, who drags his finger through molten lead on page 337, and Tim Gardner, demonstrating Bernoulli's principle on page 278. My friend and mentor from sign painting days, Burl Grey, is on page 22, and is discussed on pages 30 and 31. Lifelong friend Ernie Brown, who designed the cover logos for all my conceptual books, is seen on page 750—not in a photo, but in a cartoon—for Ernie is a cartoonist and my cartooning mentor of earlier years. Physics buddy John Hubisz opens Chapter 12, page 229, and appears in the entropy photo on page 356. Friends Larry and Tammy Tunison wear radiation badges on page 656. Suzanne Lyons, co-author of *Conceptual Science*, poses with her children Tristan and Simone on page 528. Phil Wolf, co-author of the *Problem Solving in Conceptual Physics* book that accompanies this edition, is shown on page 600. Helping create that book is Diane Riendeau, shown on page 362.

My dear Hawaii friends include Walter Steiger, page 634, Jean and George Curtis, pages 477 and 582, Richard Crowe, page 720, Praful Shah, page 161, and the Hu family of Honolulu, beginning with Meidor, page 430, who took many photos for previous editions that carry over here. Mom Ping Hu is on page 137, with uncle Chiu Man Wu on page 326, and his daughter, Andrea, on page 129.

The inclusion of these people who are so dear to me makes *Conceptual Physics* all the more my labor of love.

To the Student

You know you can't enjoy a game unless you know its rules; whether it's a ball game, a computer game, or simply a party game. Likewise, you can't fully appreciate your surroundings until you understand the rules of nature. Physics is the study of these rules, which show how everything in nature is beautifully connected. So the main reason to study physics is to enhance the way you see the physical world. You'll see the mathematical structure of physics in frequent equations, but more than being recipes for computation, you'll see the equations as *guides to thinking*.



I enjoy physics, and you will too — because you'll understand it. If you get hooked and take a follow-up course, *then* you can focus on mathematical problems. Go for comprehension of concepts now, and if computation follows, it will be with understanding.

Enjoy your physics!

Paul G. Hewitt

To the Instructor

The sequence of chapters in this Tenth Edition is identical to that of the previous edition. In addition to extensive edits in every chapter, there are many new photographs, new chapter-end material, and other new features described below.

As with the previous edition, Chapter 1, "About Science," begins your course on a high note with coverage on early measurements of the Earth and distances to the Moon and the Sun.

Part One, "Mechanics," begins with Chapter 2, which, as in the previous edition, presents a brief historical overview of Aristotle and Galileo, progressing to Newton's first law and to mechanical equilibrium. The high tone of Chapter 1 is maintained as forces are treated before velocity and acceleration. Students get their first taste of physics via a very comprehensible treatment of parallel force vectors. They enter a comfortable part of physics before being introduced to kinematics.

Chapter 3, "Linear Motion," is the only chapter in Part One that is devoid of physics laws. Kinematics has no laws, only definitions, mainly for *speed, velocity,* and *acceleration*—likely the least exciting concepts that your course has to offer. Too often kinematics becomes a pedagogical "black hole" of instruction—too much time for too little physics. Being more math than physics, the kinematics equations can appear to the student as the most intimidating in the book. Although the experienced eye doesn't see them as such, this is how *students* first see them:

$$\varsigma = \varsigma_o + \delta\mathfrak{d}$$
$$\zeta = \varsigma_o\mathfrak{d} + \tfrac{1}{2}\,\delta\mathfrak{d}^2$$
$$\varsigma^2 = \varsigma_o{}^2 + 2\delta\,\zeta$$
$$\varsigma_\alpha = \tfrac{1}{2}(\varsigma_o + \varsigma)$$

If you wish to reduce class size, display these equations on the first day and announce that class effort for much of the term will be making sense of them. Don't we do much the same with the standard symbols?

Ask any college graduate these two questions: What is the acceleration of an object in free fall? What keeps Earth's interior hot? You'll see where their education was focused, for many more will correctly answer the first question than the second. Traditionally, physics courses have been top-heavy in kinematics with little or no coverage of modern physics. Radioactive decay almost never gets the attention given to falling bodies. So my recommendation is to pass quickly through Chapter 3, making the distinction between velocity and acceleration, and then to move on to Chapter 4, "Newton's Second Law of Motion," where the concepts of velocity and acceleration find their application.

Chapter 5 continues with Newton's third law. The end of the chapter treats the parallelogram rule for combining vectors—first force vectors and then velocity vectors. It also introduces vector components. More on vectors is found in Appendix D, and especially in the *Practicing Physics* book.

Chapter 6, "Momentum," is a logical extension of Newton's third law. One reason I prefer teaching it before energy is that students find mv much simpler and easier to grasp than $\frac{1}{2}mv^2$. Another reason for treating

momentum first is that the vectors of the previous chapter are employed with momentum but not with energy.

Chapter 7, "Energy," is a longer chapter, rich with everyday examples and current energy concerns. Energy is central to mechanics, so this chapter has the greatest number of exercises (70) in the chapter-end material. Work, energy, and power also get generous coverage in the *Practicing Physics* book.

After Chapters 8 and 9 (on rotational mechanics and gravity), mechanics culminates with Chapter 10 (on projectile motion and satellite motion). Students are fascinated to learn that any projectile moving fast enough can become an Earth satellite. Moving faster, it can become a satellite of the Sun. Projectile motion and satellite motion belong together.

Part Two, "Properties of Matter," begins with a new chapter on atoms, with much of the historical treatment of the previous edition moved forward to Chapter 32 in an expanded treatment of atoms and quanta.

Parts Three through Eight continue, like earlier parts, with enriched examples of current technology. The chapter with the fewest changes is Chapter 36, "General Theory of Relativity," which now acknowledges the recent finding that the universe is flat.

This edition retains the boxes with short essays on such topics as energy and technology, railroad train wheels, magnetic strips on credit cards, and magnetically levitated trains. Also featured are boxes on pseudoscience, crystal power, the placebo effect, water dowsing, magnetic therapy, electromagnetic waves surrounding power lines, and the phobia about food irradiation and anything nuclear. To the person who works in the arena of science, who knows about the care, checking, and cross-checking that go into understanding something, these fads and misconceptions are laughable. But to those who don't work in the science arena, including even your best students, pseudoscience can seem compelling when purveyors clothe their wares in the language of science while skillfully sidestepping the tenets of science. It is my hope that these boxes may help to stem this rising tide.

A new feature of this edition is "One-Step Calculations," sets of simple "plug-and-chug" problems requiring only single-step solutions. They appear in more equation-oriented chapters. Students become familiar with the equations by substitution of given numerical values. More math-physics challenges are found in the problem sets. These are preceded by qualitative exercises, expanded by an average of ten additional new ones per chapter throughout the book.

New to this edition are the insightful boxes in many of the margins. Every page of every introductory textbook ought to have information that perks up the brain. The Insight boxes add to that.

The most striking new feature of this edition is the student supplement *Problem Solving in Conceptual Physics,* co-authored with Phil Wolf. While problem solving is not the main thrust of a conceptual course, Phil and I nevertheless love solving problems. In a novel and student-friendly way, our supplement features problems that are more physics than math, nicely extending *Conceptual Physics*—even to courses oriented to problem solving. We think that many professors will enjoy the options offered by this student supplement to the textbook. Problem solutions are posted on the website in the Instructor's Resource area.

Supporting this edition is the *Instructor's Manual,* with suggested lectures, demonstrations, and answers to all chapter-end material. The *Next-Time*

Questions book has a greater number of questions, which are now in a horizontal format to make them more compatible with computer monitors and PowerPoint® displays. Although the printed book is still in black and white, the electronic version is in color. The student *Practicing Physics* book (with answers to the odd-numbered exercises and problems herein) has several new practice pages and is now available electronically. The *Laboratory Manual* has been improved. Still available is the set of *Transparencies* with an accompanying instruction guide. The *Test Bank* (both in print and in computerized format) has been revised and has many contributions by Herb Gottlieb. Perhaps most important, however, is the ambitious range of teaching and learning media developed to support this new edition.

To help with your in-class presentations, we have built a new instructor supplement called *The Conceptual Physics Lecture Launcher*. This CD-ROM provides a wealth of presentation tools to help support your fun and dynamic lectures. It includes more than 100 clips from my favorite video demonstrations, more than 130 interactive applets developed specifically to help you illustrate particularly tricky concepts, and chapter-by-chapter weekly in-class quizzes in PPT for use with Classroom Response Systems (easy-to-use wireless polling systems that allow you to pose questions in class, have each student vote, and then display and discuss results in real time). *The Conceptual Physics Lecture Launcher* also provides all the line images from the book (in high resolution) and the *Instructor's Manual* in convenient, editable Word format.

For out-of-class help for your students, a critically acclaimed website, which can be found at http://www.physicsplace.com, now provides even more study resources. The Physics Place is the most educationally advanced, most highly rated by students, and most widely used website available for students taking this course. The enhanced website now provides more of the students' favorite interactive online tutorials (covering topics that many of you requested), and a new library of Interactive Figures (key figures from each chapter in the book that are better understood through interactive experimentation owing to reasons of scale, geometry, time evolution, or multiple representation). Quizzes, flash cards, and a wealth of other chapter-specific study aids are also provided.

All of these innovative, targeted, and effective online learning media are easily integrated in your course using a new online gradebook (allowing you to "assign" the tutorials, quizzes, and other activities as out-of-class homework or projects that are automatically graded and recorded), simple icons throughout the text (highlighting for you and your students key tutorials, Interactive Figures, and other online resources), and *The Conceptual Physics Lecture Launcher* CD-ROM. A new Online Resources section at the Physics Place summarizes the media available to you and your students, chapter by chapter, week by week.

For more information on the support ancillaries, check out http://www.aw-bc.com/physics or contact your Addison Wesley representative, or contact me, Pghewitt@aol.com.

Acknowledgments

I am enormously grateful to Ken Ford for checking this edition for accuracy and for his many insightful suggestions. Many years ago, I admired Ken's own books, one of which, *Basic Physics*, first inspired me to write *Conceptual Physics*. Today I am honored that he has given so much of his time and energy to assist in making this edition my best edition ever. Errors invariably crop up after manuscript is submitted, so I take full responsibility for any errors that have survived his scrutiny.

For extensive feedback, I'm thankful to Diane Riendeau. For valued suggestions, I thank my friends Dean Baird, Howie Brand, George Curtis, Marshall Ellenstein, Mona El Tawil-Nassar, Jim Hicks, John Hubisz, Dan Johnson, Fred Myers, Kenn Sherey, Chuck Stone, Pablo Robinson, and Phil Wolf. I'm grateful for suggestions from Matthew Griffiths, Paul Hammer, Francisco Izaguirre, Les Sawyer, Dan Sulke, Richard W. Tarara, and Lawrence Weinstein. I am grateful to the resourcefulness of my Exploratorium friends and colleagues: Judith Brand, Paul Doherty, Ron Hipschman, and Modesto Tamez. For photos, I thank my brother Dave Hewitt, my son Paul Hewitt, Keith Bardin, Burl Grey, Lillian Lee Hewitt, Will Maynez, Fred Myers, Milo Patterson, Jay Pasachoff, and David Willey. For strengthening the test bank, I thank Herb Gottlieb.

I remain grateful to the authors of books that initially served as influences and references many years ago: Theodore Ashford, *From Atoms to Stars;* Albert Baez, *The New College Physics: A Spiral Approach;* John N. Cooper and Alpheus W. Smith, *Elements of Physics;* Richard P. Feynman, *The Feynman Lectures on Physics;* Kenneth Ford, *Basic Physics;* Eric Rogers, *Physics for the Inquiring Mind;* Alexander Taffel, *Physics: Its Methods and Meanings;* UNESCO, *700 Science Experiments for Everyone;* and Harvey E. White, *Descriptive College Physics*. For this and the previous edition, I'm thankful to Bob Park, whose book *Voodoo Science* motivated me to include the boxes on pseudoscience.

For the *Problem Solving in Conceptual Physics* ancillary, co-authored with Phil Wolf, we both thank Tsing Bardin, Howie Brand, George Curtis, Ken Ford, Herb Gottlieb, Jim Hicks, David Housden, Chelcie Liu, Fred Myers, Stan Schiocchio, Diane Riendeau, and David Williamson for valuable feedback.

I am particularly grateful to my wife, Lillian Lee Hewitt, for her assistance in all phases of book-and-ancillary preparation. I'm grateful to my niece Gretchen Hewitt Rojas for keyboarding help. Thanks go to my lifelong friend Ernie Brown for designing the physics logo and for chapter headers in the new problems book.

For their dedication to this edition, I am grateful to the staff at Addison Wesley in San Francisco. I am especially thankful to Liana Allday and Editor-in-Chief Adam Black. I'm grateful to Ira Kleinberg for securing the many new photographs. A note of appreciation is due Claire Masson for the cyberspace components of this and the previous edition. I thank David Vasquez, my dear friend of many years, for his insightful tutorials. And I thank the production folks at Techbooks GTS for their patience with my last-minute changes. I've been blessed with a first-rate team!

Paul G. Hewitt
St. Petersburg, Florida

Conceptual Physics

tenth edition

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