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Book Reviews

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Computational Fluid Dynamics: An Introduction, 3rd Edition

Edited by John F. Wendt, Springer, New York, 2009, 332 pp., $109

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The book, now in its third edition, initially grew out of a lecture series on computational fluid dynamics (CFD) held at the von Kármán Institute for Fluid Dynamics in 1985. The objective of the book is to introduce a reader with limited prior knowledge of numerical techniques to the computation of fluid flows. The stated goal of the third edition is to present updates and clarifications while preserving the book's introductory nature. The focus of the book is exclusively on aeronautical applications. The book consists of 12 chapters arranged into three parts.

In part 1 (147 pages), seven introductory chapters by J. D. Anderson contain an explanation of the motivation for CFD, a derivation of the governing equations, a description of the source and vortex panel methods for inviscid incompressible flow, a discussion of the mathematical properties of the governing equations, an introduction to the finite difference method and von Neumann stability analysis, an outline of the transformation of the governing equations using curvilinear coordinates, and an overview of some selected CFD applications for inviscid and viscous flows. These chapters, written in J. D. Anderson's usual clear and informal style, are likely to further stimulate the interest of the reader. Three highlights worth mentioning explicitly are the use of the blunt-body problem to motivate the use of CFD, an excellent example of the application of the source-panel method to the potential flow around a circular cylinder, and the discussion of the benefits of the strong conservation form. One weakness of part 1, admitted by the author in a footnote in Chapter 5, is the absence of references to more modern works and/or textbooks that an interested reader could consult for additional information. For example, only one reference that was published after 1995 (when the second edition of this book appeared) could be found.

In part 2 (149 pages), four chapters cover more advanced material. The derivation and implicit solution of the boundary-layer equations for laminar flows are presented in a chapter by Grundmann. The chapter on implicit solution methods for time-dependent inviscid and viscous compressible flows and numerical dissipation by Degrez is one of highlights of the book. In a clear and systematic manner, Degrez introduces explicit and implicit solution methods, their stability properties, A-stability, numerical dissipation, and describes how efficient implicit methods can be developed. The explanation of the need for numerical dissipation and its extension from scalar problems to systems of conservation laws is excellent. The last two chapters of part 2 by Dick introduce finite element and finite volume methods. In the chapter on finite element methods, the reader is exposed to a clear and systematic description of weighted-residual methods, the Galerkin method, weak formulations, and shape functions. The implementation of the finite element method is described and illustrated through two examples. The chapter on finite volume methods follows a similar style and is particularly successful at pointing out similarities and differences of cell-centered and node-centered formulations in comparison to finite element and finite difference methods. With the exception of the chapters by Dick, only one reference to works published after 1995 has been added to part 2.

Compared to the second edition of the book, the most significant change is the addition of part 3 (24 pages). In that part's only chapter, Vierendeels and Degroote outline the basic steps required in obtaining a flow solution using commercial CFD packages. The authors devote several pages each to point out potential pitfalls such as tolerance issues related to the geometry description and the generation of grids with suitable resolution. However, the danger of inexperienced users with limited understanding being seduced by black-box codes with graphical user interfaces and complex physical models into trusting any simulation result is barely mentioned. Sections instructing readers about how to carry out rigorous verification and validation studies, including references to appropriate exact solutions and experimental data sets, would have been very useful.

In the reviewer's opinion, this book succeeds in achieving its goal of introducing readers to CFD. The absence of exercises suggests that the book is not intended as a textbook, but that it should be read in conjunction with other materials. Given this need for consulting additional sources, the relative lack of references to recent works and textbooks is less critical, but it makes a less expensive paperback edition desirable.

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