explain the historical context and to update and expand selected topics. The notes are wonderfully clear and succinct. For example, in slightly more than half a page, a note on π summarizes Archimedes's use of polygons on a circle to bracket the value of π, mentions the 1761 proof that π is irrational and the 1882 proof that π is transcendental, and defines irrational and transcendental numbers. A longer note discusses Euclidean construction of regular polygons (those familiar Flatland shapes), and even mentions Gauss's proof of when such constructions are possible. In a note on cellular automata, Stewart observes that if Flatlanders had cellular-automata brains, their intelligence would not be limited by their dimensionality. I found the notes in *The Annotated Flatland* to be gripping and enjoyable.

Flatterland and *The Annotated Flatland* are instructive, stimulating, and great fun. I highly recommend both books to physicists and students who enjoy having fun with mathematics.

Physics and the Art of Dance: Understanding Movement

Kenneth Laws
Oxford U. Press, New York, 2002. $39.95 (236 pp.).
ISBN 0-19-514482-1

What do Maxwell's equations and Fokine's *Les Sylphides* have in common? Both are towering and seminal achievements—and almost completely unfamiliar outside their respective areas. Both have beauty that is generally inaccessible without knowledge of their language and tradition. Each is couched in a precise vocabulary. Few people outside the fields know that vocabulary, and even fewer are familiar with the vocabularies of both.

Kenneth Laws is evidently one of those few. He has written a most unusual book, *Physics and the Art of Dance: Understanding Movement*, to bridge the gap between the two worlds. After teaching college-level physics for more than a dozen years at Dickinson College in Carlisle, Pennsylvania, Laws became interested in classical ballet and in the application of physics principles to it. The preface gives an intriguing hint of how strange the experience must have been: In his acknowledgements, Laws thanks the artistic director of the Central Pennsylvania Youth Ballet, who "has accepted me in classes in which the next oldest dancers were sometimes fifty years younger than I!" (preface, p. XV).

Laws has been teaching ballet classes since the 1980s, wrote two previous books about physics applied to dance, and wrote an article on the subject for PHYSICS TODAY (February, 1985, page 24). *Physics and the Art of Dance* is an extended and enhanced addition to the earlier works. Addressed to dancers, the book is a detailed and practical exposition of the mechanics of certain basic and complicated movements of classical ballet. The physics in the book is at the first-year college level, but it is interesting to see the principles of mechanics applied in such detail to management of the human body.

The book is organized in logical order around problems of motion, from simple retention of balance to more complicated movements. All positions are given their proper French terminology, and details are scrupulously accurate. The first section discusses such concepts as equilibrium and center of gravity, and explains how they apply to the dancer's body. The author suggests adjustments the dancer can make to retain or regain balance by applying these concepts. After dealing with balance, he turns to motion: horizontal motion, vertical jumps, the role of acceleration, the use of arm motion to affect the height of a jump, and illusions caused by the configuration of the body while it is in the air. One section deals with the elasticity and friction of floors.

In a chapter that clearly explains torque and angular momentum in a pirouette, the book progresses to more complex movement involving turns. I find entertaining the very fact that "torque" and "pirouette" appear in one sentence, and it may convey some of the flavor of this book. Subsequent chapters address turns in the air, and then the more complicated problems of dancing with a partner.

The writing is lucid, friendly, and to the point. Laws obviously knows his ballet as well as his physics. Each chapter begins with a "challenge problem" similar in style to those in introductory science textbooks—but here, rather then finding "what causes your hair to stand on end before a storm," we find such questions as how to do a 16-turn pirouette at constant tempo (p. 63). The text then shows how such problems may be solved by use of physical principles. The accompanying photographs clarify the text and accent details of the movement. The nonprofessional reader will gain from the photographs a heightened awareness of the structure of ballet positions, a sense of the beauty of "line," and a sense of the attempt the dancer must make to achieve a specific body shape.

Following the text are 11 appendices that give a more detailed examination of the physics. They begin with an outline of the principles of mechanics and follow up with quantitative analyses of various problems of movement. The appendices can be quite entertaining, as in a table that shows the time evolution of tilt from the vertical for tall and short toppling dancers.

This book will surely have immense value to dancers. Its value to nondancers is less obvious, and lies mainly in the insight it gives into the classical ballet, which in its own way is as precise and formal as mathematics. The methodical approach of the book may make ballet more accessible to the scientist. The detailed analysis of ballet movements will enhance the reader's understanding and appreciation of ballet performance. And I found it fascinating to see physical principles applied in such practical detail to positioning the human body in the beautiful and abstract movement of the ballet.

The book ends with an appeal for bridges between science and dance. "We know that the basic physical principles are sound and do indeed apply to the human body. The challenge is to make an understanding of this framework not a mere abstraction but *useful* in a way that contributes to improvement in dance technique and to an appreciation of the beauty of dance." Indeed the book fulfills that aim.

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Envisioning Science: The Design and Craft of the Science Image

Felice Frankel
MIT Press, Cambridge, Mass., 2002. $55.00 (328 pp.).
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The mechanics of continuous media—fluids, deformable solids, and fractures—was long considered a natural part of theoretical physics. Well known and widely used were the multivolume courses of theoretical physics by Max Planck, Arnold Sommerfeld, Lev Davidovich Landau and Evgenii Mikhailovich Lifschitz; each of those courses contained one or two volumes on continuum mechanics. Nowadays, continuum mechanics is not extensively taught as a part of fundamental physics. Because continuum mechanics is not just a formal mathematical construction, but a reliable tool in creating models of real phenomena, the best students and young researchers feel that lack in their education and try to compensate for it.

Although deemphasized in formal physics curricula, continuum mechanics is widely taught in mathematics and engineeering departments. Several graphical aids for teaching continuum mechanics have appeared over the past decades. The September 1967 issue of *Scientific American* has had immense value for teaching continuum mechanics and maintains its value even now. That issue presented, under appropriate magnification, many microphotographs of real materials, such as metals, glasses, polymers, and composites of various kinds. The diverse photographs allowed teachers of continuum mechanics to show their students the "intermediate-asymptotic" character of the continuum approach to materials science. Another example, from fluid mechanics, is Milton Van Dyke's *An Album of Fluid Motion* (Parabolic Press, 1982). Van Dyke selected for his album the photographs (again in appropriate scales) of most characteristic fluid-mechanical phenomena, including shock waves, boundary layers, water waves, transition to turbulence, and turbulent currents. Thanks to that album, students could be shown the details of important fluid mechanical phenomena, and I can testify that, during the last two decades, the level of presentation of fluid mechanics became much deeper. Teachers, myself included, have been able to present fluid mechanics as a branch of theoretical physics closely related to experiment. A third example, perhaps unintentional, of a successful teaching aid in continuum mechanics is James Trefil's *Other Worlds: A Collection of Images of the Cosmos from Earth and Space* (National Geographic Society, 1999). Nowadays, the basics of continuum physics can be taught on a much higher level than if the teacher were restricted to using chalk and an "acoustic representation."

However, the subject is changing rapidly. As new phenomena and fields appear, they should be presented to students and the scientific community as efficiently as possible. *Envisioning Science: The Design and Craft of the Science Image*, by Felice Frankel, explains how scientific photography is performed and how the photographs should be presented at talks and in scientific and popular journals. The author, a photographer and research scientist at MIT, draws on ample experience in scientific photography.

In the wake of this truly remarkable book, the teaching and presentation of scientific results should reach a new and much higher level.

The core of the book (chapters 4–8) systematically presents the art of scientific photography. As with every art, this one cannot be assimilated only by reading a book; additional hands-on training is needed as well. However, after being prepared by this book, a researcher will be able to learn scientific photography rather quickly. The presentation is definitely directed at making microphotographs. After chapter 4, "Basics of Picture Making," the next three chapters address microphotography: "Photographing Small Things," "Photographing through a Stereo Microscope," and "Photographing through a Compound Microscope." However, the general approach developed in chapters 4–7 can be successfully used for photographing objects in space. I hope the next edition will include a chapter about space photographs. Chapter 8 contains practical recommendations on how to present the pictures to various audiences. The material is interesting, original, sometimes unexpected, and, on the whole, very useful.

Chapter 3, a special discussion by Phylis Morrison, presents the history of documentary, not necessarily scientific, photography. I was pleased to see such old acquaintances as an ionic-microscope photograph of the tip of a tungsten needle that clearly reveals the atoms. I was astonished not to see Harold Edgerton's now-vintage photograph of the high-velocity impact of a water drop on a solid surface; the crown-like image illustrates loss of symmetry and transition to a periodic structure. It was a historic photograph, and I think the author should include it in the next edition.

It is known that, after a certain crash in his career, Winston Churchill unexpectedly had a lot of spare time, a lot of worries, and an inability to act. By chance he became interested in oil painting, and in the subsequent 50 years, he interspersed oil painting with his diverse and important business. In his book, *Painting as a Pastime* (republished by Levenger Press, 2002), Churchill strongly recommended painting as a remedy for worry and mental overstrain. After reading Felice Frankel's book, I have a feeling that scientists may find the envisioning of science a useful pursuit that could diversify their lives and be a reliable remedy for stress. Perhaps a great scientist in the future will write a book, *Envisioning Science as a Pastime*, and therein acknowledge the author with gratitude.

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Fundamentals and Applications of Ultrasonic Waves

J. David N. Cheeke
CRC Press, Boca Raton, Fla., 2002. $99.95 (462 pp.). ISBN 0-8493-0130-0

Imagine an introduction to ultrasonics that brings a student from basic acoustics to the forefront of current ultrasonics research. Such a textbook could become indispensable, and David Cheeke's *Fundamentals and Applications of Ultrasonic Waves* succeeds in its avowed purpose of becoming such a text. Since Cheeke has made significant contributions in the applied ultrasonics fields he discusses in the latter part of his book, he can present the topics authoritatively.

Throughout the book, Cheeke balances elementary introduction and advanced application; his discussion of advanced application extends to current research in theoretical and experimental ultrasonics. Nonetheless, wherever possible, Cheeke uses qualitative models to elucidate complex concepts he has derived mathematically but whose full physical implications may be opaque to the neophyte. In introducing ultrasonic measurement techniques, he enumerates the steps and methods—and also the pitfalls that await the unsuspecting novice.

After a beautiful introduction to the prevalence of ultrasonics in nature and its emergence in our technological world, Cheeke devotes six chapters to fundamental acoustics. Much of that material could be found in a few undergraduate textbooks, the most familiar being *Fundamentals of Acoustics* by Lawrence Kinsler, Austin Frey, Alan Coppens, and James Sanders (Wiley, 2000). However, even in his first six chapters, Cheeke goes beyond the usual scope of undergraduate textbooks when discussing certain topics to be used in later chapters.

After chapter 6, Cheeke begins to discuss topics more specific to ultrasonic propagation, gradually introducing the reader to Rayleigh waves, Lamb waves, and acoustic waveguides. The propagating waves discussed are the main ones used in the succeeding application chapters. In a transition chapter, he discusses group velocities, velocity surfaces, and slowness surfaces, important concepts for analyzing wave propagation and in designing ultrasonic-measurement systems. An ultrasonic device requires some sort of mechanical transduction to produce sound energy. To introduce transduction, Cheeke first discusses piezoelectricity and then presents the piezoelectric constitutive relations and the piezoelectric coupling factor. Once he acquaints the reader well with these concepts, he qualitatively extends them to other forms of transduction involving electricity and magnetism, optics, and heat.

The final six chapters successfully present modern applications of ultrasonics. Cheeke starts with the most elementary applications, namely piezoelectric transducers, delay lines, and analog signal processing. He ends with one of the most intriguing problems of modern ultrasonics—sonoluminescence, the emission of light by collapsing bubbles in a liquid undergoing cavitation. At its minimum radius, such a bubble is predicted to have a central temperature between 20 000 K and 30 000 K. Poetically, the author describes the phenomenon as " 'a star in a bottle' with a hot optically opaque center and a cooler optically thin outer region." For a discussion of