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BOOK REVIEWS

Mathematical and Computational Methods for Compressible Flow. By M. Feistauer, J. Felcman & I. Straskraba. Oxford University Press, 2003. 550 pp. ISBN 0198505884. £59.95 (hardback).

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This book presents an up-to-date overview of numerical methods for the solution of inviscid and viscous flows with particular emphasis on finite volume and finite element methods. The book comprises four chapters which provide comprehensive information for: (i) basic concepts and equations; (ii) basic facts from the theory of Euler and Navier-Stokes equations; (iii) numerical methods for nonlinear hyperbolic systems in the context of finite volume methods; and (iv) numerical methods for finite element solution of compressible flow.

The fundamental concepts and equations are comprehensively described in Chapter 1. This includes a discussion on boundary conditions and advanced mathematical concepts, as well concepts and results from functional analysis. The second chapter presents a number of properties of the Euler and Navier–Stokes equations. It discusses the existence of smooth solutions, breakdown of solution features, theory of weak solutions, the Riemann problem in one dimension, as well as providing a short overview of existence theory for the Navier–Stokes equations of compressible flow. All these topics are covered in detail by presenting several theorems and indicative examples.

Analysis of numerical methods begins in Chapter 3. The chapter starts with a discussion on the properties of the Euler equations, focusing on those properties which are important for the construction of numerical schemes; this part follows from the discussion on properties of the Euler equations presented in Chapter 2. Chapter 3 also provides the basic definitions and concepts for several methods, but a few important schemes or variants of schemes in the framework of Riemann solvers, flux vector splitting schemes and total variation diminishing methods are not discussed. A distinction between high-order and very high-order methods should also have been made. The category of high-order methods includes second-order methods, for example, flux limiting schemes which aim to overcome the theoretical barrier of first-order methods as set by Godunovs theorem. The category of very high-order methods includes ENO and WENO schemes, but also other schemes which are not discussed by the authors. Nevertheless, the chapter gives a fair introduction to several methods for hyperbolic systems including discussion on stability and convergence properties. Most importantly, the chapter presents the implementation of the schemes in the context of unstructured grids. This is followed by a presentation of adaptive mesh refinement and several examples from the implementation of the methods in external and internal aerodynamic flows.

The last part of the book, Chapter 4, presents the streamline diffusion finite element method, the combined finite volume-finite element method and the discontinuous Galerkin finite element method. This chapter is mainly concerned with viscous compressible flows. The authors present interesting results from the application of these methods in both low and high Reynolds number flows. However, they should show how turbulent flow effects (indeed, some cases may also feature transition to turbulence) are modelled in those computations. This omission will create some confusion for the reader. Nevertheless, a comprehensive description of the methods and their properties is given, including several references from recent and past literature.

Overall, despite the limitations mentioned above, the book contains substantial information on numerical schemes within the finite volume and finite element frameworks. A particularly interesting part in this book is the implementation of state-of-the-art methods in the context of unstructured grids. The book is therefore a welcome addition to the computational fluid dynamics literature.

Dimitris Drikakis

Applied Computational Fluid Dynamics Techniques: An Introduction Based on Finite Element Methods. By Rainald Löhner. Wiley, 2001. 376 pp. ISBN 0 471 49843 2. £65 (hardback).

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This fresh new book should be read by anybody who is interested in computational fluid dynamics. CFD books usually treat the subject as an attractive application for applied mathematics; pages of integrals are lovingly converted to differentials, then to tensors, then back to integrals again. Interesting properties are explored: monotone solutions; entropy principles; and so on. Towards the end of such books the author apologetically mentions meshes and hints that real flows around real geometries might produce meshes that are rather ugly and rather spoil the basic elegance of the discretized integrals.

Löhner inverts this traditional rite of passage and starts with data structures. Data structures represent the fundamental architecture used to construct a CFD code. Efficient storage of the mesh, choice of elements, sorting and searching efficiently, linked lists, binary trees, spatial proximity, static and dynamic data derivation, and so on are key considerations and key differentiators between useful and useless CFD. There is clear discussion, illustrated with pseudo-code, of the major issues – I have never seen this in any previous book which purported to inform students about CFD. (My own knowledge in this area was gleaned from painful trial and error and *Numerical Recipes*, (Press *et al.*, Cambridge University Press).) Next, mesh generation is surveyed along with the various families of generation methodology. Again, helpful pieces of pseudo code inform the reader – CFD is a practical subject to be done rather than admired. The author concentrates heavily on unstructured meshes, but, as he clearly explains, all commercial codes these days are based on unstructured meshes, like it or not.

Next come the flow solvers themselves. The description is hierarchical, starting with basic approximation theory on discrete meshes and working via Laplace to Euler then Navier Stokes. The presentation is in the context of finite element methods but it is easy to translate the message into the alternative finite volume one. (Finite element theory is only used in the sense that linear or quadratic basic functions are deployed to discretize the flow equations onto the mesh; minimum energy principles and so on are not used (they are not valid anyway for transonic flow).) It is nice to see a chapter showing how the discrete equations can be deployed on an edge-based data structure (the current orthodoxy) again supported by helpful pseudo-code. It is nice also to have a chapter describing the Flux Corrected Transport schemes which were a precursor to the modern and more fashionable TVD methods. I had forgotten the simplicity and effectiveness of these FCT schemes and resolved to go back to them myself.

Three more chapters, again focused heavily on efficient data structures, complete the book: mesh movement – for moving bodies etc.; mesh-to-mesh interpolation – for multi-grid etc.; and adaptive mesh refinement.

Overall, an excellent book, thoroughly recommended – the best book on CFD, in my view, since Patrick Roache in 1974 (*Computational Fluid Dynamics*, Hermosa). If I have a criticism, it is that nowhere does the author make a coherent case for the need for CFD in the first place nor where it fits in the triad wilh experiments and analysis. Nor does he present an interesting enough range of results to convince a non-specialist of the power and the glory of modern CFD.

W. N. Dawes

Computational Fluid and Solid Mechanics 2003, Volumes 1 and 2. Edited by K. J. Bathe. Elsevier, 2003. 2474 pp. ISBN 0-08-044046-0. $ 450 or € 450.

These two, heavy volumes – proceedings of a conference held at MIT – represent a modern trend: hire an attractive location and then invite hundreds of people to present short 3–4 page papers on a common theme – CFD and Continuum Mechanics in this case. All the papers, loosely refereed then are bound and distributed. I love this sort of thing: hundreds of papers, new ideas and old ones recycled, good work and bad, new topic areas and old favourites, all jostling for attention. It is probably the scientific world's equivalent of a 'coffee table book'. When I have a quiet moment I dip in and read and am always entertained, enthralled and informed. Books like these represent the actual, vibrant, current living community of science and engineering not the stale, two-year old, quality assured archival journals. Required reading for anyone practising in the field.

W. N. Dawes

SHORT NOTICE

Annual Review of Fluid Mechanics, vol. 36. Edited by J. L. Lumley, S. H. Davis & P. Moin. Annual Reviews, 2004. 493 pp. ISBN 0-8243-0736-4. Institutions: $168 (print or online only) or $202 (print + online); Individuals $74 (print + online).

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