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BOOK REVIEW

"COMPUTATIONAL GASDYNAMICS", BY C.B. LANEY, CAMBRIDGE UNIVERSITY PRESS 1998.

THIS BOOK CONCERNS mainly numerical methods for simulating unsteady one-dimensional high-speed flows of inviscid perfect gases containing shocks. Although the material presented could appear limited, it allows the author to make this 600-plus page book self-contained. The choice of the material is well justified because, although few gas flows of practical interest are truly one dimensional, the techniques for solving unsteady one-dimensional flows lead naturally to techniques for solving unsteady two- and three-dimensional flows. Furthermore, such flows serve as important model problems for, and constitute an essential first step toward, a broader range of practical compressible flows, including viscous and real gas flows.

On the whole the book is very readable. Most of the material presented was developed between the mid-1950s and the late 1980s. The material is well organized and presented without forgetting the underlying physics. This book prepares its readers to understand the literature related to computational gasdynamics by decomposing complicated numerical methods into simple modular parts, showing how each part fits, how each method relates to competing methods. Furthermore, it gives the reader the necessary background to intelligently evaluate and use the available software. In my view, this book creates an interdisciplinary reference easily usable by practitioners of different disciplines.

The book is organized in five parts. Part 1 gives an unconventional review of gas dynamics. Part 2 reviews numerical methods devoted specifically to computational gas dynamics. Part 3 presents the basic principles of computational gas dynamics. Part 4 introduces the basic methods of computational gas dynamics for scalar conservation laws, such as Burgers' equation, and the Euler equations. Part 5 introduces recent solution-sensitive methods.

The review of gas dynamics, Part 1, varies from the traditional reviews because the book is focused on the numerical solution of one-dimensional compressible inviscid unsteady flows rather than the traditional hand calculations. Consequently, the book does not discuss linearized approximations or steady two-dimensional flows. Besides conservation laws, characteristic and shock wave theory, and simple models described by scalar conservation equations, this part discusses the Riemann problem. The discussion of the Riemann problem is especially important because the solution of the Riemann problem has assumed a primary role in modern computational gas dynamics as a fundamental element of the numerical methods.

The computational review, Part 2, presents only topics of greatest relevance to the rest of the book, in particular, it presents polynomial and piecewise polynomial approximations. In addition to the standard topics, the author devotes one quarter of Part 2 to introduce something unusual: piecewise-polynomial essentially nonoscillatory (ENO) reconstruction and reconstruction via the primitive function. These advanced reconstruction techniques are rightly presented in this section because their applicability encompasses the field of computational gas dynamics.

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In the last three parts of this book the author leads the reader through the intricacy of what he defines as three generations of numerical methods for computational gas dynamics. Part 3 combines the gas dynamics described in Part 1 with the computational techniques described in Part 2. It introduces the basic principles of computational gas dynamics, including shock-capturing based on conservative numerical fluxes, the CFL condition, artificial viscosity, stability, and upwinding. Although these simple methods have no practical application because of the stability problems, they are essential to understand the more sophisticated methods described in the following parts.

Part 4 describes solution-insensitive numerical methods except for upwindings techniques, or first-generation numerical methods for gas dynamics. These methods experience a sharp trade-off between accuracy and stability. However, they are useful in undemanding applications and, more importantly, are the basic building blocks of second- and third-generation methods. The author uses a set of five test cases to explain and compare the performances and weaknesses of the different methods for scalar conservation laws. These simple test cases involve shocks, contacts, expansion fans, sonic points and smooth regions. The author also uses a set of two test cases to explain and compare the performances and weaknesses of the different methods for the Euler equations. All these test cases have been designed to objectively challenge the different schemes and test for amplitude, phase and dissipative errors. In my opinion, these test cases are very useful for beginners as well as for practitioners because they provide a benchmark to validate and compare computer codes.

Part 5 describes over a dozen recently published numerical methods that are well organized in logical and chronological order, to give the necessary sense of history and the logical connections between apparently disparate methods. This is not an easy task. The first section in each chapter of Part 5 describes a seminal second-generation method designed in the 1970s that has inspired successful third-generation methods. The third-generation methods are categorized as: flux-limited, flux-corrected, self-adjusting hybrids and reconstruction-evolution methods. The last chapter explains how one-dimensional concepts carry over directly to multidimensions. The third-generation methods are evaluated using the same five test cases used in Part 4. The application of these methods to Euler's equations is briefly presented at the end of each chapter. Unfortunately, these methods are not compared using the two test cases introduced in Part 4. Although a careful reader could extrapolate the behavior of the different methods when applied to Euler's equations based on the results presented for the scalar conservation law, it is unfortunate that this precious material is missing from Part 5.

In conclusion, in the opinion of the reviewer this book has the rare virtue of playing two roles well at the same time. On the one hand, it can be appreciated as a valuable text book for an introductory, as well as for an advanced course on numerical gas dynamics. On the other hand, it can be appreciated as a reference book or a "user manual" for the practitioners interested in numerically solving engineering or research problems in gas dynamics. I think the author should be congratulated on producing such a useful work, including the comprehensive and well-organized bibliography.

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