J. Fluid Mech. (1995), *vol.* 282, *pp.* 404–407

REVIEWS

Incompressible Computational Fluid Dynamics. Edited by M. D. GUNZBURGER and R. A. NICOLAIDES. Cambridge University Press, 1993. 481 pp. £35.
Numerical Methods for Advection-Diffusion Problems. Edited by C. B. VREUGDENHIL and B. KOREN. Vieweg, 1993. 373 pp. 138 DM.

The difficulty in keeping apace with modern work has probably always been a *cri de coeur* of academics but nowhere is this difficulty better illustrated than in Computational Fluid Dynamics (CFD). Indeed CFD involves developments in two fields, numerical analysis and fluid dynamics, so that it is little wonder that advances in each field seem to race without much reference to the other. In addition to the diverse disciplines of numerical analysis and fluid dynamics there is a great diversity of application of CFD. Thus one use may be to predict a coarse global physical quantity such as lift or drag on a body whilst another use may involve the precise interaction of eddies with different length and time scales. How is the numerical analyst to understand and appreciate the differences which a fluid dynamicist sees in these two situations and how is the fluid dynamicist to appreciate that an algorithm which successfully predicts the former of these two examples may be very poor when used to predict the latter without meaning that it is a poor algorithm? It is the case that the researcher who comes from either field often can do little but feel a tyro in the other field. It is with this background that one approaches texts which can bridge the two disciplines of CFD, both for existing research workers and as a source for teachers of the next generation of researchers.

The first of these books, *Incompressible Computational Fluid Dynamics*, is a collection of fourteen articles intended to give an overview of current thought within CFD about incompressible flow. One's first reaction on seeing the book is that here will be a systematic study of the interaction between incompressible flow theory and numerical analysis. With chapters which address primitive variable methods, finite element methods, spectral methods, covolume methods, vortex methods and adaptive mesh refinement one looks for but fails to find any cohesion between the chapters. Indeed the editors could not even face the prospect of attempting cohesion so the chapters are presented in alphabetical order of the first author's name! Thus to some extent the book merely saves one the task of looking for papers on individual topics in different journals. Nevertheless within the book there are chapters well worth reading, probably more use to numerical analysis graduates seeking to move into CFD than fluid dynamicists trying to understand which methods might or might not be appropriate for simulating a particular problem. Overall if one is looking for a text on incompressible CFD then one would do better to read a unified text such as the two volumes by Hirsch, and if one wants to see what methods are at the forefront of research then this merely provides an entry and it is still necessary to look to journal publications.

The second book, *Numerical Methods for Advection-Diffusion Problems*, is also a collection of papers, but this time based on a seminar organized at the Institute of Marine and Atmospheric Research in Utrecht. This, and the relatively narrow remit, means that the book does have a cohesive feel. Following an introductory chapter, the book has chapters on traditional finite difference schemes, spectral methods, finite element methods, Lagrangian-type methods and flux splitting methods. The last third of the book is not about advection-diffusion directly, but describes conjugate gradient and multi-grid methods for solving large systems of linear equations. I found the book stimulating to read and it could easily be used as the basis for a graduate course. Naturally there have been developments in the time taken to produce the book which are not covered, but it does give a reasonably broad view of numerical methods for advection-diffusion. What I found missing was any real physical insight into the origin of the advection-diffusion problems or insight into the consequences of different approximation errors. The book seems to present the view of numerical analysts who have been given a dry partial differential equation rather than a study of the single most important equation in fluid dynamics. Thus for instance, the authors use a cell Péclet number and consider values around 2 or 3 when nearly all practical problems cry out for methods which will be effective at cell Péclet numbers of thousands or tens of thousands. The book describes how numerical schemes can introduce wiggles in the values of an advected quantity, yet bypasses the question of the physical consequences of these wiggles: are they important; always or only sometimes? I think this book could be read by fluid dynamicists, and the authors have made an effort in the final chapter to compare the effectiveness of different schemes, but in the end, and despite the wide backgrounds of the various authors, this reads as a book by numerical analysts for numerical analysts.

I. J. SOBEY

Fundamentals of Two-Fluid Dynamics. By D. D. JOSEPH and Y. Y. RENARDY. Springer, 1993. Part I: Mathematical theory and applications, 443 pp., DM 168. Part II: Lubricated transport, drops and miscible liquids, 445 pp., DM 168.

The principal function of this book is to bring together the work on the dynamics of two-fluid flows performed by Joseph and collaborators at Minnesota over the past 15 years. Most of this work has already been published in fluid mechanical journals (including *JFM*). The principal topics discussed are: two-fluid flows induced by a rotating cylinder; Bénard convection in a two-layer system; stability of unidirectional two-fluid flows including planar channel flow under gravity, lubricated pipelining and core–annular flows in vertical pipes. Two final chapters consider the formation of vortex rings by a sedimenting liquid drop and the motion of miscible liquids. This is an eclectic choice of topics for a two-volume set entitled *Fundamentals of Two-Fluid Dynamics*: only passing reference is made to (say) evaporation, the properties of surfactants, Marangoni effects, the problems of contact-line motion, emulsion formation by shear, drop coalescence, bubbly liquids, foams or water waves. In fact, the core of the work described here is the *stability* analysis of some two-fluid flows. This is not a textbook for those interested in fundamentals.

The style of presentation of theory is equally idiosyncratic. Some chapters include careful, disciplined and mathematically complex, weakly nonlinear stability analysis. Others descend to the folksiness of 'High viscosity liquids are lazy. Low viscosity liquids are the victims of the laziness of high viscosity liquids because they are easy to push around'. This latter insight is even translated into a 'variational principle', a phrase used by the authors, but no-one else, to mean a statement of principle 'in which some people believe but cannot prove'. Of course, analysis elsewhere in the text shows that the principle is in general false.

The books also include accounts of several experimental studies with beautifully reproduced colour photographs of some free-surface flows, including the best that I have seen of an apparent cusp, of instabilities on rotating free surfaces, and of vortex rings. But here again the style is uneven with, for example, a table showing whether vortex rings will form for pairs of poorly characterized liquids – some exhibiting surfactant effects at their interface, some probably non-Newtonian. One wonders whether the fundamentals are here being obscured.

For those with a research interest in the theory of instabilities of two-fluid flows this collection of papers may prove useful. Those students less directly involved, and those whose libraries operate on more limited budgets, will consult, as necessary, the journals where the papers first appeared.

J. M. RALLISON

Flow-Induced Vibrations: An Engineering Guide. By E. NAUDASCHER and D. ROCKWELL. Balkema, 1994. 413 pp. Hfl 195.

This book is concerned with the vibration of bodies surrounded by fluid. In principle the study of such problems is very difficult, since in typical engineering systems they involve a structure with complicated geometrical and elastic properties, whose motion is fully coupled with the motion of the (often turbulent) fluid. An extraordinarily wide range of such problems exists, across the whole spectrum of mechanical engineering. In order to make progress one therefore needs to make both considerable physical simplifications and to adopt some classification of the various types of motion, and that is exactly the approach adopted by Naudascher & Rockwell. Their generic system is viewed as a set of body oscillators and fluid oscillators, and the first four chapters describe the basic theory concerned with the dynamic response of these oscillators. The system is then forced by some external excitation, and these are classified as lying in one of three categories: extraneously induced excitation, such as turbulence buffeting of large structures (chapter 5); instability induced excitation, arising from the development of flow instabilities and including such phenomena as vortex shedding from bluff bodies and the jet–edge feedback cycle (chapter 6); and motion-induced instability, which unlike the other two is intrinsically linked to the motion of the body, and of which flutter is a typical example (chapter 7). The final two chapters are rather different in style, and concentrate on the application of the simple ideas developed earlier in the book to studying the vibration of more practical systems (chapter 8 with regard to the response of the flow and chapter 9 the response of the structure).

The authors have succeeded in their aims of writing a clear and comprehensive review of what is a vast area, and of presenting the material in a logical and modular form which will allow its ready application to particular practical problems. By necessity some sections of the book are rather short (the coverage of fluid loading seems particularly brief), but copious references are given, and the important thing is that the key ideas are communicated clearly. The fluid-mechanical purist might also object to some of the simplifications used (representation of complicated flows by single oscillators, etc.), but the authors demonstrate that such ideas are entirely relevant by providing extensive experimental justification throughout the text. In short, the book is to be thoroughly recommended, and would be invaluable both as a handbook for practising engineers and as an introduction for researchers interested in this fascinating subject.

N. PEAKE

Numerical Modeling of Ocean Dynamics. By Z. Kowalik and T. S. Murty. World Scientific, 1993. 481 pp. £49.

The upsurge in numerical solutions to oceanographic problems, increasingly concentrating on the nonlinear aspects of ocean circulation, has left the majority of oceanographers lacking a suitable reference to the plethora of approaches now possible. This idiosyncratic books attempts to provide such a reference. The topics extend from one- to three-dimensional models, although the bias is away from three-dimensional modelling, which is somewhat disappointing given the current emphasis on climate change. There is an in-depth treatment of fjord circulations, which seems out of place here. In many cases the book succeeds: its treatment of advection methods and semi-implicit approaches is excellent. Unfortunately the book's technical flaws outweigh its usefulness. The two authors do not appear to have discussed the contents with each other, so that we find sigma-coordinates and nested grids developed twice, but isopycnic coordinates never appear; notation changes abruptly (one section working with both left- and right-handed coordinates). There is no sign of any technical editing: there is an enormous number of errors (especially in the discussion of Cox models), contradictions (especially when problems are solved for the second time), omissions (the top of p. 341 promises model test problems which never appear), confusing and unlabelled diagrams, repetitions, and misplacements (Kelvin waves appear in a chapter on normal modes, and the solution of the time-varying stream-function Poisson equation appears in a chapter on the steady state). The index is extremely cursory. Most references are from the 1970s and before; indeed, in the normal mode chapter only two pieces of work after 1980 are mentioned.

I would like to be able to recommend this book for students of numerical oceanography, but the errors would be more likely to confuse than to assist. However, those already possessing some knowledge of the subject should find the collection of methods of great use, as I shall.

P. D. Killworth