

beam photoionization and photofragmentation, particularly by the absorption of multiple photons, a research area in which Bernstein and coworkers have made pioneering advances. But, on balance, the choice of material is first class, and the synthesis of this material into a readable account of this active research field is truly remarkable.

The Mathematical Experience

P. Davis, R. Hersh

440 pp. Birkhäuser, Boston, 1981. \$24.00

Mathematics Tomorrow

L. Steen

250 pp. Springer, New York, 1981. \$18.00

When Gulliver in his travels visited the great academy of Lagado, he observed an unusually simple method for learning mathematics. The teacher merely wrote each theorem (with its proof) on a wafer, using as ink an extract from brain tissue. As the wafer was digested, the extract mounted to the student's brain, bearing the theorem with it. Unfortunately, even our most successful gene-splicers have not yet matched this accomplishment, and the study of mathematics remains as long and hard as ever. Consequently, there is always a need for books that give a general audience some understanding of mathematics, some feeling for what mathematicians do and how their work is related to the other arts and sciences. One such book is *Mathematics Today*, which came out in 1978 and is now available in paperback. It contains essays specially commissioned to present accessible recent work in mathematics and its applications, from scheduling problems to black holes, and it is worth recommending to anyone who missed it.

Mathematics Tomorrow is the bastard brother of *Mathematics Today*. It is another collection of essays, with the same editor and publisher, but (to put it plainly) without any mathematics. The first, 60-page, section is called "What is Mathematics?" but it contains mainly expressions of personal enthusiasm and recommendations for an undergraduate curriculum. In the longest section devoted to teaching, two separate authors from two-year colleges complain that they don't get enough respect. A section on "Issues of Equality" reminds us that women used to be kept away from mathematics and to some extent still are. The final section is called "Mathematics for Tomorrow," but it is devoted almost entirely to discussing which topics (all quite well-known today) should be taught to undergraduates.

Certainly some of the essays are attractive in themselves. Paul Halmos, in his usual felicitous style, contrasts the general attitudes that accompany work in pure mathematics and in applications. Peter Hilton complains with all too much reason that "mathematics avoidance" may be a healthy reaction to the dull, pointless, unrealistic drill that passes for mathematics in many elementary classrooms. Executives from Springer-Verlag and Birkhäuser suggest that publishers will soon be primarily editors: Electronic text transmission will make almost everything widely available, but many more people will read a book or article if it is included in the list of some respected "publisher." Others of the essays also contain some interesting ideas, but there is no common focus; at its worst the book seems like a set of background reports prepared for a faculty meeting.

The Mathematical Experience is a quite different book, reminiscent less of faculty meetings than of lunch-table monologs. The style is informal and enthusiastic, rather inclined to overstatement. The eight chapters share certain concerns and viewpoints, but are otherwise almost completely independent. Each consists of five to fifteen sections that again are only loosely related. There are brief expositions of actual mathematics, with topics chosen almost at random (these are mainly taken from earlier articles by the authors). There are snatches of history, especially on the interactions between mathematics and other cultural areas. There are odds and ends such as "mathematical eccentrics" and "how many theorems are published each year?" There are eight pages on astrology, with no mathematics at all. And there is quite a lot about the "philosophy" of mathematics.

The liveliness of the style entails a fair amount of stretching for effect. The section on mathematics and religion, for instance, ends with the sentence, "Can we conclude that mathematics is a form of religion, and in fact the true religion?" Few readers will be seriously tempted to suppose that the four pages of the section justify this conclusion (or any other conclusion). At another place, the authors point out that the prime numbers do not occur in any simple pattern, but we still know that the number of primes less than a large x will be asymptotic to $x/\ln(x)$. They add that this provides "a moral lesson on how individual eccentricities can exist side by side with law and order." (As the Dutchess said to Alice, everything's got a moral, if only you can find it.) But this sort of overwriting is usually easy to recognize and easy to discount.

There are, however, a couple of areas where readers who are not mathematicians should be on their guard. The authors' training and sympathy lie primarily in applied mathematics, and this leads them to express contempt regularly for what they tend to call "formal" mathematics. They use the term, however, to refer to a variety of things. Sometimes they mean the epistemological theory that the truth of mathematics lies in the structure of its proofs, regardless of its nominal subject. Sometimes they mean the use of a great many symbols instead of words. Sometimes they mean writing out all the details of an argument. Sometimes they mean leaving out examples. Sometimes they mean the use of axioms. Sometimes, indeed, they seem to mean most of mathematics. Now some of these quite different things may indeed be bad, but some are not, and there is no special connection between them. Readers should be wary of the authors' attempt to tar them all with the same brush.

The other problem area is "philosophy." The authors say that they have become as much interested in the philosophy of mathematics as in mathematics itself. But philosophy is notoriously coy, not nearly so easy to pick up as people first think. The authors criticize most current work on the philosophy of mathematics, for instance, on the grounds that it does not reflect how mathematics is discovered. But they never really explain why the truth of something *should* depend on how it is discovered. Sometimes they write as though mathematics were purely cultural, a matter of convention; at other times they think it is "reproducible." (Curiously, they never mention Noam Chomsky's ideas on innate linguistic capabilities, which seem to be the sort of idea they are reaching for.) Still, their confusion may serve to provoke thought—and the same is true of the rest of the book. As long as readers are not tempted to take the authors' word as law, they may well enjoy browsing through some of the many different topics discussed.

WILLIAM C. WATERHOUSE
Pennsylvania State University

Quantum Mechanics for Applied Physics and Engineering

A. T. Fromhold Jr

430 pp. Academic, New York, 1981. \$34.50

This book has a promising title. It has long been a strong opinion of mine that applied physicists and electrical engineers should learn quantum mechanics, not only to acquire a broader understanding but also to learn the



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basis of transistors, lasers, solar cells, and so many other devices that have transformed technology over the past twenty-five years. Of course, many applied scientists and engineers will never need to know how, much less why, the devices they use operate, but it is very difficult to make such an assessment as an undergraduate and it is still more difficult to learn quantum mechanics while working as a professional. I have tried to teach electrical-engineering undergraduates the funda-

mentals of quantum physics for the past several years, and I have had great difficulty in choosing a text that combines a clear development of the concepts with an overall direction towards device applications.

I am sorry to conclude after reading this book that an acceptable text with an applied viewpoint is still sorely lacking. The problems begin in Chapter 1, and they continue throughout the book. On page one, "particlelike" is defined as "localized and acting

in some sense as individual entities," and "wavelike" as "nonlocalized and periodic, with the capability of interacting and constructively or destructively with similar entities"; the text goes on to identify the wave-particle duality as "the coexistence of wavelike and particlelike aspects in a single physical entity." I doubt that a student who has not had previous experience with quantum mechanics could be anything but totally confused before the end of the first page. Fromhold next points out that "certain properties of matter and certain properties of radiation are found to be quantized," spin angular momentum being given as one of the examples. How could any student with just a knowledge of classical physics know what spin angular momentum is at this point? The other examples of quantization, noted here, such as the fixed mass and charge of the electron, are entirely consistent with a classical viewpoint and do little to establish the unique nature of quantum phenomena. Fromhold then introduces the experimental basis for quantum mechanics with short discussions of the photoelectric and Compton effects. The discussion of the photoelectric effect invokes the (undefined) work function. The Compton effect is described as "an increase in the wavelength of electromagnetic radiation due to particlelike collisions of photons (such as x rays) with unbound electrons in a solid." I wonder how many students will understand how a "particlelike collision" could change the wavelength of light at this point.

Even glossing over confusion about the conceptual basis of quantum mechanics, I am very disappointed with the text. The important problems of the harmonic oscillator and the hydrogen atom are unsolved, leaving large gaps in the reader's knowledge. The eigenfunctions for these problems are not even written down, an amazing omission for a text primarily concerned with applications to solids. The Pauli exclusion principle is mentioned for the first time on page 125, within the context of the discussion of the *hydrogen* atom, surely an unfortunate place to bring up a result that controls the physics of multi-electron systems.

I am most disturbed by the chapters on applications, which I would have expected from the title and the preface to be the *raison d'être* of the entire book. In these chapters, there is no mention of the physics of transistors, lasers or solar cells. In fact, the only reference to even a p-n junction is during a discussion of the tunnel diode. The text continues with a discussion of band bending, space charge, and response to an applied voltage. All this might be acceptable were it not the case

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that the band theory of solids is not even introduced until the last chapter, about 100 pages later. The fact that semiconductors are not Fromhold's area of expertise is easily deduced from an earlier paragraph in the section on metal-insulator-metal structures which reads: "Typically the energy gap in an intrinsic semiconductor is of the order of a few multiples of the thermal energy ($k_B T \approx 0.025$ eV) at $T = 300$ K), instead of having values exceeding an electron volt or so as is the case for good electrical insulators."

Fromhold is a well-respected, highly honored physicist. I wish that he had taken the time to write a good quantum mechanics text.

DAVID ADLER

Massachusetts Institute of Technology

Analysis, Manifolds and Physics. Revised Edition

Y. Choquet-Bruhat, C. DeWitt-Morette
Elsevier, New York, 1982. \$29.50

No one familiar with present-day elementary-particle physics can fail to be aware of the striking shift of emphasis that has emerged over the last fifteen years. The empirical, and sometimes pessimistic, attitudes of the late 1960s have been replaced. Recent theoretical activity has been anchored in the significance and applicability of renormalized quantum field theory. Physicists are now using mathematical tools that have not been part of their conventional armory. This trend is nowhere more marked than in those areas of quantum field theory that concern classical solutions of the field equation. In particular, the study of solitons, monopoles, instantons, and indeed the entire structure of gauge theories, has drawn extensively on the methodology of differential geometry. Of course, general relativists have long employed such techniques, but it is only recently that they and particle physicists have communicated to any considerable degree. For many theoretical physicists, the need to come to terms with this new mathematics has entailed something of a culture shock.

It must be admitted that, for physicists, differential geometry is not the easiest subject to learn. Many of the otherwise excellent standard texts adopt an analytic approach that is geared to the interests of pure mathematicians and that frequently presupposes a prior degree of mathematical expertise that most physicists do not possess. Thus we must especially welcome this text by Yvonne Choquet-Bruhat and Cécile DeWitt-Morette. While it in no way sacrifices any degree of mathematical accuracy, it presents the crucial ideas within a framework

that is specifically geared to the needs of theoretical physicists. In particular, the authors have managed to place within one coherent volume almost all of the topics that a student would need. Previously this material could only be found dispersed in a number of different mathematical works. Thus we find not only the anticipated sections on manifolds and Riemannian geometry, but also extensive discussions of integration, submanifolds (especially useful for canonical studies of gravity), the theory of distributions and Sobolev spaces, an introduction to finite-dimensional manifolds and the Wiener measure that underpins so much of modern quantum theory, and, in this revised edition, a new and comprehensive account of fiber bundles.

It is a truism that mathematics can only be learned by practice. The authors, fortunately, have included substantial collection of carefully presented problems and exercises. The discussion in these sections is consistently oriented around physical applications and introduces many topics of specific interest to physicists. Thus, for example, there is a nice account of spinors (a notoriously difficult topic on which to obtain information at just the right level) and many illustrations of the use and significance of characteristic classes. (Throughout the book there is a steady but gentle introduction to the basic ideas of differential cohomology.)

The high quality of French mathematics, combined in this volume with the wide professional expertise of the authors in mathematical physics, has resulted in a work of great value. The price is low enough to place the book realistically within the reach of most graduate students. I can wholeheartedly recommend it to anyone who aspires to participate in the exciting developments in modern elementary-particle physics and relativity.

C. J. ISHAM

Imperial College of Science and
Technology, London

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