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REVIEWS

An Introduction to Computational Fluid Mechanics. BY CHUEN-YEN CHOW. Wiley, 1979. 396 pp. £11.50.

Applications of Numerical Heat Transfer. BY E. F. NOGOTOV. McGraw-Hill, 1978. 142 pp. $27.50.

What should a book on computational fluid mechanics contain? There are numerous possibilities. For example, it could simply catalogue various techniques of solving a limited range of problems with few, or no, numerical illustrations; or at the other extreme it could cover a large number of topics with many illustrative numerical examples. The book by Chow falls into the latter category. It is an introductory volume which describes numerical techniques of use in a wide variety of topics in fluid mechanics. The presentation of the material is largely by means of specific problems. Each is introduced by a statement of the relevant theory, giving at least the equations to be solved. The computational problem is then formulated by means of a computer program written in FORTRAN and is solved with specific data giving a definite solution with tangible results. Many examples are solved in this way and the computer programs, including the list of principal variables and the output, take up almost one third of the book.

The first chapter deals with various cases of the dynamics of a body which is in motion through a fluid. The numerical equipment needed here is simply a suitable method for solving systems of ordinary differential equations with given initial conditions, such as the Runge–Kutta method. Several versions of this method are exploited quite thoroughly and a number of the illustrations are, allowing for the assumptions made, probably quite instructive to a student of fluid mechanics. The second chapter is concerned with inviscid flows. It starts with finite-difference methods for one-dimensional problems of boundary-value type and then turns to problems in which flows are created by superposition of basic elementary flows. The foundations of these methods are to be found in books on inviscid fluid mechanics and aeronautical engineering, although sufficient introduction is given for each topic to be intelligible. Some methods, such as the method of conformal mapping and von Kármán's method of source distribution, have a long history. The new point here is the illustration by computer studies. Many of the programs are quite simple, but for those readers unfamiliar with computing there is an amount of useful information. Some two-dimensional flow problems of elliptic and hyperbolic type are considered later in the chapter. The numerical treatment of these is standard and similar to that to be found in most books on the numerical solution of partial differential equations.

Chapter 3 considers numerical methods for viscous fluid flows. First, there are treatments of one-dimensional problems for the motion of plane shock waves and incompressible boundary-layer flows. Problems of flow in pipes and open channels governed by Poisson's equation in two dimensions are considered and then there is some material on methods for solving parabolic equations and, finally, a section on Stokes' flow. This last section has many of the elements necessary to solve the full Navier–Stokes equations for two-dimensional flow. The author could fairly easily

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have extended his treatment to these equations at this stage by including the nonlinear terms. As a minor point in this section, I could not understand all the equations used to derive a formula for calculating the wall scalar vorticity given on p. 280. The fourth chapter again gives numerical treatments of numerous problems, from flow past a sphere using the method of Galerkin through to Bénard convection and problems involving the spin-up of fluids. It includes on the way such problems as the rolling up of the trailing vortex sheet behind a finite aerofoil and Helmholtz instability of a velocity discontinuity. There is a section on upwing differencing and artificial viscosity in finite-difference approximations without much detailed discussion, although the method is used in subsequent problems.

Because of the large number of topics considered, it is not possible to give a detailed study of any of them in depth and there is a tendency to move from one type of problem to another with a lack of cohesion in places. I would like to have seen more on different techniques of solving Poisson's equation, which is quite a central problem in fluid mechanics, and perhaps a bit more on solving the Navier–Stokes equations. In fact, a few less topics with a little more detail might have been an improvement. Nevertheless, the book is addressed to senior undergraduate and graduate students and if its object is to acquaint them with the subject of numerical fluid mechanics and the many different problems which can be solved by computational methods, along with programming methods, then it should succeed. There are many suggested problems for a reader to try.

The book by Nogotov is of quite a different character. Largely speaking it is not about fluid mechanics but rather about heat transfer, although there is a chapter devoted to convective heat transfer in fluids subject to the Boussinesq approximation. However, the numerical methods discussed are applicable with some modification to many of the problems which arise in fluid mechanics. In this sense the book falls into the class of a detailed study of a limited range of problems mentioned at the start of this review.

There are five chapters. The first and last give, respectively, mainly a brief summary of the contents and an equally brief review of some of the methods. The book is entirely on finite-difference methods. The second chapter discusses methods of solution of the heat-conduction equation in a fairly general way, including the concepts of convergence and stability and is in some ways preliminary to chapter 3, in which many detailed methods of solving the heat-conduction equation in one and more space variables are given. All the standard methods of approximation are described, with a sketch of the solution procedure in each case, but no specific problems are solved and no numerical illustrations of any kind are given. In this sense the book is more of a theoretical exposition of methods, which differentiates it greatly from the book of Chow. Of course, the readers of the book will also be quite different and be drawn from professional engineers and research workers in the field of heat transfer.

Chapter 4 deals with convective heat transfer in the same rather theoretical manner. The basic equations are given and then methods follow for the approximation of the governing equations and boundary conditions. They are all reasonably straightforward and are accompanied by an outline of the algorithms for solving the various equations. Most of the usual methods of approximation are discussed including the scheme of upwind differences. The main work of the chapter is on time-dependent problems but steady-state problems are also considered. There is, finally, a brief section on the effects of compressibility. Again there are no numerical examples. As a small comment on this chapter, I found the references in the text to some of the methods and approximations used by other authors very obscure, with no corresponding references in the list at the end. In general, the book does tend to be rather a catalogue of methods. However, there is a considerable amount of material in this book which will be useful to numerical workers in the fields of heat transfer and fluid mechanics.

S. C. R. DENNIS

A Mathematical Introduction to Fluid Mechanics. By A. CHORIN and J. MARSDEN. Springer, 1979. 205 pp. $16.00 (soft cover).

Fluid mechanics has proved to be a fruitful source of challenging mathematical problems since Lamb's first edition of Hydrodynamics appeared, and there is every indication that the source strength is increasing. This book is designed as a graduate text for students well versed in modern analysis who would like to learn about problems in Fluid Mechanics with a view to applying their analytical skills. The authors admit to being highly selective in the topics presented and do not attempt to assess the engineering value of the mathematical models discussed. This is a bold approach which has been attempted two or three times by other authors in recent years, usually with only mixed success because of the intrinsic difficulties and complexities of the subject, wherein lies its attraction.

There are three chapters in the book, each written in lively style. The first discusses the derivation of the Navier–Stokes equation as a model for a viscous fluid and the Euler equation for an inviscid fluid. Particular attention is paid to proofs of theorems about vorticity and the reader is given a sound appreciation of the difficulties in proving existence and uniqueness results. The second chapter discusses potential flow solutions, and gives a derivation of the boundary layer equations, followed by a description of a numerical random-walk procedure for constructing approximate solutions of these equations in terms of the vorticity. It is difficult to believe that either of these chapters will illuminate classical fluid mechanics for the student unless he already has considerable insight into the subject, and the sophisticated analytical presentation seems hardly worthwhile since few proofs are yet available. Moreover, the elementary nature of the applied mathematical material, at least to a student in Britain, conflicts with quite difficult pure analytical ideas. Thus for example on page 86 the equations for a system of vortices are written in Hamiltonian form, with reference made to the fact that the Euler equations themselves form a Hamiltonian system. The question of the integrability of such a system is a difficult one and contrasts with typical velocity and vorticity profiles which are incorrectly sketched on pages 95 and 102.

The third chapter concerns inviscid compressible flow and shock waves and is much more coherent. A careful account of the integral formulation of the conservation laws and of weak solutions of the governing equations gives considerable insight into this topic. Characteristics and Riemann invariants are carefully discussed together with the problems of uniqueness of shocks and the 'entropy' condition. This is extended into an excellent account of combustion waves which fully justifies the approach used.

It would be difficult to recommend this book as a graduate course text in Britain but, with careful selection, there are a number of interesting new looks at traditional material and some introduction to new approaches to long established problems.

A. B. TAYLER

SHORTER NOTICES

Proceedings of the 8th U.S. National Congress of Applied Mechanics. UCLA, June 1978. Edited by R. E. KELLY. Western Periodicals, 1979. 261 pp. $ 4.50.

This volume contains the written version of 13 of the main lectures delivered at the Congress. The lectures cover solid and fluid mechanics, and most present topical reviews of their subjects. The authors of fluid mechanical articles include Dr DiPrima, Emmons, Liepmann, Messiter, Phillips and Tulin.

Flow Measurement of Fluids. Edited by H. H. DIJSTELBERGEN and E. A. SPENCER. North-Holland, 1978. 587 pp. $80.00.

This contains the Proceedings of FLOMEKO 1978, the conference sponsored by IMEKO (the International Measurement Confederation Technical Committee on Flow Measurement) in Groningen, Netherlands, 11–15 September 1978. For those concerned with flow measurement of fluids in pipes and open channels, this was an important conference and drew together many leading authorities from industry, government laboratories and universities. In the published volume, the editors have included a list of international standards dealing with flow measurement. The list of contents is subdivided into subject headings which reflect the editorial emphasis on calibration and industrial experience. However, the rather unusual procedure is adopted of repeating the title and page number of a paper which falls into more than one category. The impression given is of very many more papers than the 73 which I estimate were presented. The first two sections (26 papers) concern metrology, standards, calibration facilities, etc. Descriptions were given of various facilities, methods of calibration and transfer standards by experts from several countries and laboratories. The remaining sections deal with each type of flowmeter (although the vortex flowmeter is under-represented) and particularly with the effects on calibration of upstream devices causing flow profile distortion, pressure and flow fluctuation, deformation of orifice plates, etc. In addition new designs and special applications were covered by some authors.

Proceedings of the Dynamic Flow Conference 1978 on Dynamic Measurements in Unsteady Flows held in IMST Marseille, France, 11–14 September 1978 and Johns Hopkins University, Baltimore, U.S.A., 18–21 September 1978. 1040 pp.

These are the proceedings of the third and in this case twin conferences in a series initiated by DISA Elektronik. The twin conferences were sponsored by their host institutions as well as DISA and emphasis was placed on invited state-of-the-art reviews and tutorial lectures. The major sections are entitled (number of papers in each section are given in brackets): Probes for Multivariant Flow Characteristics (6);

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Measurements in Intermittent and Periodic Flow (9); Measurements in Two-Phase Flow (7); Transducer Techniques (11); Special Problems (8); Signal and Data Processing (7); Multichannel Measurements and High Order Statistics (6). Two papers are in French, the rest in English. Most of the papers concern laser doppler anemometry or hot-wire anemometry and the emphasis is on measuring methods and signal and data processing rather than results. However, other techniques are included where the scope of the review requires it, and one or two papers concentrate on other techniques (e.g. sonic anemometer). Also the 'Special Problems' section discusses very varied applications including internal combustion engines and artificial heart valves. Many of the contributors to this volume are internationally known and respected and several of the reviews will provide a valuable source of information, the more specialized papers being useful to a smaller readership. Its greatest value may be in directing the reader to other references (for one paper as many as 239 references).

Light Scattering in Solids. Edited by J. L. BIRMAN, H. Z. CUMMINS and K. K. REBANE. Plenum Press, 1979. 535 pp. $ 55.00

The papers in this volume were presented at the Second U.S.A.–U.S.S.R. Symposium on Light Scattering in Condensed Media held in New York in May 1979. The majority of the 50 papers deal with light scattering from solids and a wide variety of topics is covered including nonlinear optics, crystals and semiconductors. There are also contributions involving phase transitions and critical phenomena (in liquid helium, gels, polymers and liquid crystals), and two papers are concerned with the transition from laminar fluid flow to turbulence. One is little more than a bibliography, the other, by Swinney, reports experiments on Taylor–Couette flow.

Lectures on Wave Propagation. By G. B. Whitham. Springer and Tata Institute of Fundamental Research, Bombay, 1979. 148 pp. $ 8.00 (paperback).

These lecture notes are based on a course given by the author at the T.I.F.R. Centre, Indian Institute of Science, Bangalore in 1978. The first three chapters provide an introduction to nonlinear waves and are abbreviated from the author's *Linear and Nonlinear Waves* (Wiley, 1974). The remaining chapters deal with water waves, especially on a sloping beach, and develop exact solutions of the Burgers, Thomas and Korteweg–de Vries equations. Several of the derivations of known results are both novel and impressive, and that (which is credited to the author's student Rosales) of the Marcenko integral equation associated with the KdV equation suggests the possibility of powerful extensions.

Mechanics of Wave-Induced Forces on Cylinders. Edited by T. L. SHAW. Pitman, 1979. 752 pp. £22.50

The 752 pages of this book provide a record of the proceedings of a conference held at Bristol in September 1978. The subject matter is less restrictive than the title suggests and the volume covers many fundamental and applied aspects of fluid loading relevant to the design of off-shore structures. There is a bias, however, towards the understanding of the complex problems that arise when the effects of viscosity are important and when loading is in the so-called drag/inertia regime. Nearly a third of the book is devoted to eight review papers that discuss wave environment as well as wave-induced forces. Research into wave-current interactions and the mechanics of breaking waves is reviewed and methods for calculating wave forces on large structures using diffraction theory are described. Forces measured on cylinders in planar oscillatory flow as well as in waves are presented and the role played by coherent vortex shedding is discussed. Analytical methods that are available, or are being developed, to calculate oscillatory flows past cylinders with vortex formation are also described. Other important aspects of the problem reviewed are the probabilistic approach to wave loading on structures in the sea and the flow-induced oscillation of underwater cables. The reviews are supplemented by a further 40 papers and together provide a useful contribution to the understanding of wave-induced forces.

CORRIGENDUM

Potential/complex-lamellar velocity decomposition and its relevance to turbulence

By Ronald L. Panton

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There is an error in the above paper. There the velocity field is split into two parts employing a seldom used decomposition. One is a potential part, denoted by $\boldsymbol{\alpha}$, and the other is a complex-lamellar part, denoted by $\boldsymbol{\beta}$:

$$\mathbf{v} = \boldsymbol{\alpha}+\boldsymbol{\beta} \tag{1}$$

where

$$\boldsymbol{\alpha} = \nabla\phi \tag{2}$$

and

$$\beta.(\nabla\times\boldsymbol{\beta}) = 0. \tag{3}$$

Since $\boldsymbol{\alpha}$ is an irrotational vector, the vorticity $\boldsymbol{\omega}$ can depend only on the complex-lamellar part:

$$\boldsymbol{\omega} = \nabla\times\mathbf{v} = \nabla\times\boldsymbol{\beta}. \tag{4}$$

Equation (3) constitutes the definition of a complex-lamellar vector, i.e. a vector which is perpendicular to its own curl. This means that $\boldsymbol{\beta}$ will be perpendicular to the vorticity $\boldsymbol{\omega}$. In addition to the equations above, a further condition or restriction is required to make the decomposition unique. It is on this point that the paper is in error. To be specific, §4 of the paper contains a discussion of various local conditions which might be used to make the decomposition unique. In fact, it is not possible to apply a local condition at every point in the flow; this would overdetermine the decomposition.

The type of extra conditions which are allowed may be illustrated by casting $\boldsymbol{\beta}$ in terms of potentials and using a simple geometric illustration. The complex-lamellar component may be expressed in terms of two potential surfaces such that

$$\boldsymbol{\beta} = \psi\nabla\chi. \tag{5}$$

It turns out (as discussed in the paper) that surfaces where ψ and χ are constant are surfaces which contain the vortex lines. Thus, the intersection of a ψ and a χ