

The background of the book cover features a dark, textured landscape on the left side, possibly representing a celestial body or a rugged terrain. Overlaid on this is a complex network of thin, blue, dashed lines that form concentric circles and intersecting paths, resembling orbital mechanics or a celestial map. The overall color palette is dominated by dark blues, blacks, and oranges.

# CONCEPTUAL Physics

SIXTH EDITION


PAUL G. HEWITT

# CONCEPTUAL **Physics** SIXTH EDITION

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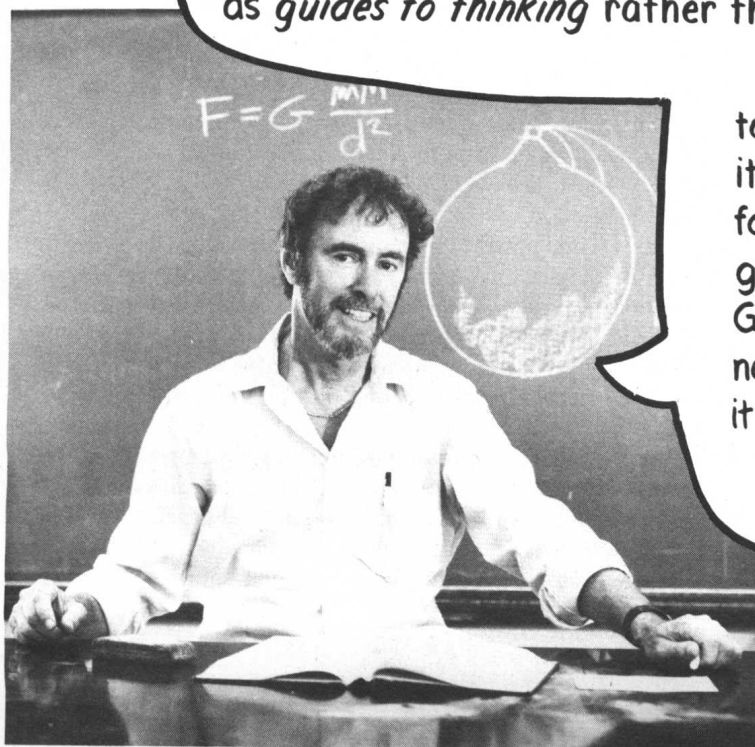
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# To the Student

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 about the rules of nature—so beautifully elegant that it can be neatly described mathematically. That's why many physics courses are treated as applied mathematics. But introductory physics that emphasizes computation misses something essential—*comprehension*—a gut feeling for the concepts. This book emphasizes comprehension rather than computation. We treat physics *conceptually*—in down-to-earth *English* rather than in mathematical language. You'll see the mathematical structure of physics in frequent equations, but you'll see the equations as *guides to thinking* rather than as recipes for computation.



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 get into 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

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Because physics is the basic science—the foundation of chemistry, biology, and all disciplines of science—it should be part of the educational mainstream for both science and nonscience students. Unfortunately, its mathematical language deters the average nonscience student. But when the ideas of physics are presented conceptually and when equations are seen to be guides to thinking rather than recipes for algebraic manipulation, our discipline is accessible to all students. And for students who will continue in the study of physics, I am convinced that the ideas of physics should be first understood conceptually before being used as a base for applied mathematics.

This book seeks to build that conceptual base. 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 as well as being a springboard to a greater involvement in physics. A first-semester overview of Newtonian and modern physics for science majors will help to correct a missing essential in physics education: the practice of conceptualizing before calculating. For nonscience and science students alike, a conceptual way of looking at physics shapes analytical thinking.

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## New to This Edition

Although the sequence from classical mechanics to modern physics and the overall organization of this edition are much the same as in previous editions, this edition has been almost completely rewritten. The chapter on astrophysics has been omitted to make room for three new chapters, on nonlinear motion, satellite motion, and the properties of light. Part I begins with linear motion in Chapter 2 and is followed with nonlinear motion in the new Chapter 3. In this new chapter, projectile motion extends to satellite motion, but unlike the previous edition, a thorough treatment of satellite motion is deferred to its own Chapter 9, which follows the chapter on gravity. Since spacefaring activities are of general interest and already capture the imagination of our students, the brief introduction of satellite motion in Chapter 3 can build an early interest in physics. Vectors, which were relegated to an appendix in previous editions, are introduced in Chapter 3. Only simple cases of velocity vectors are treated in this early chapter, and a more general treatment is in Appendix III. As with the fifth edition, the chapter on momentum logically follows the chapter on Newton's laws, so there is no gap between Newton's third law and momentum conservation. Appendix IV of the fifth edition, "The Universal Gravitational Constant,  $G$ ," is now incorporated in Chapter 8, on gravity. There are no major changes in the order of topics in Parts 2, 3, and 4. In Part 5 minor reordering of topics occurs in the chapters on magnetism and electromagnetic induction. Part 6 now begins with a new chapter on the properties of light. The chapter on color now precedes the chapter on reflection and refraction. Part 6 ends with an introduction to quantum physics, which carries into the first chapter in Part 7. Part 8 is confined to special and general relativity, with no chapter on astrophysics. I feel that this edition is a smoother and more readable treatment than the previous edition, with many new insights sprinkled throughout that I hope your students will enjoy.

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## Pedagogy

An important change concerns the review questions at the end of each chapter. All important ideas are framed in relatively easy-to-answer review questions and are cited 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. These have been streamlined, with new ones added. Some are moderately simple and are designed to prompt the application of physics to everyday situations, while others are more sophisticated and call for considerable critical thinking. Some are quantitative and involve simple, straightforward calculations that will help your students capture the idea being treated without requiring algebraic skills. The challenge to your students will be in the conceptual reasoning and critical thinking that are called for in the exercises.

As in previous editions, units of measurement are not emphasized. 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.

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## Ancillary Materials

More than enough material is included for a one-semester course, which allows for a variety of course designs to fit your taste. These are suggested in the *Instructor's Manual*, 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.

Be sure to get the ancillary packet, which includes, among other important items, transparency masters titled "Next-Time Questions." These are like the "Figuring Physics" cartooned questions and answers that appear each month in *The Physics Teacher*. New to this edition are "Conceptual Physics Illustrations," which can help make your chalkboard presentations more interesting. The "Test Bank" booklet has been expanded and is also available on upgraded computer disks not only for Apple II and IBM PCs, but for the Macintosh as well.

Last but not least, there is finally a lab manual for *Conceptual Physics*, written by Paul Robinson. In addition to interesting laboratory experiments, it includes a range of activities similar to the home projects in *Conceptual Physics*. These guide students to experience phenomena before they quantify the same phenomena in a follow-up laboratory experiment.

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

# Acknowledgments

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*San Francisco*

*Paul G. Hewitt*



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