

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 some-

times 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 than 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.,
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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