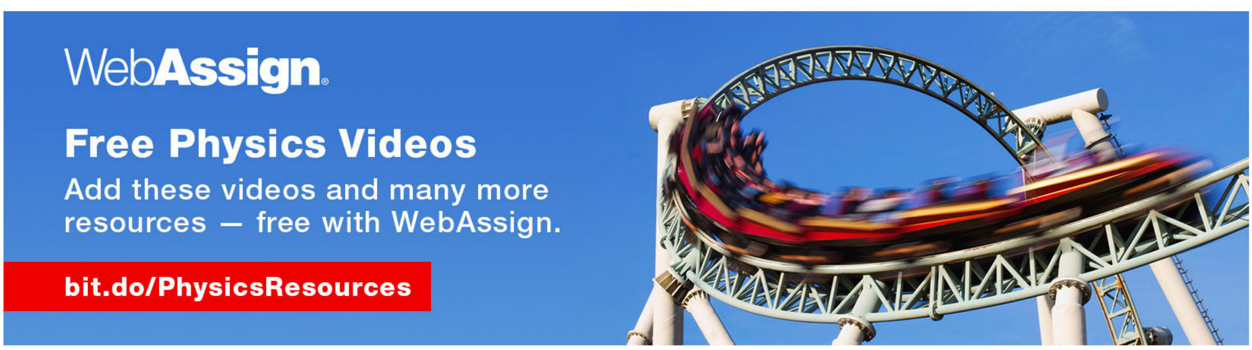
AMERICAN JOURNAL of PHYSICS

PostUse Review. Physics for Scientists and Engineers, Extended Version

Paul M. Fishbane, Stephen Gasiorowicz, Stephen T. Thornton, Steven E. Jones, Lawrence B. Rees, and William E. Dibble

Citation: American Journal of Physics **63**, 188 (1995); doi: 10.1119/1.17984
View online: http://dx.doi.org/10.1119/1.17984
View Table of Contents: http://scitation.aip.org/content/aapt/journal/ajp/63/2?ver=pdfcov
Published by the American Association of Physics Teachers



BOOK REVIEWS

Ralph Baierlein, *Editor*
Department of Physics, Wesleyan University, Middletown, Connecticut 06457

Post-Use Review. Physics for Scientists and Engineers, Extended Version. Paul M. Fishbane, Stephen Gasiorowicz, and Stephen T. Thornton. 1440 pp. Prentice-Hall, Englewood Cliffs, New Jersey, 1993. Price: $57.00 ISBN 0-13-663238-6. (Reviewed by Steven E. Jones, Lawrence B. Rees, and William E. Dibble.)

Choosing a text for introductory physics courses is akin to choosing a toothbrush: Each option is designed to do the same thing, and they are all basically functional. Differences tend to lie in relatively minor particulars. After reviewing specific strengths and weaknesses of *Physics*, we will address some areas where textbooks in general might be changed to better address common student misconceptions.

This textbook incorporates a number of features which help the students. The text provides an exceptionally clear use of mathematical tools as these are progressively needed, such as vector algebra in chapter 1 and calculus concepts in chapter 3. Presentations of examples and problem-solving techniques are well done. The use of red-line strike-outs of units in numerical solutions is novel and effective. Indeed, overall, the use of color in the text is done in a consistent and pedagogically helpful manner, not merely to "colorize" the text.

We acknowledge the effective descriptions of historical background in the discussion of physics concepts. At the same time, the orientation toward modern applications of physics increases student interest, and special sections on topics in modern physics are well written. An example is the discussion of barrier tunneling in quantum physics provided in chapter 7, where the point is made that most fusion reactions in stars occur via Coulomb barrier penetration. Unfortunately, when stellar fusion is again discussed in chapter 45, barrier penetration is not referred to, but instead we read the common misconception: "The internal temperature of stars is high enough to give some colliding nuclei sufficient energy to *overcome the Coulomb repulsion* involved in [fusion reactions]."

The discussion of geometrical optics in chapter 37 is particularly complete, including treatment of virtual objects. Another feature that attracts us to this textbook is its use of the unit vector $\hat{\mathbf{r}}$, which is introduced in chapter 3. However, many students had difficulty with this concept, and the discussion needs to be amplified. Also, when central forces are defined and discussed in chapter 10, the text reverts to $(\mathbf{r}/r)$ rather than using $\hat{\mathbf{r}}$; yet here the usefulness of the $\hat{\mathbf{r}}$ notation may become particularly clear to the student.

The homework problems are well done, and the indication of difficulty (I, II, or III) was generally accurate and helpful in organizing assignments. The solutions manual provided enough details to be understood by students. Our experience with the Learning Guide was that it was of most use to students who understood most of the material already but needed some help in doing the more difficult problems. The Interactive Physics Player allows students to vary parameters for many examples discussed in the text and to observe on a computer display the effects—a pedagogically useful technique. The color transparency set is well done, although a number of useful figures from the text were not included.

Several sections were confusing to the students. Chapter 15 introduces a definition of beats different from that in any other text we have used at any level. There seems also to be inconsistency in the terminology in the text and solutions manual. Likewise, the discussion of phase relationship is complicated by the switching of usual conventions of sine and cosine; the discussion in chapter 34 on phases in AC circuits is particularly confusing to students. If the authors insist on using unusual terminology, they should be consistent in the text as well as problem sets and the solutions manual. Hopefully, such problems are just a reflection of the newness of the text and will be corrected in future editions.

Chapter 7 includes a discussion of how conservation of energy can be "derived" from Newton's laws of motion. But a general equation for conservation of total energy for an isolated system is wanting. Similarly, chapter 8 provides a useful derivation of conservation of momentum from Newton's Third Law.

Unfortunately, a discussion of the primacy and utility of conservation laws in general in the modern view of physics is not sufficiently advanced in the text.

And here we mount our soapbox. In most physicists' minds, the conservation laws are more fundamental than Newton's laws. Yet the introductory textbooks generally follow the pattern of introducing Newton's laws first and foremost. Beginning students end up with a picture of the primacy of force, mass, velocity, and acceleration, rather than of energy, momentum, angular momentum, and their universal conservation.

Moreover, introductory texts do little to acknowledge and confront the "naive" mechanics which research has shown that most of us develop early in life: "Chief among the major misconceptions we place the *impetus concept of motion* and the dominance principle or the *conflict concept of interaction.* These are the most difficult and usually the last of the misconceptions to be overcome. Unless dealt with effectively, they may persist in the minds of students for a long time." [1]

Consider the case of a small car pushing a large (disabled) truck and speeding up: Is the magnitude of the force exerted by the car pushing against the truck greater than that of the truck pushing against the car? Beginning students commonly think so, evidently a reflection of the notion that the car is "winning" and obviously pushing harder.[1] Newton's Third Law is difficult for many to understand correctly and to accept.

Our own teaching experience also shows that students generally believe that moving objects posses a kind of "go power" that keeps them moving. This "impetus concept of motion" is evidently based on everyday experience, a commonsense mechanics which seems to develop naturally in our friction-dominant world.[1] The notion of conservation of momentum, or alternatively of Newton's First Law, is quite foreign to most beginning students, and it helps to confront the misconception head on. "Centrifugal force" provides another example of a commonly entrenched but misleading notion.

The introductory textbook is arguably the place to include a discussion of commonplace misconceptions as the correct concepts are being taught. And why not teach conservation laws of momentum, energy and angular momentum as fundamental, and Newton's "laws" as limited but very useful relations?

The authors teach physics at Brigham Young University in Provo, Utah, and have interests in statistical, environmental, and nuclear physics. At present, they plan to continue using the Fishbane et al. text for undergraduate courses in Newtonian mechanics, electricity and magnetism, and modern physics.

[1]David Hestenes, Malcolm Wells, and Gregg Swackhamer, "Force concept inventory," Phys. Teach. **30**, 141–158 (March 1992).

Einstein Lived Here. Abraham Pais. 282 pp. Oxford U.P., New York, 1994. Price: $25.00 ISBN 0-19-853994-0. (Reviewed by A. P. French.)

Abraham Pais has put all physicists and physics teachers in his debt with a trio of splendid books: *Subtle is the Lord*, his biography of Einstein; *Niels Bohr's Times*, a kind of companion volume to it; and *Inward Bound*, his masterly history of atomic nuclear, and particle physics from the discovery of x-rays in 1895 to the discovery of the W and Z particles in 1983. Each of them is imbued with the author's love of physics and his mastery of its subject matter, together with a scholarly thoroughness that makes one feel (probably correctly) that he has tracked down, digested, and referenced every piece of documentation that bears on the subject at hand. Each one of these books is a fascinating blend, although in differing proportions, of narrative, biography, and straight physics.

The most austere (in the sense of being least personal) of the three books is the first of them—the Einstein biography. The new book, *Einstein Lived Here*—its title taken from the famous Herblock cartoon published a few days after Einstein's death (and reproduced in the book's frontispiece)—is designed to compensate for this and is concerned primarily with Einstein the man. It is addressed, also, to a more general public; its physics content is slight. It is Pais's thesis that (to quote his own words): "Einstein, creator of some of the best science of all time, is himself a creation of the media in so far as he is and remains a public figure." The second half of the book consists of a single oversize chapter in which Pais supplies detailed support for this proposition. By following the press reports more or less chronologically, the book develops what is in effect a selective biography of Einstein from the early 1900s until his death—and even a little beyond. More about that later (as Pais himself might say); but first a glance at the other chapters.

The first half of the book consists of a set of ten separate essays. Five of these in their entirety were written for other purposes, and all ten address different aspects of Einstein and his world. Probably the first chapter comes closest to breaking new ground; it is basically the story of Mileva Marić, Einstein's first wife and the mother of his two sons. The story is, for the most part, a melancholy one, with two tantalizing questions: the fate of the daughter born to the couple before they were married (and whom Einstein probably never saw), and the role, if any, that Mileva played in the creation of special relativity. On the latter point, Pais concludes that there is no solid evidence that the theory was anything but Einstein's unaided work, despite suggestions to the contrary from Mileva's Serbian biographer.

Perhaps the other most interesting chapter is the one entitled "Reflections on Bohr and Einstein." As Pais points out, he is one of the few surviving people who knew both men well over a number of years; he is almost uniquely qualified to comment about them as individuals and in their relationship to one another. This relationship was of great importance to both men, and a discussion of it in a book about Einstein alone is amply justified. (There is a very similar chapter in *Niels Bohr's Times*, and those who have already read that book will recognize a number of familiar passages.) Pais paints a fascinating picture of their differences in personality and style, but he argues that their similarities outweighed their differences. His judgment is that Einstein " is the only scientist to be justly held equal to Newton." However, he considers Bohr's contributions to quantum theory to be of outstanding importance, largely on philosophical grounds (although he says that neither Einstein nor Bohr had much time for professional philosophers).

There is a brief chapter on Einstein's contacts with Louis de Broglie at the time when de Broglie first introduced the matter–wave concept, which had a role in Einstein's development of the theory of what came to be known as Bose–Einstein condensation. There is a similarly short chapter entitled "A mini-briefing on relativity, for the layman." This is a praiseworthy attempt, although I suspect that the average layman will be mystified by the bald statement that in special relativity, despite the introduction of four-dimensional space-time, "space remains flat."

Pais also retells the story (reprinted from *Subtle is the Lord*) of how Einstein got the Nobel Prize, a rare insight into the workings of the Nobel Committee. And there is Pais's affectionate memorial tribute to Einstein's devoted helper, Helen Dukas, and an account of Einstein's limited connections with Tagore and Gandhi. The latter's doctrine of non-violence was, of course, very much in keeping with Einstein's own views.

The readers for whom this book is primarily intended will probably be especially interested in the chapter about Einstein's views on religion and philosophy. Despite his numerous references to God in connection with both relativity and quantum theory, and his expressions of a cosmic religious feeling, Einstein was quite blunt in repudiating the concept of a deity who is involved with individual human affairs. As for philosophy, he denied that relativity was philosophically innovative. His chief philosophical position, so far as physics is concerned, was his unshakable belief in the existence of an objective reality independent of the observer—in which, of course, he was totally at odds with Bohr and with the current mainstream of thought regarding quantum phenomena.

One other brief chapter is a set of selections from the huge number of letters sent to Einstein by strangers; I must confess that I found this disjointed and of rather little interest.

But now, back to "Einstein and the Press." Although the record begins in 1902, with an advertisement from Einstein himself (offering his services as a tutor in mathematics and physics), the story really starts with the explosion of excitement in 1919 over the observations on the deflection of starlight by the Sun. Headlines such as "Lights All Askew in the Heavens" and "Space Caught Bending" appeared on the front pages of major newspapers, and life for Einstein afterward was never the same. From then until his death he was a