

BOOKS

relaxation techniques for elliptic partial differential equations."

▷ *This series serves as both a reference book and a textbook.* However, it lacks a cumulative index. One has to consult the six indexes of the English translation (one per volume), which are excellent, or the three indexes of the original French version (one per tome), which are so skimpy as to be useless. On the other hand, several excellent features help the reader find answers to his or her questions, both formulated and unformulated. For one, enough explanation is given in each section to make each sufficiently self-contained. Also, the "reviews" (*bilan* in the French version) scattered throughout the book are in fact retrospective commentaries examining previously solved problems from new perspectives: Problems are regrouped so that they enhance each other. The table of notations, repeated at the end of each volume includes brief definitions.

For a textbook, the book is pitched at a rather advanced level. It is entirely proper that the French paperbacks appear in the "Collection Enseignement" of the Institut National des Sciences et Techniques Nucléaires. Scientists nowadays cannot expect to learn in college all the basic material they will need in a lifetime—whether in an academic or an industrial career. They will therefore have to rely on books such as the present treatise. Appendixes, short and long, and various sections (for example, 33 pages to introduce the mathematical problems of quantum physics) bring back to the reader's mind topics seen in college but not really absorbed.

The typesetting in the English edition is more elegant than in the French original but the English version is harder to read for two reasons: The translation is often awkward—particularly in the first two volumes—because it follows the French too closely (at press time the translations of the last two volumes were not available); and the indentation of the paragraphs, so useful in studying a difficult text, has been eliminated in the English text. [The French original is available from SMPF, 100 East 42nd Street, Suite 1002, New York, NY 10017, (212) 983-6287. The French Tome I (or equivalently the French paperback volumes 1-4) has been translated into the English volumes 1-2, Tome II (paperback volumes 5-6) into the English volumes 3-4 and Tome III (paperback volumes 7-9) into the English volumes 5-6.]

This treatise is desirable for individual researchers and indispensable

for libraries, where it will be a basic tool for many years to come.

CÉCILE DEWITT-MORETTE
AND ERIC MYERS

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Elementary Fluid Dynamics

D. J. Acheson

Clarendon (Oxford), New York,
1990. 397 pp. \$85.00 hc
ISBN 0-19-859660-X

A Mathematical Introduction to Fluid Mechanics

A. J. Chorin and
J. E. Marsden

Second edition.

Springer-Verlag, New York,
1990 [1979]. 168 pp. \$29.00 hc
ISBN 0-387-97300-1

The National Science Foundation has relegated fluid mechanics to the catch-all desk, which oversees fluid, particulate and hydraulic systems. Some say that since the equations are known, fluid mechanics is a problem in applied mathematics. Physicists generally spurn it, except for certain areas of turbulence. Yet it is an exceptionally difficult subject that continues to present phenomena that are not well understood and often nearly impossible to calculate, attracting the attention of experimenters and mathematicians alike. These phenomena have enormous influence on every phase of existence, determining rates of transport and reaction in biology, the environment and technology and ultimately controlling much in the processes of manufacturing, energy consumption, pollution and life itself.

These two books are intended to introduce students to a subject they nearly always find difficult. A. J. Chorin and J. E. Marsden are distinguished mathematicians at Berkeley; this is the second edition of their book, originally published in 1979. D. J. Acheson is at Jesus College, Oxford, where he teaches fluid mechanics. Although probably less well-known, he has to his credit a non-negligible body of work in the field.

Despite the title, Chorin and Marsden's book is not in substance particularly mathematical—not much more so than similar courses we teach at Cornell. What does give it a slightly mathematical flavor is the style, which has a certain purity and economy, a perhaps deceptive simplicity.

The book has interesting exercises and good drawings throughout. The

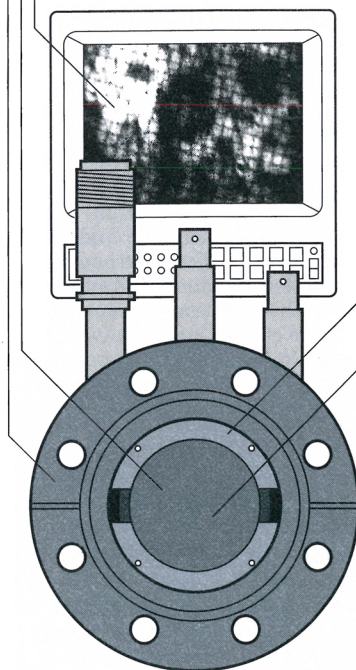
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authors cover the derivation of the equations of motion; the definition of vorticity and a few of the classical theorems; some material on classical potential flow; an introduction to boundary layers (with a glance at matched asymptotic expansions); and one-dimensional gas flow. This material may all be found elsewhere, in books by the likes of George Batchelor, L. M. Milne-Thompson, Hans Liepmann and Anatol Roshko, but nowhere else is it collected in a single volume. Added in this edition are a few pages on stability and bifurcation from a dynamical systems point of view.

In some respects this book would make a good text for one of the introductory graduate-level fluid mechanics courses we teach. However, the authors have also included a section on vortex sheets, a very strange construction of Chorin's in which the boundary layer is replaced by little vortex sheets that appear randomly at the boundary and diffuse outward into the flow. Although this construction produces formal solutions to the equations of motion and may have computational advantages, I object to its inclusion here on the grounds that it creates in the student's mind a very unphysical picture of what is going on in the boundary layer.

There are a few other small things about the book that I did not like. The authors use vector notation throughout, despite the fact that this is a text intended for graduate students in mathematics and that it is not possible in general to write the Navier-Stokes equations unambiguously in vector notation. The fluid dynamics community generally uses Cartesian tensor notation to avoid these problems, and it is a good idea to get students accustomed to this notation as early as possible. I also feel that the authors' terminology sometimes sets a poor example for precision and clarity, and is sometimes wrong.

In another vein, I was pleased to see that the authors use a fixed volume in laboratory coordinates to derive the equation of conservation of mass, but I was disappointed to see that they shied away from such usage for the momentum equation, presumably because they felt more comfortable, or thought the students would feel more comfortable, with Newton's second law in the form commonly used in particle mechanics.

Acheson's book is of quite a different sort. It covers much more: elementary viscous flow, waves, classical airfoil theory, vortex motion, the Navier-Stokes equations, very viscous

flow, boundary layers and instability. However, the main difference is one of tone. Throughout he lovingly describes experiments and presents drawings of the results. There is a large number of other illustrations throughout the text. He includes from time to time a little historical perspective, which I feel makes the topic far more palatable for the interested student. I can vouch for the fact that this historical material is very difficult to come by. In the sciences we seem to present the current state of the subject as a *ding an sich*, as though it had come into being by magical intervention, seldom giving the student a hint of the ups and downs of the professional careers of those responsible.

Acheson's voice is almost conversational. Here he is introducing boundary layers: "The amount of insight packed into this part of Prandtl's paper is staggering." He includes many good exercises (with hints and answers in the back) and uses a mix of vector notation, component notation and some Cartesian tensor notation. His section introducing the stress tensor is self-contained and can be understood by a student who has taken no previous course in tensors. He includes some cute explanations, along with excellent drawings, that should interest students—for example, the Weis-Fogh mechanism for lift generation in insect flight. He goes so far as to discuss at the end of the book the various routes to chaos and Albert Libchaber's experiments.

Acheson is in fact sneakily mathematical without seeming to be; in discussing Rayleigh's jerked-plate problem, he approaches the similarity solution by off-handedly bringing in invariance under affine transformations or Lie groups, but without naming them. I really find this a very attractive book and am happy to recommend it for a first graduate course in fluid mechanics.

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Undulators and Free-Electron Lasers

P. Luchini and H. Motz
Oxford U. P., New York, 1990.
332 pp. \$85.00 hc
ISBN 0-19-852019-0

Synchrotron radiation from relativistic electron beams, extending from the far infrared to the x-ray region, has become an important tool for the study of solid-state and surface physics, chemistry and biology, and has a growing number of applications in

medicine and industry. A reflection of this growing importance is the increasing number of facilities worldwide dedicated to the production of this form of radiation. Free-electron lasers, which also use the radiation from relativistic electrons, enhance the coherence properties and peak power of undulator radiation and are the natural evolutionary next step for synchrotron radiation sources.

Since the early 1950s Hans Motz has been a pioneer in the introduction and development of undulator radiation. This book, written with his younger colleague Paolo Luchini, reflects Motz's historical vision of the development of this field and his understanding of the physics of these devices, as well as a modern view of the field. It is unfortunate that Motz, who died in 1987, could not see the book finished. However, this volume will help remind us of his contributions to this area of physics.

Several recent monographs and a volume of the *Laser Handbook* describe free-electron lasers and synchrotron and undulator radiation. Because to understand and design these systems one needs to draw from particle-beam physics, accelerator technology, laser physics and optics, it is very difficult to cover completely in a monograph both the theoretical and experimental aspects of the subject. Luchini and Motz, after giving an excellent historical introduction to this subject and an overview of its basic physical principles, prefer to concentrate more on the theory, providing a very detailed and accurate description of the spontaneous radiation from a relativistic beam traversing an undulator, with or without a waveguide. This description is then extended to stimulated radiation and free-electron laser theory, which is discussed in the small- and large-gain regime, and includes optical guiding effects and the effects of beam emittance and energy spread.

The part of the book that covers experiments and the descriptions of particle-beam properties and particle accelerators are presented on a more qualitative, introductory level. A reader interested in the experimental aspects of undulators and free-electron lasers will need to supplement his or her reading with material given in some of the references.

The authors have attempted to make the book as self-contained as possible by, for example, including an appendix on Hamiltonian mechanics and discussing in detail the solutions of the Maxwell equations appropriate to these problems. Thus the book can be used as a text for graduate students