CONCEPTUAL Physical Physical SECOND EDITION

HEWITT SUCHOCKI HEWITT

CONCEPTUAL

Physical Science

SECOND EDITION



Paul G. Hewitt
City College of San Francisco

John Suchocki Leeward Community College

Leslie A. Hewitt
Westlake School



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About the cover: The image is Kilauea Volcano on the island of Hawaii, the most active volcano on Earth. Brad Lewis describes this photo:

"In March of 1992, I journeyed to Pu'u O'o Vent to experience the beginning of an eruptive episode and began photographing when the spatter cone was less than 12 hours old. Shortly after sunrise, a rainbow formed above the forest, and the elements came together. Nowhere else is there a more visual reminder that the Earth is alive and continually recreating itself."

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Conceptual Physical Science Photo Album

Conceptual Physical Science is a very personalized book, a family undertaking shown in many photographs throughout the book. Photos of Marjorie Hewitt Suchocki and James Hewitt, to whom this book is dedicated, are both found in Chapter 12. James, who died at the age of 24 in a car crash, is shown at the age of 10 in Figure 12.39, page 301. Marjorie, who is alive and well, teaching theology and philosophy in the graduate programs of the Claremont Colleges, is shown in Figure 12.3 on page 287.

Charlie Spiegel, our mentor to whom the first edition was dedicated, and who passed away in 1997, opens the book facing page 1. Great grand-daughter Sarah Stafford holding the chickie sits on Charlie's lap.

All eight part openers feature children who are friends and family. Part I, page 11, is tiny friend Andrea Wu (who shows up again on page 66); Part II on page 133 is Terrance Jones, son of niece Corine Jones; Part III on page 183 is Hayli Holmes; Part IV on page 231 is author Paul's grandson (and Leslie's and John's nephew) Alexander Hewitt; Part V, page 313, is author Paul's first grandson, Manuel Hewitt (son of James); Part VI on page 361 is John and Tracy's first son, Ian Suchocki (pronounced Su-hock'-ee, with a silent c); Part VII on page 531 is Ian's brother, Reece Suchocki. Concluding Part VIII, page 683, is W.J. Akil Marshall, son of artist and UH Hilo colleague, Mike Marshall.

Author Paul is shown with friend and high-school physics teacher Pablo Robinson, who is sandwiched between beds of nails in Figure 5.3 on page 108. Pablo is the author of the lab manuals that accompany the 7th and 8th Editions of Hewitt's physics text, Conceptual Physics. Some of those labs appear in the Conceptual Physical Science lab manual. Dear friend Marshall Ellenstein, Chicago's finest physics teacher, walks barefoot on broken glass on page 128. Paul's friend since childhood, Paul Ryan, dips his hand in molten lead in Figure 6.30 on page 154. In a much less violent activity, friend Ken Ford demonstrates noise-canceling earphones in Figure 10.23 on page 245. Close friend Tim Gardner safely demonstrates Bernoulli's Principle in Figure 5.33 on page 123, and stands among the telescopes atop Mauna Kea in Hawaii in the opening photo to Chapter 29, page 706. In the same chapter in Figure 29.21, page 722, is little Melissa, daughter of friends Dennis and Tai McNelis. Physics buddy John Hubisz stands next to a decayed building to illustrate entropy in Figure 7.26, page 178. Brother David Hewitt (no, not a twin) and his wife Barbara work the water pump shown in Figure 5.27, page 119. Niece Stephanie Hewitt, of Costa Rica, holds up a redwood tree on page 367.

Author John walks barefoot across red-hot coals in Figure 7.2, page 160 (his first fire walk— an assignment from senior author Uncle Paul!). Wife Tracy and son Ian illustrate Newton's Third Law in Figure 2.25 on page 48. Tracy and son Reece appear on page 487, and Ian and Reece appear together on page 488. Figure 10.43 on page 254 is part of the wedding party of John and Tracy, including, left to right, John's

brother-in-law Butch Orr, sister Cathy Orr, bride and groom, sister Joan Lucas, mom Marjorie Hewitt Suchocki, Tracy's parents Sharon and David Hopwood, friends Kellie Dippel and Mark Werkmeister, and Uncle Paul. John's niece Alexandra Lucas is shown on page 368, and nephew Graham Orr drinks water on page 372.

Author Leslie, at her dad's insistence, appears in three figures. The first is Leslie at the age of 16 in Figure 13.1, page 315 (the black and white photo that has been in the last six editions of Conceptual Physics). The second is more recent, Figure 25.4 on page 621, and the third is with her dad in Figure 22.40 on page 556. Leslie's mom fearlessly holds her hand above expanding steam in Figure 7.7, page 162, and on the same page in Figure 7.6, Leslie's brother Paul demonstrates adiabatic expansion. Paul again demonstrates adiabatic compresssion by pumping air in his tire on page 170. Paul's wife, Ludmila, looks through Polaroid filters in Figure 11.43 on page 281, and is shown with son Alexander in Figure 11.18 on page 268. Alexander's dog Hanz is shown in Figure 6.20, page 147. Last but certainly not least of Leslie's entourage is her husband, Bob Abrams, who helped considerably with Part VII, shown in Figure 22.9 on page 538, and Figure 24.29 on page 606. Leslie's and Bob's first child is shown before birth in the sonogram in Figure 10.14 on page 240.

Author Paul's dear friends include former teaching assistants at CCSF. The first to appear in the book is Tenny Lim, seen pulling back her arrow in Figure 3.13 on page 62. Tenny went on from CCSF to a degree in mechanical engineering and is presently a design engineer at JPL in Pasadena. A more recent photo of Tenny, with yet another "arrow," a probe that will be injected into Comet Tempel 1 to analyze its nucleus, is shown on page 703. The second teaching assistant shown, in Figure 7.16 on page 166, is Helen Yan, now a physics instructor at CCSF, who did the hand lettering for the part openers. Helen poses again with the same black-hole box she posed with more than fifteen year ago for the black and white photo that appeared in three editions of Conceptual Physics. The third shown in the book, Figure 10.10 on page 237, is Lillian Lee, who was Paul's TA back in 1978-79. Twenty years later she remains a close friend and assisted in the production of the ancillaries to this edition. More recent CCSF teaching assistants are shown in the air track photo of Figure 3.10 on page 59. They are, left to right, Alex Diaz and Glenda Gin. In the same photo are colleagues Annette Rappleyea, who assisted with test bank materials, and Will Maynez, who designed and built the air track. His assistants are to his right; Ray Choi and Kumiko Furukawa.

Many of the photographs in this book were taken by artist Meidor Hu, who stands electrified in Figure 8.10, page 191. Meidor is shown again in Figure 10.22 on page 245. Of the several photos Meidor took are one of her brother Tin Hoy in Figure 9.9, page 215, her sister Mei Tuck with friend Gabe Vitelli on page 174, her Uncle Chiu Man Wu in Figure 6.19, page 146, and Meidor's bunny in Figure 11.11 on page 264.

The inclusion of these people who are so dear to the authors makes *Conceptual Physical Science* all the more our labor of love.

To the Students

Physical Science is about the rules of the physical world-physics, chemistry, geology, and astronomy. Just as you can't enjoy a ball game, computer game, or party game until you know its rules, so it is with nature. Nature's rules are beautifully elegant and can be neatly described mathematically. That's why many physical sciences texts are treated as applied mathematics. But too much emphasis on computation misses something essential—comprehension—a gut feeling for the concepts. This book is conceptual, focusing on concepts in down—to—earth English rather than in mathematical language. You'll see the mathematical structure in frequent equations, but you'll find them guides to thinking rather than recipes for computation.

We enjoy physical science, and you will too--because you'll understand it. Just as a person who knows the rules of botany best

appreciates plants, and a person who knows the intricacies of music best appreciates music, you'll better appreciate the physical world about you when you learn its rules.

Enjoy your physical science!



Fau G. H= Witt

John Suchah:

Leslie a. Heurtt

To the Instructor

Conceptual Physical Science, Second Edition, with its important ancillaries, provides a first introduction to physics, chemistry, earth science, and astronomy, melded in a manner to captivate student interest. It builds a conceptual base in physics and chemistry, which is then applied to earth science and astronomy. For the nonscience student, it is a base from which to view nature more perceptively—to see that surprisingly few relationships make up its rules. For the science student, it is this and a springboard to involvement in other sciences such as biology and health related fields.

As in the first edition, the book begins with physics—the most basic of the sciences because it reaches up to chemistry, which in turn reaches to the earth sciences, and ultimately up to the life sciences. Physics is about the laws of motion, energy, electricity, heat, sound, and light. The three chapters on heat in the first edition have been tightened to make two chapters in this edition. Likewise with the three previous chapters on the atom and radioactivity, which now make up two chapters. Like the first edition, the physics is treated conceptually, meaning that its focus is on qualitative comprehension more than on mathematical expression. Physics in this text is not treated as applied mathematics. We minimize mathematical language and mathematical problems that are road-blocks to many students. Although a flip through the pages will show that the equations are there, they are presented as guides to thinking rather than recipes for algebraic manipulation. Their derivations are addressed in the footnotes. The treatment of physics concludes with the realm of the atom—a bridge to chemistry.

The chemistry chapters in this edition have been completely reworked, with new art by the chemistry co-author. The historical flavor of the first edition has been toned down in favor of chemistry concepts as they relate to the chemist's submicroscopic perspective. Two new chapters have been added, the first an expanded discussion of chemical bonding as it relates to the periodic table, and the second an expanded discussion of acid/base and redox reactions. Expansion of the organic chapter includes discussions of natural and synthetic polymers. As with the first edition, emphasis is on visual models. Because most physical science students have neither the time nor resources to adequately delve into a quantum mechanical approach to chemistry, electron configurations are treated via the easy-to-visualize shell model and chemical bonding is treated in terms of overlapping atomic shells and Coulomb's law. Throughout Part 6, chemistry is related to the student's familiar world—the fluorine in their toothpaste, the Teflon on their frying pans, and how washing soda serves to soften water—with many environmental aspects of chemistry addressed.

Like the first edition, Earth Science encompasses the science of geology and the science of meteorology. Geology, the study of planet Earth, includes the formation of rocks and minerals, the study of the internal dynamics that have and continue to influence Earth's surface, and the study of water that nourishes it. New sections on the oceans have been added to the chapter on surface properties, and two new chapters are added—one that integrates oceans and the atmosphere, and a new chapter on weather. Like the rest of the book, the treatment is conceptual, focusing on the central concepts

of geology with emphasis on processes. The treatment is quite visual, as the many figures attest. The theme of the Earth Science chapters is that change is an ongoing process, where the present is the key to the past.

The applications of physics, chemistry, and geology applied to other massive bodies in the universe culminate with astronomy. Astronomy is about "out there," where space and time differ from the students' everyday notions. As in the previous edition, both special and general relativity make up most of concluding Chapter 30. So our tour of physical science begins with the physics of atoms, then proceeds to the chemistry of molecules, then to the geology of aggregates of molecules, and finally to the aggregates of matter in the cosmos—astronomy.

This second edition has a greater number of exercises and problems at the end of each chapters. Another new feature throughout the book is the "Link-To" Boxes, that show the connections of subject matter to real world applications and phenomena.

Pedagogy

At the end of each chapter are Review Questions, Exercises, and in many chapters, Home Projects and Problems. All of the important ideas from each chapter are framed in the relatively easy-to-answer Review Questions, grouped by chapter sections. They are, as the name implies, a review of chapter material. Their purpose is simply to provide a structured way to review the chapter. They are not meant to challenge the student's intellect, for in the vast majority of cases, the answers can be simply looked up. The Exercises, on the other hand, play a different role. Some of these are designed to prompt the application of physical science to everyday situations, while others are more sophisticated and call for considerable critical thinking.

The Problems are mainly simple computations that aid in learning concepts. There are fewer Problems than Exercises to decrease the likelihood of students focusing on number crunching rather than conceptual reasoning. Exercises call for critical thinking. Although building confidence in math is a worthy goal, it is not what this book is about.

Students can find the answers to the odd-numbered Exercises and Problems in the back part of the *Conceptual Physical Science Practice Book*. Complete answers to all Exercises and Problems are in the Instructor's Manual.

Units of measurement are not emphasized in this text. When used, they are almost exclusively expressed in SI (exceptions include such units as calories, grams per centimeter cubed, and light years). Mathematical derivations are avoided in the main body of the text and appear in footnotes or in the appendixes.

Linking physical science to real world applications and phenomena is now enhanced with a new feature in this second edition—the "Link-to" boxes. Most every chapter has one or more of these boxes.

Ancillary Materials

More than enough material is included for a one-year course, which allows for a variety of course designs to fit your taste. These are suggested in the **Instructor's Manual** (0-321-03536-4), which you'll find to be different from most instructor's manuals. It contains many lecture ideas and topics not treated in the textbook, as well as teaching tips and suggested step-by-step lectures and demonstrations. It has full-page answers to all Exercises and Problems in the text.

Answers to the odd-numbered Exercises and Problems are available to students in the student supplement, Conceptual Physical Science Practice Book (0-321-03531-

3). This very important and greatly expanded book, our most creative work, guides your students to a sometimes computational way of developing concepts. It spans a wide use of analogies and intriguing situations, all with a "user friendly" tone.

The **Next-Time Questions** book (0-321-03539-9) has 143 insightful full-page questions with Hewitt cartoons, with answers on the back of each page. Use these as overhead transparencies, or for posting. There are Next-Time Questions for every chapter.

The expanded **Test Bank** book (0-321-03535-6) has more than 2400 multiple choice questions as well as short answer and essay questions. The questions are categorized according to level of difficulty. The **TestGen-EQ Computerized Testing Software** (Win: 0-321-03533-X; Mac: 0-321-03534-8) contains everything in the Test Bank and allows you to edit and change the order of the questions, add new questions, and print different versions of a test. Available for PC or Macintosh.

The Conceptual Physical Science Laboratory Manual (0-321-03531-3) is written by the authors. In addition to interesting laboratory experiments, it includes a range of activities similar to the home projects in the textbook. These guide students to experience phenomena before they quantify the same phenomena in a follow-up laboratory experiment. Answers to questions in the lab manual are in the Instructor's Manual.

Transparency Acetates (0-3212-03532-1) features more than 100 important figures from the text, which are available to qualified adopters from your Addison Wesley Longman representative.

Last, but not least, is a **video** on home projects in physics and chemistry (0-321-05194-7). Consult your Addison Wesley Longman representative about other videos, including the 34-video set of Hewitt's *Conceptual Physics Alive!*

Go to it! Your conceptual physical science course really can be the most interesting, informative, and worthwhile science course available to your students.

Acknowledgments

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Enormous thanks to very talented Irene Nunes for her first-rate edits in greatly improving our manuscripts, which are now much more readable. And last but not least, we thank Addison-Wesley Science Editor Sami Iwata and her staff for their professional care.

Paul G. Hewitt John Suchocki Leslie Hewitt Wow, Great Grandpa Charlie! Before this chickie exhausted its inner space resources and poked out of its shell, it must have thought it was at its last moments. But what seemed like its end was a new beginning. Are we like chickies, ready to poke through to a new environment and new beginning—like humanizing outer space maybe?



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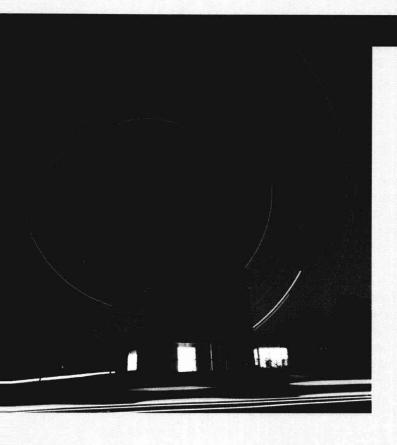
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About Science

Much of science is organized common sense about the physical world. Science as a body of knowledge about nature is the result of the collective efforts, experimental findings, insights, and wisdom of the human race. Above all, science is the process of discovering and explaining the order of nature and how its parts connect to one another. The earliest preludes to science predate recorded history, when people first discovered regularities and relationships in nature, such as star patterns in the night sky and weather patterns. From these regularities and relationships, people learned to make predictions that gave them some control over their surroundings.

Rational thinking, the premise of science, gained headway in Greece in the third and fourth centuries B.C. and spread throughout the Mediterranean world. Advancement toward scientific methods came to a halt in Europe when the Roman Empire fell in the fifth century A.D. Barbarian hordes destroyed much in their path as they overran Europe and ushered in the Dark Ages. During this time the Chinese and Polynesians continued charting the stars