

# *Introduction to the Second Edition*

Robert Karplus wrote this innovative textbook on physics for non-science students between 1965 and 1969. The book first appeared in 1966 as a preliminary edition, and in 1969 W. A. Benjamin, Inc. published the first edition in hardback. For reasons not connected with the quality of the book, it never got to a second edition and has been out of print for many years.

As Karplus says in the Author's Preface below, ". . . this book is addressed particularly to readers with little scientific or mathematical background: the only requirements are common sense, experience, and reasoning ability." Writing an understandable physics textbook for readers with little background is a laudable goal – often announced, but seldom achieved. In fact, a large variety of magazines, popular books, and textbooks have been published for this audience since 1969. So, you ask, why republish *Introductory Physics: A Model Approach* now?

The reason is that this is a genuinely outstanding physics textbook - understandable to students and rewarding to teach. Whether you are a physics student, a teacher, a prospective teacher, or a general reader, you can benefit from the many insights and innovations that Karplus poured into *Introductory Physics*. As in all his work, you will find here an original attack on the subject at the most fundamental level expressed in clear, direct language with an extraordinary sense of the joy of discovery.

The feature of *Introductory Physics* that is most valuable to students and teachers, and which sets it off from most other physics texts, is that Karplus really does start at a beginner's level. In fact, the first four chapters (Part One, a full quarter of the book) are a carefully graduated "on ramp," a *tour de force* of physics teaching.

Karplus and his team at SCIS had worked hard and long to create, test and revise an entire curriculum (including a sequence of topics and activities exemplifying Piaget's ideas, plus an imaginative set of hands-on investigations grounded in children's experiences). Karplus took full advantage of all this; Part One of *Introductory Physics* focuses on the topics he knew to be essential: reference frames, relative motion, working and mathematical models, systems and subsystems, interaction, radiation, and energy. In his unique way, Karplus develops these ideas in Part One, drawing on many illustrations and concrete examples from SCIS plus his mastery of Piaget's theory, to build the reader's concrete and abstract reasoning skills.

In Chapters 3 and 4, Karplus' extraordinary capacity to see physics as a whole, and his skills in simplifying and synthesizing, come into play: he focuses on the concepts of interaction, fields, radiation and energy, drawing upon gravity, electricity, magnetism, heat, and many other phenomena as examples to provide an accessible, powerful, integrated and satisfying overview of the field. By the end of Chapter 4, the student has some real experience with the process of understanding the natural world and is familiar with what physics involves, how it is done, the key concepts and terminology, and its rewards and shortcomings.

Beyond its value as a textbook, *Introductory Physics* provides a window through which we can see how a master synthesized his expertise in physics, psychology, and education, and how he built on the innovations generated by the dynamic curriculum and teaching reform projects of the time. Naturally, as described above, he drew upon his 15 years of work with elementary school children and elementary science curricula to create Part One of the book. Another very important influence on Karplus' thinking about how to make physics understandable to a beginner was Francis Friedman, the convenor of the Physical Science Study Committee (PSSC) at MIT in 1956. By 1969, the PSSC, now under the direction of Jerrold Zacharias and with ongoing support from the National Science Foundation, had generated the first and second editions (1960 and 1965) of the innovative *PSSC Physics Course* for secondary schools.

*PSSC Physics* was based on Friedman's willingness to face the fact that velocity, acceleration, force and Newton's laws of motion, though the starting point for all physics courses of the time, actually demanded a level of abstract thinking for which most students were not prepared. Friedman identified other topics, particularly the study of light (ray and wave optics), as requiring substantially less abstract thinking. Therefore, *PSSC Physics* reversed the conventional order of topics, using the study of light, especially a critical comparison of the wave and particle models, plus other topics, to build up the reasoning skills needed to understand Newtonian mechanics.

Karplus enthusiastically adopted this approach, which fitted well with his own view of physics as well as his research on the development of reasoning. Karplus had also spent more than 10 years on the forefront of theoretical quantum field theory; he was intimately familiar with the difficulties of trying to apply the classical Newtonian approach in modern physics, and he was very aware of the on-going value of concepts such as interaction, radiation, field, momentum, and energy. This conceptual background very likely also made Karplus especially receptive to Friedman's idea.

Karplus also built on the PSSC comparison of the wave and particle models. But, in Karplus' hands the study of scientific models became the main theme. In Part One, he explains many trenchant examples illustrating how models are built, adapted and discarded. In Part Two (Chaps. 5-8), he compares the wave and particle models for light and (in distinction with PSSC) also for sound. Chapter 8 ("Models for Atoms") represents the climax of the first half of the book. Karplus uses the wave model (rather than force and Newton's laws) as his primary tool to elucidate modern physics. He succeeds brilliantly here: allowing the concepts to grow naturally from their context and explaining ideas such as the Bohr model, electron diffraction, wave mechanics, the wave-particle duality and the uncertainty principle in a way that makes sense to beginners.

Karplus' teaching approach was also strongly influenced by Gerald Holton, a former colleague in graduate school at Harvard. Holton, a physicist and a historian of science at Harvard, had a deep understanding of the rela-

tionships between science and other human concerns. In collaboration with Fletcher Watson and F. James Rutherford, Holton developed the *Project Physics Course*, which took a substantially different approach to secondary school physics than PSSC. Karplus was very appreciative of *Project Physics*, which identified ways to teach physics as part of the human experience and integrated the development of scientific concepts within a historical and cultural context. Karplus borrowed some specific ideas from *Project Physics*, for example the attempt to isolate a single light ray in Section 7.2, and he drew upon Holton's wonderful textbook *Development of Concepts and Theories in Physical Science* (1952) as well as Thomas Kuhn's seminal work, *The Structure of Scientific Revolutions*, which came out in 1962. Karplus also clearly did substantial reading of his own in the scientific and historical literature.

There are many notes in the margins about the historical context. More important, there are innumerable points in the course of an explanation of the physics content where Karplus calls up the historical context or the thinking of the discoverer in just the way needed to help a beginner gain a deeper understanding or to relate the concepts together in a memorable way.

This edition of Karplus' book is still quite close to its original form. While I edited the text in many ways – to clarify key points, correct typos, and modernize the most glaringly out-of-date items – I kept the page layout as close to its original form as possible. This imposed a rather demanding, yet salutary, requirement: modifications had to fit within the same number of pages as the original. Matching words in this way with the master gave me a workout at a level that I had not experienced since I completed my dissertation under his direction over 30 years ago.

This edition of Karplus' text could well be updated and supplemented in many ways. In particular, the references could be brought more up to date, many valuable innovations in physics teaching of the last 30 years could be incorporated, and additional hands-on experiments could be included. I would hope that the value of Karplus' work will not be dimmed by any shortcomings in the editing or by the fact that it has been out of print for so long.

Is understanding of the fundamental concepts of science necessary for non-scientists today? Is the capacity to apply scientific principles, think logically, and solve problems important for national and world citizenship? To Karplus the answers were obvious. His book provided and, I believe, still provides a positive and realistic response to these on-going challenges. I hope that a new generation of teachers and students find the book as valuable, provocative, and on-target as I, and many others, did during its brief life in print.

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