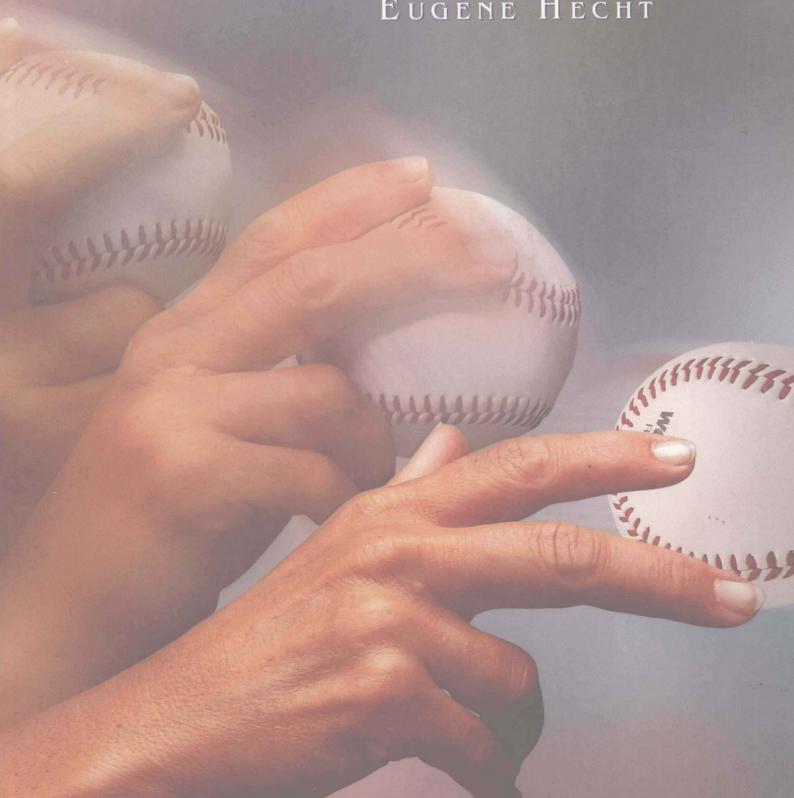
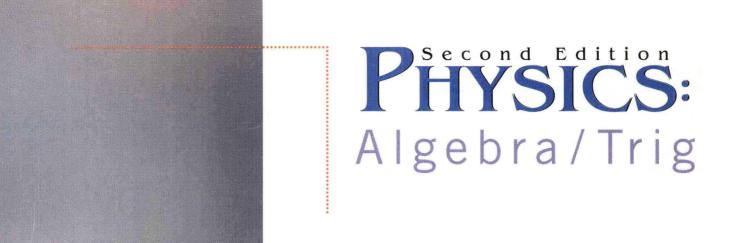
# PHYSICS: ALGEBRA/TRIG

EUGENE HECHT





## EUGENE HECHT

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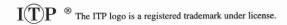




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## PREFACE

Physics is the study of the material Universe—all there is. And that's a bold and wonderful agenda. The Universe is incredibly awesome and tantalizingly mysterious, and we, after all, are just beginning to understand it. Almost 3000 years in the making, physics—incomplete as it is—stands as one of the great creations of the human intellect. It's been a privilege and an unending joy to have spent much of my life studying physics, and it is out of my gratitude to and admiration of physics that this book takes its form. If this work, while insightfully teaching basic physics, transmits a sense of the grandeur, unity, and vitality of the subject, it will have met my primary objectives.

#### The Basis of This Revision

The first edition of *Physics: Algebra/Trig* appeared in 1994 and was quite successful. Once it was certain that a second edition was inevitable, attention was turned to evaluating and further enhancing the teaching effectiveness of the book. To that end, we began to communicate with hundreds of its users—both faculty and students. What we wanted was the detailed impressions of those people struggling (standing and sitting) in the classroom.

During the next several years it became clear that the first edition had both assets and shortcomings. The illustrations, which were conceived and created by the author, were widely appreciated for their unique ability to support the physics. The writing style, humor, and candor were invariably praised. The clarity, rigor, and correctness of the exposition, as well as the error-free presentation, were seen as tremendously important and all too rare. The problem sets got high grades, particularly because of the inclusion of "real-life" data and situations. The Quick Checks and Selected Solutions in the back of the book were especially well received by students. The Multiple Choice Questions were a big help to those taking exams in that format (e.g., the MCAT). The vast majority of respondents agreed that the history of ideas made the physics far more approachable and the book more enjoyable. And, up to a point, the integration of modern physics throughout the text was seen as a necessary and appropriate advance.

On the other hand, the book was *too* thorough. The math level was just right, but too many side issues were considered. Because conceptual and motivational materials were integrated into the body of the discussion, students sometimes had difficulty discerning what was important. There were too many long derivations that few instructors had the time to utilize. Putting conservation of momentum before F = ma, although more in keeping with the modern perspective, was widely felt to be pedagogically less effective. Similarly, treating angular momentum immediately after linear momentum postponed the discussion of energy, and teachers preferred the more traditional sequence. The majority of instructors would have been happier with less Statics (formerly Chapter 6) and even less material on Solids (formerly Chapter 10). The problem sets were deliberately organized without overt reference to specific sections. That made the selection of homework problems by instructors a bit of a nuisance, and the doing of the problems by the students more challenging. And finally, apparently no one liked problems requiring gratuitous unit conversions (even if students need the practice).

The basic agenda for the revision was clear: the first half of the book would have to be reorganized and the entire text completely reworked line-by-line, making it tighter, less thorough, faster to the point, and more easily negotiable. Every criticism would be addressed, every shortcoming corrected.

#### Philosophy and Goals

Designed for a one-year algebra/trig-based course, this text assumes little more than a rudimentary knowledge of algebra and just the basics of geometry. Special attention is paid to developing mathematical ideas that might be new to the student—graphs, vectors, logarithms, basic trigonometry, and so forth—carefully and slowly. The central glory of twentieth-century physics is the discovery of an overarching unity in Nature; everything physical is presumably understandable within this context. To treat the subject as if it were an encyclopedic collection of unrelated ideas is to miss the point of the twentieth century. From the beginning of this text to its end, we will study the unity of natural phenomena, the various manifestations of matter interacting with matter via the fundamental Four Forces. We have learned a great deal during this century (just think of the strides in atomic theory) and that knowledge should inform everything taught, including Classical Physics.

#### **Practical Emphasis**

A driving force shaping this text is the belief that students are motivated to learn about what directly affects their lives and concerns. The perspective of the book is therefore largely practical: How do we walk? How does a speedometer work? How does an airplane really fly? Throughout the text there are photographs of commonplace phenomena that usually go unnoticed (for example, standing-wave patterns in a teacup). The work is rich in life-science applications although it strives to be broadly interdisciplinary, drawing from and reflecting back upon biology, geology, astronomy, architecture, medicine, and meteorology. A new feature called Exploring Physics on Your Own consists of easy-to-do home experiments that can be performed without any special equipment (e.g., adiabatic cooling using a rubber band). These allow students to personally experience how the physical concepts under study relate to everyday phenomena.

#### **Problem Solving**

Every physicist who has ever taught this course has heard the universal student lament, "I understand everything; I just can't do the problems." Nonetheless, most instructors believe that the "doing" of problems is the culmination of the entire experience. This edition (along with its CD) goes considerably further than any other text has ever gone in systematically addressing this challenge. Every worked Example now follows the same five-step approach (discussed in detail on page 18). For example, the first step is the Translation in which the problem is restated in generic scientific prose. This forces students to read the problem carefully and organize their thoughts before jumping in. It strips off the extraneous and trains students to extract the essential aspects of the problems. Happily, it overcomes the "same-problem syndrome" in which the "identical" question, written once in terms of running chickens, and then again in terms of speeding locomotives, is perceived as two totally different questions. All such variations have the same translation. The five-step approach carries students from one necessary phase of the analysis to the next, providing the organizational framework that so many students desperately need. Classroom testing during the last five years has proven the efficacy of the technique and students have been consistently enthusiastic.

To encourage students to draw diagrams and, indeed, to teach them how to do it, the text now contains hundreds of pieces of "sticker art." These illustrate how to transform a verbal statement into a simple visual one. Again, the process helps to distill out the essential elements of the problem and has proven to be highly useful.

The back-of-the-chapter problem sets now contain special groupings, each consisting of three very similar problems, which are set off in color. The first in each such group has

ix

an elaborate hint and, if that's not enough, there's a solution in the back of the book. Once that lead problem is mastered, the next two in the group should be manageable by even the weakest student. This is yet another mechanism to help build expertise and confidence. More than 500 new problems have been added, most of which are of the straightforward variety. As in the previous edition, a representative selection of problems (those bearing a boldfaced number) have tight, but complete, solutions in the back of the book—another self-study aid.

Each chapter ends with a section called Core Material & Study Guide. This is an indepth summary of what's important if one is to be able to do the problems: it outlines what should be studied and reread, which Examples should be mastered, and so forth.

#### The CD

Every text has limited resources; there are just so many pages. Discussions must be cut short and topics have to be excluded. Although it would be wonderful if the book could take all students by the hand and walk them through the analysis of two or three hundred additional problems—exploring the logic and pointing out the pitfalls in each—that's simply not possible in the traditional textbook format. Ergo, the CD.

The second edition comes with a free CD that complements and extends the book. If you'd like to see an in-depth discussion of the gyroscope, or read a complete derivation of the Thin Lens Equation, or learn how a refrigerator works, or view a proof showing that the magnitude of the velocity vector is indeed the speed, it (and a great deal more) is there, fully illustrated, on the CD.

Even more importantly, the CD continues the problem-solving program with hundreds of completely worked out Walk-Through Examples. Each chapter-set begins with a selection of spoken solutions in which a voice guides students through every step, explaining the logic as the math unfolds on the screen. Students are first taught how to "read" a problem, how to draw an appropriate diagram, and how to analyze that problem. The problems and solutions in a given chapter keep coming, but students are gradually weaned off the support system as successive solutions become less elaborate.

All references to the CD in the text are marked with a icon, alerting students to the availability of more extensive coverage.

#### A Complete Ancillary Package

Accompanying the text is a complete ancillary package including the following instructional aids:

Instructor's Solutions Manual, which includes answers to all discussion questions, answers to all multiple choice questions and complete solutions to all exercises in the text.

Student Solutions Manual for Selected Problems, which includes answers to selected odd-numbered problems (approximately 10%) not already solved in the book.

*Transparencies*, including approximately 100 full-color transparencies that illustrate key concepts.

*Test Bank*, which includes more than 1000 multiple-choice and short-answer questions. *Computerized Testing*. A computerized version of the printed test items is available for DOS, Windows, and Macintosh platforms.

CNN Physics Today. This 50 minute video contains numerous segments highlighting everyday physics - from spiderwebs to Cirque du Soleil. Available to adoptors of the text.

Physics Instructor's Resource CD-ROM. This tool for instructors includes 200 illustrations from the text, the Interactive Physics Textbook Edition Version 4.0 from Knowledge Revolution, and 50 interactive Physics simulations. Available to adoptors of the text.

#### **Acknowledgments**

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The book was produced by HRS Electronic Text Management, which did a superb job of putting it all together despite having to deal with an uncompromising, relentless author. Lorraine Burke watched over every aspect of the process with remarkable skill, attention to detail, and unflagging good humor; Ed Burke's design was strong, innovative, and beautiful, his high standards and unerring artistic judgment were an inspiration; Karen Mahakian is the quintessential compositor; Pat Hannagan patiently produced incomparable art, and Erica Smythe skillfully managed the photographs. It was a joy to work with such gifted, creative people and they all have my deepest appreciation.

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If you have any comments about this edition, suggestions for the next edition, or favorite problems you'd like to share, send them to E. Hecht, Adelphi University, Physics Department, Garden City, N.Y. 11530 (or GeneHecht@aol.com).

Eugene Hecht

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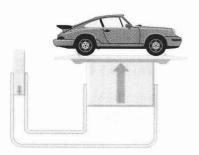
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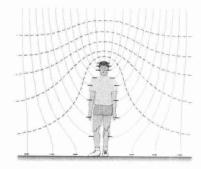
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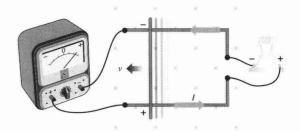
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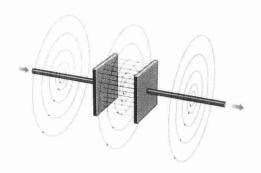
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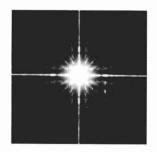
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