J. Fluid Mech. (1998), *vol.* 360, *pp.* 375–378. Printed in the United Kingdom

BOOK REVIEWS

Computational Fluid Dynamics, 2nd Edn. Edited by J. F. WENDT. Springer, 1995. 301 pp. DM 148. ISBN 3 540 59947 1 X.

In the preface, the editor explains that this book is an outgrowth of a von Kármán Institute Lecture Series by the same title, first presented in 1985 and then repeated with modifications in succeeding years. The lectures were delivered by J. D. Anderson, G. Degrez, E. Dick and R. Grundmann. Numerous comments and suggestions encouraged the authors and the editor to improve the content and to streamline the organization, and this resulted in the first edition of this book published in 1991. The second edition features an expanded Chapter 9 on implicit methods for unsteady flows, and additional paragraphs dispersed throughout the book updating the remaining chapters. The objective, as stated by the Editor, is to present the subject of computational fluid dynamics (CFD) to an audience that is unfamiliar with all but the most rudimentary aspects of numerical techniques, and to do so in a way that the practical application of CFD would become clear to everyone.

The authors and the editor were thus confronted by two issues. First, they had to transform lecture notes that were written especially for students who attended the course and had the benefit of physical interaction into a stand-alone and complete text. Secondly, they had to secure uniform quality, avoid duplications, and ensure smooth transitions at the seams, as one author concludes his subject to be followed by another. On the other hand, a multiple-author book benefits from the diversity of expertise and experiences of the contributors.

This book successfully maintains a uniformly good quality and avoids duplication as much as possible; occasional repetitions are instructive. More importantly, differences in style and approach are refreshing rather than confusing. The book covers a broad variety of techniques for computing steady and unsteady flows of incompressible and compressible fluids. It is my impression that it is not meant to serve as a main textbook of a graduate class, and this is suggested by the absence of unsolved problems, but rather as a companion and a reference book.

The book is divided into two parts. The seven chapters of Part I, 179 pages, were written by J. D. Anderson. A footnote on page 94 indicates that this part was not revised since its original writing in 1985, and asks the reader to consult the last six cited references for updates. The four chapters of Part II, 120 pages, were written by G. Degrez, E. Dick and R. Grundmann. Part I will be of interest to those who have no previous experience with CFD and desire a crash course approach. Part II will be of interest to a more experienced audience.

Chapter 1, entitled *Basic Philosophy of CFD*, is an enjoyable advertising campaign for CFD, with arguments and examples drawn from the field of aerodynamics. A successful effort is made to convince the reader that CFD is not a passing fad but a *bona fide* field.

To most academicians and practitioners, the acronym CFD connotes the use of finite-difference, finite-element, and spectral methods, and the finer classifications of them, to solve the equations of mass, momentum, and energy transport for a single fluid possibly with varying physical properties, in their differential or integrated form. Methods for particulate and multi-fluid flow receive scant attention; vortex methods are occasionally mentioned but usually not discussed; and boundary-integral formulations are explained only in the context of irrotational flow. This disparity is in stark contrast not only with the practical usefulness of these methods, but also with the Herculean efforts that have been expended for their development. It would seem appropriate that these methods, and perhaps several others, be placed under the auspices of CFD, and described or at least acknowledged as such in texts that bear the title of CFD without additional qualifiers to indicate a particular focus. An alternative would be to unify the other methods under the auspices of Numerical Fluid Dynamics (NFD) which could then be established as a competitive field.

Chapter 2 is a brief introduction to the governing equations of fluid dynamics written in an informal lecturing mode (it addresses the reader in the second person). It includes the derivation and discussion of the substantial derivative, the physical meaning of the divergence of the velocity, the continuity equation, the momentum equation, the energy equation, and the boundary conditions. The equations are presented in an expanded form; use of vector notation or of repeated-index summation convention is not made, presumably to help avoid errors in the computer implementation. The chapter concludes with an illuminating discussion of the preferable form of the governing equations in the context of CFD.

Chapter 3 addresses boundary-integral methods for incompressible and irrotational flow (source and vortex panel methods) from the perspective of applied aerodynamics. As is common in books on practical aerodynamics, the implementation of the single-layer or vortex-sheet representation of an external flow past a two-dimensional body are discussed in detail, but the feasibility of the representations and the uniqueness of solution of the discrete forms of the integral equations are assumed. A few comments to assure the reader that a firm mathematical basis for these methods is available would be desirable.

Chapters 4 and 5 are brief introductions to linear second-order partial differential equations and finite-difference methods. Chapter 6 is an instructive introduction to structured boundary-fitted grid generation for use with finite-difference methods, including heuristic, elliptic, and adaptive grid generation. Part I culminates in Chapter 7 which presents the results of sample computations worked out by the author and his graduate students, including a detailed discussion of one-dimensional compressible flow through a nozzle. This reviewer wholeheartedly subscribes to the author's preference that a student should have the experience of starting with paper and pencil, developing the numerical method, programming, and post-processing; the use of canned programs is not conducive to learning.

Part II begins with Chapter 8 on boundary-layer equations and their numerical solution, written by R. Grundmann. This is a brief but instructive account of methods for computing two-dimensional and axisymmetric boundary-layer flows over solid surfaces. Boundary layers in homogeneous fluids or along interfaces are not discussed.

Chapter 9, by G. Degrez, addresses implicit time-dependent methods for inviscid and viscous compressible flows, including a thorough discussion of the concept of numerical dissipation. At first sight, this seems too specialized a topic to occupy a whole chapter. As one reads through the well-written sections, however, one is convinced that the attractiveness of CFD lies in the detail. This chapter is written with authority and clarity in a way that is accessible to the beginner; in fact, this chapter alone should be worth the price of the book. Section 9.3, in particular, on the construction of implicit methods for time-dependent problems guides the reader through the fundamental steps involved in deriving intelligent and efficient numerical solvers.

Chapters 10 and 11, on finite-element and finite-volume methods, respectively, were written by E. Dick. Chapter 10 begins with a discussion of the basic idea and fundamentals of the finite-element method, and then proceeds to illustrate specific implementations in fluid mechanics. It is admirable that the author has managed to present a coherent account of the finite-element methodology in a mere 38 pages. Chapter 11 is a survey of finite-volume methods. Different possibilities for cell-centred and cell-vertex formulations are presented, and the stability of methods for solving the equations of inviscid flow are discussed. These chapters will be useful to those who wish to get a quick idea of what these methods are all about, and then proceed to specialized monographs for more details.

Overall, I enjoyed reading this book and I recommend it as a supplement in a short course on CFD (problems and computer projects must be made up by the instructor), as a concise guide to the subject areas addressed, and as a research reference.

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A Practical Guide to Pseudospectral Methods. By B. Fornberg. Cambridge University Press, 1996. 231 pp. ISBN 0 521 49582 2. £37.50.

Pseudospectral methods were developed in the late 1960s. By the mid-1980s much of the research was directed at easing geometric restrictions, at finding effective iterative schemes, and at handling shocks and discontinuities. That progress is well summarized by Canuto *et al.* (1988), and by Boyd (1989). What does Fornberg's book add?

First, Fornberg omits many technical details in favour of a more concise rundown of the practical issues in pseudospectral modelling. Secondly, Fornberg pushes a derivation of the spectral expansion that is based on the limit of high-accuracy finite differences, and then continually explores intermediate approximations ranging from second-order to spectral accuracy. Thirdly, Fornberg selects different applications, including solitons, seismic waves, electromagnetic waves, and numerical meteorology.

Though intentionally sketchy on derivations, this book is dense with helpful diagrams, bullet-list summaries, and implementation tips. The approach strengthens understanding through examples. The references are complete and current. Some Fortran code is provided, though it should be added that pseudospectral routines are on the internet, e.g. the packages of Daniele Funaro (anonymous ftp.ian.pv.cnr.it, in /pub/splib) and of Wai Sun Don and Alex Solomonoff (http://www.cfm.brown.edu/people/wsdon/home.html).

Chapters 1–4 introduce pseudospectral methods and their properties. Chapter 5 covers enhancements to the basic implementations, such as staggered grids and coordinate mappings. Elliptic solvers, in their most robust form, belong to this section as an application of finite-difference and finite-element preconditioning, but readers will need to consult Canuto *et al.* (1988) or Boyd (1989) for real help on elliptic solvers. Chapter 6 features polar and spherical coordinates. As an example of the advice that Fornberg has to offer, here he gives an effective way to reduce the severe grid-point clustering near the polar origin when using Chebyshev series in τ and Fourier series in θ. Instead of the conventional discretization, $0 \leqslant \tau \leqslant 1$, $-\pi \leqslant \theta \leqslant \pi$, the idea is to use $-1 \leqslant \tau \leqslant 1$, $-\pi/2 \leqslant \theta \leqslant \pi/2$, and to note that Fourier series can be retained in θ. Chapter 7 compares pseudospectral and finite-difference computational costs. Chapter 8 is applications. The appendices survey technical matters, including Lebesgue constants, Jacobi polynomials, timestep stability bounds, and fast transforms.

This book will attract and benefit researchers most concerned about model accuracy and resolution, and in this context, concerned about defending their choice of numerical scheme, whatever that choice turns out to be.

REFERENCES

Boyd, J. P. 1989 *Chebyshev and Fourier Spectral Methods*. Springer.

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