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REVIEWS

Fluid Physics for Oceanographers and Physicists. By J. WILLIAMS and S. A. ELDER. Pergamon, 1989. 300 pp. £36 or $65 (hardback), £15 or $27.50 (paperback).

Applied Fluid Mechanics. By D. N. ROY. Ellis Horwood, 1988. 556 pp. £39.95.

Fundamentals of Fluid Mechanics. By B. R. MUNSON, D. F. YOUNG and T. H. OKIISHI. Wiley, 1990. 843 pp. £48.85 (hardback) or £18.50 (paperback).

Intermediate Fluid Mechanics. By R. H. NUNN. Hemisphere, 1989. 343 pp. £35.

A good introductory text book in any area should be clear, accurate, literate and reasonably comprehensive; it should give the student a sense of accomplishment, an understanding of some things worth knowing. Such a book in fluid mechanics must also develop analytical skills and physical insight as twin bases for those indispensable skills involved in the art of approximation. It must be comprehensive and correct. It may lead off in any one of a number of directions, towards oceanography, hydraulics, compressible flow, engineering, bio-fluid mechanics or whatever, but by general consent there is a core of basic notions and techniques that is common to all. Of these four contenders, none are to this reviewer completely satisfactory, though *Fundamentals of Fluid Mechanics* comes fairly close.

In terms of content, the first three all include chapters on the mechanical properties of fluids, fluid statics and dimensional analysis; *Intermediate Fluid Mechanics*, being somewhat more advanced, presumes that these topics are already understood. All four consider kinematics, perfect fluids, simple viscous fluid situations and a bit about turbulence. All four discuss laminar boundary layers, *Intermediate Fluid Mechanics* quite well, though *Applied Fluid Mechanics* is curiously opaque – in a long section on the flat-plate laminar boundary layer, several obsolete approximation techniques are described in detail, but the Blazius solution is not even mentioned. *Applied Fluid Mechanics* includes extensive sections on pipe networks, open channel flows, flow measurments and turbo machines; about one-third of *Intermediate Fluid Mechanics* is devoted to one-dimensional compressible flow. *Fundamentals of Fluid Mechanics* is the most comprehensive and has good chapters on dimensional analysis and kinematics; it is attractively produced (in two colours!) with photographs. *Applied Fluid Mechanics* does not use vectors at all and *Fluid Physics* is very tentative about them. All include many exercises and problems whose demands on the students range from finding the right formula and substituting numbers (predominantly in *Applied Fluid Mechanics*) to the need for some analytical and reasoning ability, with simple computing in *Fundamentals of Fluid Mechanics*.

It is surprising that in none of these books is Kelvin's circulation theorem derived or even stated accurately – surprising because this is surely one of the basic concepts needed to understand perfect fluid flow. None mentions the stretching of vortex lines. The steady version of Bernoulli's theorem is used with gay abandon in *Applied Fluid Mechanics*, while *Fundamentals of Fluid Mechanics* goes to the other extreme, repeatedly warning the student that its validity is restricted to inviscid, steady, incompressible, flow. No $\partial\phi/\partial t$ term in irrotational flow? No $\boldsymbol{u}\times\boldsymbol{\omega}=0$?

A few misprints or slips in calculations are perhaps excusable in the first edition of a textbook, but statements that are incomprehensible, nonsense or completely erroneous are not. The following examples are culled from an unfortunately much larger set noted in these books. From *Fluid Physics*, p. 11: 'The coefficient of viscosity may vary with temperature and pressure perhaps, but it is more or less unique for a specific fluid'. *Applied Fluid Mechanics* p. 330: 'Only frictionless fluid can undergo irrotational motion'. *Intermediate Fluid Mechanics*, p. 27: 'The vorticity vector satisfies the relationship $\nabla \cdot \zeta = 0$. This divergence relationship is similar to that for the velocity when conservation of mass is expressed for steady incompressible flow. Thus, vorticity is conserved'. And on p. 29: 'We see that the mathematical expression for the *kinematic* notion of irrotational flow (i.e. to do with motions) is

$$\nabla \times \boldsymbol{q} = 0. \qquad (3.5)$$

If this is the case, as it is in ideal fluid flow, then the operator ∇ must be parallel or antiparallel to the velocity vector $\boldsymbol{q}$. The gradient of any scalar, ∇ (anything), must be a vector aligned with ∇ and hence aligned with $\boldsymbol{q}$ according to (3.5)'. From *Applied Fluid Mechanics*, question 9.7 on p. 335: 'Show that if a flow is incompressible and steady, then the density field must be homogeneous'.

Enough. An instructor responsible for beginning a course in fluid mechanics may wish to consider the book by Munson, Young & Okiishi, but this reviewer cannot recommend the others.

O. M. Phillips

Studies in Nonlinear Aeroelasticity. By Earl H. Dowell and Marat Ilgamov. Springer, 1988. 455 pp. $68.

This book will serve as a valuable introduction to the title theme, although Soviet work is under-represented in some aspects. Indeed, the two authors appear to have written their sections quite independently, with little attempt to do more than juxtapose work from Western and Soviet scientists in different sections. The book begins with sections on basic fluid mechanics and the nonlinear theory of thin elastic shells. These are followed by careful general formulation of problems of the interaction between fluid and thin shells, classified three-fold according to the degree of bending of the shell. Shells with small and large bending, in separated and unseparated flows, are then considered, in a section sixty pages long and based very largely on Soviet work not easily accessible in the West (with thirty references to recent Soviet work). Chapter IV, on interaction of a permeable shell with flow (with applications to the dynamics of parachutes and nets), also draws heavily on Soviet work. It is followed by Chapter V, which deals with self-excited nonlinear oscillations of bodies in flow on the basis of Galerkin (modal) expansions of the solutions of a nonlinear partial integrodifferential equation for displacement, taking the example of flutter of a buckled plate. This gives a deterministic autonomous system displaying regular and chaotic behaviour; it is studied by classical and modern dynamical systems approaches. As a second example, model nonlinear oscillator systems are constructed to describe the dynamics of bluff bodies, a van der Pol equation for the lift force being driven by nonlinear functions of the displacement, this displacement satisfying a linear oscillator equation driven by the lift force. Flutter of airfoils in transonic regions is also studied, using a variant of the 'describing function' technique to include, approximately, aerodynamic nonlinearity. Chapter VI discusses unsteady effects in transonic aerodynamics more generally and in more detail, to determine conditions under which the aerodynamic forces can be taken as linear in the airfoil motion, and discussing the significance of the multiple solutions that are sometimes found in conditions for which the aerodynamic forces are nonlinear functions. Also included here are discussions of computational procedures for attacking the fluid mechanical equations for unsteady transonic conditions, and the use of such computer codes in flutter analyses. This chapter concludes with extensive analysis of nonlinear flutter in the frequency domain (describing functions, the attainment of limit cycles, etc.) and comparisons with time-marching computations. There is much useful mention of open questions in this section, and a good set of references up to 1985 (the chapter appeared in earlier form in *Recent Advances in Aerodynamics*, eds. A. Krothapalli & C. A. Smith, Springer 1986, but the references have not been updated). Chapter VII forms an introduction to modern dynamical systems ideas in an appropriate context – that of a forced Duffing equation, with brief notes on the Lorenz equations; the material is standard, but is explained effectively and informally. The last chapter reports work up to 1986 on stability of flow over compliant coatings and the delay of transition to turbulence. The status of many ideas in this field is less clear than in flutter analysis (and many of the problems relate to linear mechanisms), and papers continue to appear in some numbers. This is nonetheless a sensible and useful account, although it is regrettable that (being written at the solicitation of the US Office of Naval Research) it makes almost no reference to an extensive body of Soviet research in this area. Three Appendices (total length 70 pages) conclude the book, on dynamical chaos, on the approximate calculation of vortex-induced oscillation of bluff bodies, and on simple ad hoc models of unsteady separated flow over streamlined bodies.

D. G. CRIGHTON

Turbulence and Combustion. By V. R. KUZNETSOV and V. A. SABEL'NIKOV. Hemisphere, 1990. 362 pp. £71.

The title of this book should be taken literally. It is on turbulence and on combustion, not so much on turbulent combustion, as one may have expected. The first four out of seven chapters treat constant-density, essentially non-reacting turbulent flows with emphasis on probability density function (p.d.f.) methods, while the remaining three chapters consider non-premixed, premixed and partially premixed combustion without really relying on the former. As the authors state in their introduction, the selection of the contents in this monograph has largely been 'dictated by the authors' own investigations'.

These investigations have been published exclusively in Russian journals and many of them seem not to have received the appropriate attention in the West. Chapter 1 deals with intermittency and its manifestation in the qualitative form of probability density functions. Chapter 2 present joint p.d.f. equations for velocity and scalars. What seems to be new and original here is the analysis of a two-point conditional velocity difference p.d.f.

In Chapter 3 equations for conditional passive scalar p.d.f.s are considered and solutions are presented. In contrast to most of the work in the West, where the closure of the molecular diffusion term in the p.d.f. equation is achieved by using Curl's model, the present authors model this term by assuming statistical independence between the scalar and the scalar dissipation. The molecular diffusion term then keeps its original structure as a negative second derivative in scalar space with the unconditional scalar dissipation replacing the diffusivity. The result is an anti-diffusion equation whose mathematical properties and solutions are discussed. A fair amount of comparison with the authors' and other experimental data is presented. This chapter is certainly one of the most interesting in the book.

Chapter 4 is on a classical subject, the statistics of small-scale turbulence. It follows the Russian tradition in this area which is well documented in the two volumes *Statistical Fluid Mechanics* by Monin and Yaglom (MIT Press, 1975). The emphasis here is again on two-point p.d.f. formulations which include intermittency in a more explicit way than moment methods. Experimental data on intermittency from various sources were to be presented in four tables, but it is annoying to find the relevant columns in these tables empty.

Chapter 5 is on non-premixed turbulent combustion. The advantages of using the mixture fraction as a conserved scalar are noted and model equations for its mean and variance are presented and solved. Unfortunately, the important difference between conventional averages and density-weighed (Favre) averages does not receive the emphasis it deserves. An interesting analysis concerns the effect of radiative heat loss in the optical thin gas approximation, in particular its consequences for NO-formation. Except for the latter, chemistry is only considered in the close-to-equilibrium, large-Damköhler-number limit, which appears questionable at least for hydrocarbon flames.

Chapter 6 is on premixed turbulent combustion. It addresses the yet unresolved problem of the turbulent burning velocity from a phenomenological point of view. Several fundamental concepts such as flame stretch, flame instability and the effect of unequal diffusivities on the laminar burning velocity are discussed qualitatively, ignoring the more rigorous work based on activation energy asymptotics due to Sivashinsky and many others. Premixed combustion in high-intensity turbulence and its consequences for flame stabilization by blunt bodies is also discussed.

Finally, Chapter 7, entitled 'Turbulent combustion of partially premixed gases' deals with a variety of problems, ranging from liquid fuel sprays and droplet combustion, local extinction effects in diffusion flames, and the burning and after burning of fuel rich premixed gas or unburned fuel in a diffusion flame. These topics are again treated essentially qualitatively without reference to detailed chemical kinetics.

The book finishes with some profound concluding remarks on p.d.f. versus moment models and the role of intermittency. The extensive qualitative discussions throughout the book are worthwhile physical interpretations of many important effects in turbulence and combustion. Often it is difficult to trace back all assumptions and approximations used in constructing the mathematical models that are examined in detail. Specialists in turbulence and combustion, however, will find very interesting analyses and observations, and they will gain access to a specific Russian scientific tradition and some important technical results that they may not have been aware of.

It seems that the English translation did not undergo a careful review by a specialist in the field. Otherwise, translations such as 'probability density fluctuations' for p.d.f.s (rather than 'probability density functions'), 'small-scale pulsations' (for small scale fluctuations), 'vortices' (for eddies), 'diffusion plume', 'frontal combustion' and many others would have been corrected.

N. PETERS

Buoyancy-Induced Flows and Transport. By B. GEBHART, Y. JALURIA, R. L. MAHAJAN and B. SAMMAKIA. Springer, 1988, pp. 1001. DM 348.

Buoyancy-induced flows occur when a body force, usually gravity, interacts with inhomogeneities in the density field of a fluid. The resulting motions occur on scales of a few centimetres, for example the motion induced by a hot-wire anemometer, to scales of hundreds of kilometres for interior planetary motions and atmospheric circulations. The flows arise in a wide range of important application areas such as technology: solutal convection in crystal growth and the cooling of printed circuits; the environment: geothermal systems; and biology: cooling of animals and photosynthesis. Thus in setting out 'to draw together current knowledge over a considerable and representative part of this broad and diverse field', the authors are faced with a formidable task.

The systems governing buoyancy-induced flow are nonlinear coupled equations, and consequently the techniques for making theoretical inroads are limited. Over the last three decades the use of asymptotic expansions has been the most popular approach and, since Gebhart and his many students have been prolific devotees, it is not surprising that it predominates in the work presented in the book. The first twelve (out of a total of seventeen) chapters of this very substantial book are concerned with boundary-layer solutions, the vast majority of which describe laminar flows. The authors exhaustively review the solutions for all the simple geometries from plates, spheres and cylinders to point and line sources. The treatment includes coverage of the stability of pure thermal convection, combined thermal and solutal convection and anomalous convection near a density extremum, and also includes experimental work. Unexpectedly, in view of the book's title, a chapter on mixed convection is included, where there is both forced and buoyancy-induced motion. The final five chapters cover (in much less detail) Rayleigh–Bénard convection, convection in enclosures and porous media, non-Newtonian fluids and more specialized situations involving rotational and radiative effects, for example.

It is not clear from reading the preface whether the authors regard the book as a research monograph or a graduate text. On the one hand, it is stated that 'the aim has been to bring certain fields up to date to help both those who use such information and those attempting to extend it'. On the other hand, it is suggested that the book would be suitable as a course text. Whatever the aim, it is certainly true that a researcher with a laminar free-convection boundary-layer problem will find the book very useful as a source text and, in the absence of comparable texts, this could also be said for workers in other fields – in porous-media convection, for example. Readers are cautioned, however, that the coverage of the various topics is uneven, and reflects very strongly the authors' own research contributions.

It is difficult to recommend the book as a course text (previous books by Gebhart and by Jaluria are better in this regard). It would have been preferable to have included more interpretation of results and more emphasis on particular applications: the reader is left to guess the usefulness of the idealized models. The style of writing is a little ponderous and repetitive, and there is too little overview (one might say too much heat, and not enough light!). Moreover, I do hope that, in any revision of the book, the authors eliminate the sloppy equating of vectors and scalars in the first two chapters.

In summary, despite reservations over the book as a recommended text, it should prove a valuable source text for work in the field of laminar free-convection boundary layers.

D. S. Riley

SHORTER NOTICES

Developments in Fluid Mechanics and Space Technology. Edited by R. NARASIMHA and A. P. J. ABDUL KALAM. Indian Academy of Sciences, 1988. 454 pp.

This collection of articles by different authors, some of which were presented as invited lectures at the 3rd Asian Congress of Fluid Mechanics held in Tokyo in 1986, has been put together as a tribute to Satish Dhawan, the father of fluid dynamics and space research in India. There is no mention of any particular event or birthday of Professor Dhawan at which the volume was presented; perhaps it was simply a recognition of his GOM status after a distinguished career as Professor, Head of the Department of Aeronautical Engineering, and later Director of the Indian Institute of Science at Bangalore, and as Chairman of the Indian Space Research Organization. The articles were chosen to reflect his wide research interests in fluid mechanics, turbulence in particular, and in space technology, and the breadth will tax a normal reader.

Advances in Transport Processes, Vol. IV. Edited by A. S. MAJUMDAR and R. A. MASHELKAR. Wiley Eastern, 1986. 617 pp.

Like its three predecessors, this nicely printed volume presents authoritative reviews of fundamental and applied topics in heat, mass and momentum transport. The topics reviewed here in nine articles are mostly ones of interest to chemical engineers, although transport processes in liquid metals and in hot plasmas are included. There is a genuinely international selection of authors, and all have tried to address practical problems from a fundamental viewpoint. A minor criticism is that in five of the articles references are listed at the end in the order of their appearance, with numbers connecting the references with the text. This seems particularly unsuitable for review articles. A sentence such as 'these models were developed for the thermal treatment of powders in d.c. plasma torches (186, 191, 198, 199, 200)' does not enable a reader to make use of his knowledge of some of the names of key contributors; and the sensible plan of scrutinizing a list of references to see what type of material is reviewed in an article is almost impossible when there are over 100 references in random order.

Particulates and Continuum: Multiphase Fluid Dynamics. By S. L. Soo. Hemisphere, 1989. 400 pp. $49 or £35.

Multiphase Fluid Dynamics. By S. L. Soo. Science Press (Beijing) and Gower Publishing, 1990. 691 pp. £55.

These two books appear to be out-growths from the author's book *Fluid Dynamics of Multiphase Systems* published in 1967. The style is similar, the contents lists have several common chapter and section headings, portions of the text of the earlier book are used again, and the references are mostly as in the earlier book. The 1967 book was not notable for its treatment of fundamentals, but it had a pioneering quality. The two recent books cannot be said to make further advances in this difficult but rapidly developing field.

Thermodynamic Tables in SI (metric) Units, 3rd Edn. By R. W. Haywood. Cambridge University Press, 1990. 42 pp. £8.95 or $14.95.

A new edition of a handy book for students which differs in some details from the previous editions published in 1968 and 1972.

Internal Flow Systems, 2nd Edn. By D. S. Miller. BHRA Information Services, 1990. 396 pp. £56.

A review of the first edition of this hand-book of flow information useful for design engineers was published in *J. Fluid Mech.* vol. 58, 1973, p. 415. The second edition has been revised in detail and brought up to date, and there are new chapters on 'Management of design of flow systems' and on 'Compressible flow'.

Algebraic and Spectral Methods for Nonlinear Wave Equations. By N. Asano and Y. Kato. Longman, 1990. 418 pp. £69.

This research monograph is a mathematical treatment of solitons and related solutions of nonlinear partial differential equations. It opens with the theory of Lie groups and moves through Bäcklund transformations to the inverse-scattering and related methods. Many of the nonlinear wave equations which appear frequently in the *Journal of Fluid Mechanics* also appear here, though sometimes cloaked by mathematics. The chapter titles are 1 Point transformation, 2 Higher order transformation, 3 Recursion operator and Lax pair, 4 Variational and Hamiltonian formalisms, 5 Inverse scattering method, 6 Inverse-scattering and related methods, 7 Waves with finite or periodic boundary value, 8 The Fredholm theory and $N\times N$ Zakharov-Shabat operator. There is a useful long list of references, including many recent ones. No applications to fluid mechanics or, indeed, other branches of science are treated. This book, then, is useful in covering mathematical methods fundamental to some nonlinear waves in fluids, but peripheral to the interests of most readers of this journal.