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REVIEWS

Introduction to the Physics of Fluids and Solids. By J. S. TREFIL. Pergamon, 1975. 304 pp. £7.50.

Physical Fluid Dynamics. By D. J. TRITTON. Van Nostrand Reinhold, 1977. 362 pp. £11.50 (hardback) or £5.50 (paperback).

Although fluid mechanics began as a branch of classical physics, few physicists these days know much about it. In this century the remarkable flowering of the subject, in so many diverse directions, and in both its fundamental and applied aspects, has been brought about mainly by individuals responsive to technological needs in virtually all branches of engineering and in other applied sciences. Only a few who call themselves physicists have participated in these profuse developments, and fluid mechanics long ago disappeared from most university curricula in physics.

Introductory books have appeared in great numbers in the past few decades, but all too many of these have suffered from a parochial outlook reflecting a particular branch of technology and, perhaps even worse, the narrowness of the writer. The reader of such a book gets no inkling of the scope, depth and richness of the subject. Thus one examines the two books under review with anticipation, as the work of physicists for students of physics, hoping for perhaps a fresh and perhaps a broader way of introducing the subject.

Trefil addresses 'graduates and advanced undergraduates in physics' who, for reasons of 'the employment situation', require 'awareness of the great body of knowledge of fluid mechanics and elasticity which was gained before the beginning of this century'. He states two objectives: 'to show...that there is no essential new knowledge which we must master to learn about continuum mechanics' and to show 'that once these few basic principles are understood, they can be applied to an almost unbelievable number of systems which are seen in nature'. Tritton addresses 'primarily...students of physics and of physics-based applied science' and 'treat(s) fluid dynamics as a branch of physics, rather than as a branch of applied mathematics or of engineering'.

In striving towards somewhat similar goals, Trefil fails dismally, Tritton is quite successful.

Trefil's book has many of the faults of those many books with titles such as 'Fluid Mechanics for...Engineering': it is narrow, despite the author's repeated assertions; it is filled with sloppy statements and arguments, if not outright error; and the numerous naiveties betray the relative inexperience of the author in fluid mechanics, as foreshadowed by the quotation from the preface given above. To its credit, several fluid-mechanical instabilities are discussed, a situation unusual in introductory texts. But, and incredibly, the word turbulence does not appear even once. Chapter 5, *Waves in Fluids*, deals with gravity and capillary waves on free surfaces, but the propagation of pressure waves is never mentioned. Many other central concepts and topics essential to a text purporting to be a general treatment of the subject are absent: vorticity, Kelvin's theorem, Helmholtz' vorticity transport equations, inertia-free flows, boundary-layer separation, streaming potential flows. Roughly one-quarter of the book deals with solids, but in the formulation of the equations of three-dimensional linear elasticity, no connexion is made with the derivation of the Navier–Stokes equations given earlier. With regard to the latter, one wonders whether the author really believes that 'the simple theory, in which the viscous force is assumed to depend only on the first derivatives of the velocity, is a perfectly adequate description of the motion of fluids', or that no further caveats are needed. One looks in vain for experimental results which might convey even vaguely that fluid mechanics as an applied science rests equally on experiment and theory.

But enough! Space forbids further belabourment of a book clearly inadequate. We turn to Tritton's book with relief, for it is a pleasure to read. In its scope and richness of content, in its blend of experiment and theory [from the preface: '...much greater emphasis on what we know through laboratory experiments and their physical interpretation and less on the mathematical formalism.'], in the many nice physical insights, the book reminds one of Prandtl's classic, *Führer durch die Strömungslehre*. Despite the remark in the preface that 'the choice of topics has been made for the insight they give into the behaviour of fluids in motion rather than for their practical importance', to this reviewer the book with some amplification here and there would be well suited as a text for introductory courses addressed to engineering students. The Bibliography and References, nicely annotated, are of particular service to the student.

After the usual introductory chapter defining the purpose and scope of the book, chapter 2, on *Pipe and Channel Flows*, develops the equations of plane and axisymmetric Poiseuille flows, introduces the Reynolds number (rather abruptly, it seems), discusses the entry length, and then, in a purely descriptive manner, passes over to the experimental manifestations of transition to turbulent flow. Chapter 3, *Flow Past a Circular Cylinder*, introduces further concepts and experimental results in a discursive rather than analytical style: frames of reference, Reynolds number, flow patterns at low and high *Re*, wakes and vortex streets, hot-wire traces in the wake, laminar *vs.* turbulent wakes, separation, and drag. Chapter 4, *Convection in Horizontal Layers*, also essentially describes experimental results: Bénard cells, Rayleigh number, flow regimes, flow patterns at low and high *Ra*.

These are healthy, interesting and stimulating precursors to chapter 5, *Equations of Motion*, which neatly and economically, using vectors freely, develops the continuity equation and the Navier–Stokes equation, and the appropriate boundary conditions. Here one finds too an order-of-magnitude discussion of the condition for incompressibility, this being the only exception to the statement in the preface that 'the major limitation is the restriction to incompressible flow'. This reviewer hopes that in a second edition there would be introduced some introductory ideas concerning compressible flow. This could in fact be accomplished quite simply, and in a manner not inconsistent with the treatment of other topics in the book.

Chapter 6, *Further Basic Ideas*, is like a cupboard storing things that do not fit elsewhere: streamlines streamtubes, particle paths and streaklines; the streamline patterns of computer solutions for flow past a circular cylinder at $Re = 40$; the stream function; vorticity and the vorticity equation; circulation. Altogether not too successful a mix.

Chapter 7, *Dynamical Similarity*, leads naturally into chapter 8, *Low and High Reynolds Numbers*, which deals with the physical significance of *Re* and the differing behaviour for low and high *Re*, including the appearance of boundary layers.

Chapter 9, *Some Solutions of the Viscous Flow Equations*, briefly deals with rotating Couette flow and Stokes flow past a sphere.

In chapter 10, *Inviscid Flow*, one regrets that Kelvin's circulation theorem is asserted without proof, and that the permanence of irrotational motion is based on the often-repeated erroneous argument that the vorticity transport equation in particular circumstances reduces to $D\omega/Dt = 0$. Bernoulli's equation and some applications are mentioned, but only briefly; this segment could well have been longer.

Chapter 11, dealing with boundary layers, develops the boundary-layer equations, derives the Blasius solution and discusses boundary-layer separation (not well), the drag on bluff bodies, streamlining, wakes, self-similar jets, and the integrated momentum and energy equations for viscous flow.

Chapter 12, *Lift*, is largely descriptive, with the Joukowsky law developed only by a rough order-of-magnitude calculation.

Chapter 13, *Thermal Flows: Basic Equations and Concepts*, chapter 14, *Free Convection*, chapter 15, *Flow in Rotating Fluids*, and chapter 16, *Stratified Flow*, all of which are a mixture of analytical and descriptive material, provide interesting introductions to the fluid-dynamical phenomena of geophysics and astrophysics.

Chapter 17, *Instability Phenomena*, and chapter 18, *The Theory of Hydrodynamical Stability*, deal with fluid-dynamical instabilities, a concept so often totally ignored in introductory texts: capillary instability; convection due to internal heat generation; Bénard convection; convection due to gradients of surface tension; Taylor instability in Couette flow; Kelvin–Helmholtz instability in shear flow; boundary-layer instability. The treatment is essentially descriptive, with a hand-waving discussion of how one approaches theoretically the question of stability.

Chapter 19 is a nice physical description of *Transition to Turbulence*, well supported by a variety of experimental observations, both visual and quantitative. Chapter 20, *Turbulence*, is mainly an introduction to the various statistical measures of turbulence and introduces the concept of the Reynolds stress. In chapter 21, *Homogeneous Isotropic Turbulence*, the important feature is a discussion of spectra and the energy cascade. Further useful and interesting information is given in chapter 22, *The Structure of Turbulent Flows*, largely through experimental results: Reynolds number similarity and self-preservation; intermittency; entrainment; wake structure; turbulent motion near a wall, and the semi-empirical theory of the logarithmic velocity profile; large eddies; the Coanda effect; stratified shear flows; reverse transition.

Chapter 23, *Experimental Methods*, is a brief introduction, far from complete, but with many references.

Finally, and with perhaps unnecessary apologies for the author's belief that the book is thin in applications, chapter 24, with the surprising title *Practical Situations*, presents brief and interesting descriptions, with references for further reading, of topics selected 'to illustrate the variety of branches of applied science in which fluid dynamics arises'. These include: cloud patterns; waves in the atmospheric circulation; continental drift and convection in the earth's mantle; solar granulation; effluent dispersal; wind effects on structures; boundary-layer control: vortex generators; fluidics; undulatory swimming; convection from the human body; and the flight of a boomerang. These might have been distributed throughout the book, to better advantage.

This is altogether a worthwhile book, with some imperfections that could easily be rectified in a second edition.

A. H. Shapiro

SHORTER NOTICES

Fluid Dynamics. Edited by R. BALIAN and J.-L. PEUBE. Gordon & Breach, 1977. 677 pp. £46.

This volume contains the expanded texts of four short lecture courses given at a session of a Summer School at Les Houches devoted to fluid dynamics in 1973, together with the texts of 11 seminars given (mostly) by participants. The purpose of this session of the Summer School was to show to participants that fluid dynamics is still an interesting and developing part of physics, despite being, as the editors put it, 'overshadowed by the extraordinary progress of microscopic physics since the beginning of the century'. The four lecturers and their subjects were as follows:

P. Germain, Méthodes asymptotiques en mécanique des fluides (147 pp.)

H. K. Moffatt, General fluid dynamics (63 pp.) and Hydromagnetic dynamo theory (22 pp.)

S. A. Orszag, Statistical theory of turbulence (138 pp.)

J.-L. Peube, Transport properties in flows (57 pp.)

Each of the four articles is a well-written account of an important topic by a recognized authority. The objectives and the degree of specialization vary considerably, but all are expository in character. They deserve a better fate than to be published four years after the Summer School in an isolated volume costing £46 which is too inhomogeneous for many individuals to wish to acquire it. Extended survey articles like these probably belong better in regular publications such as *Advances in Applied Mechanics*, where one may find them when there is need.

Basic Lubrication Theory, 2nd Edition. By A. CAMERON. Halstead Press, 1976. 195 pp. $15.50.

The first edition of this book (Longmans, 1970) was prepared for the use of students from the author's weightier text, *Principles of Lubrication* (Longmans, 1966). Professor Cameron was anxious to produce a book for teaching purposes in which the physical principles of lubrication theory were not obscured for the average engineering student by algebraic manipulation. To this end he sacrificed 'practical' bearing profiles in order to obtain solutions in terms of elementary integrals. This 2nd edition of the book makes a further step in this direction. The chapter on the 'converging–diverging wedge' has been completely re-written, but the rest of the book is unchanged. Teachers of the subject will be grateful to the new publishers for keeping this excellent student text in print.

Turbulence in Liquids. Proceedings of the Fourth Biennial Symposium on Turbulence in Liquids, September 1975. Edited by J. L. ZAKIN and G. K. PATTERSON. Science Press, Princeton, 1977. 356 pp.

This interesting and well-produced volume contains 32 papers largely concerned with different methods of measuring turbulence characteristics (hot-wire and hot-film measurements, flow-visualization studies, measurements based on laser-Doppler anemometry, and measurements based on electrochemical diffusion techniques). A number of the papers are concerned with specific applications of turbulence (in liquid-metal flow, two-phase flow, blood flow, capsule transport, fluid–structure interaction, etc.). Other papers in the collection are concerned with improved measurement techniques, or with general turbulence behaviour (e.g. the identification of large-scale structures in turbulent flows). It is perhaps worth noting that, despite the title of the volume, some of the papers are not specifically concerned with liquids and others are not specifically concerned with turbulence. The volume will be no less valuable to researchers in experimental aspects of turbulence.