BOOK REVIEWS

Introduction to Computational Fluid Dynamics. By A. W. Date. Cambridge University Press 2005. 398 pp. ISBN 0521 853265. £40.

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The growing importance of Computational Fluid Dynamics (CFD) in many branches of science and engineering has created an increasing demand for properly educated users. Over the years, CFD has gained something of a reputation for promising considerably more than it has delivered. In part this has been due to a succession of over-enthusiastic proponents, but in larger part the difficulty has lain with insufficient appreciation on the part of everyday users of the true strengths and weaknesses of CFD as a tool for analysis and design.

Nowadays CFD is a mature discipline, with robust and efficient solution algorithms as well as reasonably realistic physical sub-models, and its usefulness and reliability are well established in a very broad range of applications. Many research problems remain to be tackled, but the basic principles of CFD are now taught in many undergraduate courses in Engineering and in Applied Mathematics. Nevertheless there is a shortage of good introductory textbooks on CFD which are aimed at an appropriate level, spanning the later undergraduate and early postgraduate years.

In his book, Anil Date offers a useful albeit rather idiosyncratic approach to the teaching of CFD. The level is well judged for a first-year postgraduate student or for a good final year undergraduate.

There are nine chapters and three appendices. The first three chapters follow a fairly obvious and straightforward path from the Navier–Stokes equations and the need for methods of numerical solution, through the discretisation of the one-dimensional heat conduction equation and on to the slightly more challenging one-dimensional conduction–convection equation. The standard second-order methods are explained in both differential and integral forms, and the classical pitfalls are described. The concepts of upwinding and implicitness are dealt with along the way, some examples of solution algorithms are given, and there is a brief discussion of numerical stability.

The next three chapters deal with two-dimensional problems, starting with boundary layers approximated using parabolic equations, moving on to elliptic problems on Cartesian meshes and ending with elliptic problems on curvilinear and unstructured meshes. Topics covered in passing include turbulence modelling, the pressure-correction solution strategy and the classic SIMPLE algorithm.

The final three chapters deal with phase change in mainly one-dimensional problems, mesh generation in two dimensions covering both structured and unstructured cases, and some methods for convergence acceleration. The first appendix provides a derivation of the transport equations, while the other two appendices provide listings of Fortran codes for one-dimensional conduction and for two-dimensional flow using a Cartesian mesh.

Examples of applications are given throughout the book and are quite broadly based, with geometries including channels, nozzles, rod bundles, turbomachinery blades and U-bends and with physics including heat transfer, two-stream mixing and combustion. There are lots of useful diagrams throughout, as well as fragments of Fortran code illustrating specific points of implementation. Every chapter ends with a set of problems to solve, ranging in scope from fairly simple questions to quite substantial programming projects.

It is worth noting that the entire development is firmly rooted in the Imperial College school of CFD, with its strong emphasis on structured meshes and pressure-correction algorithms. This is not necessarily a disadvantage in an introductory text especially since so many of today's commercial CFD codes can trace their ancestry back to the same point of origin. On the other hand, a broader perspective might have been useful in the later chapters, where the advantages and disadvantages of other approaches to CFD could have been discussed with educational benefit. The underlying focus on heat transfer is also slightly too obtrusive in a general text on CFD, and the chapter on phase change seems oddly misplaced.

In terms of the exposition, the English is perfectly readable but does contain some delightfully old-fashioned turns of phrase and rather too many missing articles. CFD is already blessed with too many acronyms: it is not necessary to invent still more such as TSE, IOCV, LRE and HRE. For the explanations, read the book. Concise notation for numerical analysis in CFD is notoriously difficult to achieve, but here some of the notation is downright irritating: does the symbol for the internal heat generation rate really need to have three primes? Worst of all is the use of 'e' instead of the universally accepted 'k' for the turbulence kinetic energy: who has ever heard of the e-epsilon model?

Finally, the book's author is greatly concerned about the need to ensure compatibility between the continuous and discrete forms of the transport equations. There is a most illuminating discussion relating to the implications of this for the discrete pressure field, and a particular formulation is suggested. Nevertheless this difficulty is inherent to many spatial discretisation methods for CFD and can be alleviated in other ways. Again, some broader perspective would have been helpful.

In summary, this is a useful introductory text covering a topic where good books are scarce, and is worthy of inclusion on CFD course reading lists.

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Fluid Dynamics: Theoretical and Computational Approaches, 3rd Edn. By Z. U. A. Warsi. CRC Press, 2006. 845 pp. ISBN 0 8493 3397 0. £39.99

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A review of the first edition of this text in 1996 (vol. 318, p. 408), by my late friend and colleague David Crighton, suggested it was insufficiently user-friendly for the highly competitive market made up by Engineering and Applied Mathematics students. Personally I feel the problem with this volume remains that it is too predominantly theoretical for the former and yet not sufficiently deeply mathematical to suit the latter. Thus, while it provides a good solid text covering all the basics each require, it does so without really satisfying or stimulating students of either discipline.

The present edition adds new sections on free surface flows, on flow instability, chaos and nonlinear dissipation, and on large eddy simulation (LES), but each of these exhibits some clear deficiencies. Particularly notably, in the first of these sections, there is no discussion of surface tracking or volume of fluids methodologies. Then, in the second, the description of 'current approaches to nonlinear modelling' discusses only the output of a single research group over the period 1990–1995, and nothing is included on the latest transition prediction developments. Indeed this key topic