Book Reviews

Bouyancy-Induced Flows and Transport

B. Gebhart, Y. Jaluria, R. L. Mahajan, and B. Sammakia, Hemisphere Publishing Corp., NY, 1988, 971 pp., hard cover $149.95, soft cover $49.50.

Gebhart and his colleagues (a selection of his former students) undertook a monumental task—nothing less than a survey of the bulk of the literature relating to bouyancy-induced flows. Surely, their task was eased by the fact that, over the past 30 or so years, they have personally disclosed much of our present understanding of buoyancy-induced flows. But that shouldn't diminish their accomplishment one whit, and this book is much more than a mere recapitulation or reprinting of the papers the book's authors have published over the years.

I use the word "survey" with some reservation. The authors introduce each topic carefully. They discuss its background and physical interpretation, develop the appropriate mathematical analysis, and provide many of the numerical and graphical results that are essential to an understanding of the phenomena involved and the solution of practical problems.

In a work of this size (slightly fewer than 1,000 pages), with multiple authors, variations in style are inevitable. So too, perhaps, are failures in grammar and syntax. Fortunately, such occurences are rare. Occasionally, the authors do become so involved in the development of the mathematical solution of a problem that they fail to convey a sense of passion for the subject.

The work is available in both text and reference form. The former contains end-of-chapter problems and appendices of selected property values. In text form, the book would be suitable for use in an advanced graduate course in buoyancy-induced flows, but in that case textbook problems usually aren't necessary. In my opinion, the book will be of principal value as a survey of the state-of-the-art in the late 1980's to engineers and scientists who already have a speaking knowledge of the subject. The list of references appears to be especially complete. I, for one, am delighted to add this volume to my bookshelf.

By buoyancy-induced flows the authors mean fluid motion in a (usually) continuous medium, driven by density differences. Such flows are often termed natural or free convection flows and are truly ubiquitous. Other buoyancy-induced phenomena, such as bubble motion, are not covered. Also, discussion of free boundary and surface tension effects, which frequently accompany buoyancy effects, is limited.

The subject of buoyancy-induced flows can be divided in a number of ways. The authors' treatment takes 17 chapters. Following a general introduction and a development of the governing differential equations, the authors take up in succession: external thermally induced flows (which is further subdivided into vertical, axisymmetric, and nonvertical cases); combined mass and thermal transport; unsteady external flows; variable fluid property effects; a special treatment of the flows of pure and saline water in mixed convection. Instability, transition, and turbulence are covered in two lengthy chapters. The balance of the book is devoted to more specialized topics: unstably stratified fluids, transport in enclosures and in porous media, and non-Newtonian effects are covered in four chapters and a number of further specialized topics are briefly introduced in the final chapter.

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Foundations of Boundary Layer Theory for Momentum, Heat and Mass Transfer

Joseph A. Schetz, Prentice-Hall, Englewood Cliffs, N.J., 309 pp. $63.00.

This book discusses boundary-layer theory up to solutions of the Navier-Stokes and energy equations based on the premise that engineering students and young, practicing engineers are today well versed in computer analysis.

Laminar and turbulent boundary layers are given the same breadth of coverage. For each of them, the discussion starts with a presentation of experimental results, proceeds to integral solutions of the momentum and energy equations, to similarity and computer solutions of the boundary-layer differential equations. Included are the effects of suction and injection as well as heat and mass transfer and compressible boundary layers.

The treatment of turbulent boundary layers is preceeded by a discussion of transition including a short outline of stability theory and presentation of experimental information. In turbulent flow, considerable space is provided for the modeling of the turbulent transport process, including time mean flow formulations (models of the inner and outer region), models based on turbulent kinetic energy, on energy and length scale (k-ϵ models), and on Reynolds stress. Chapters are devoted to turbulent-free shear layers, boundary layers with variable density, and heat and mass transfer.

The book presents a well-rounded and up-to-date introduction to our present knowledge of boundary-layer flow and its analysis. The author offers the book as text for upper division undergraduate and first-year graduate courses for mechanical, chemical, aeronautical, civil, and ocean engineering students. This reviewer suspects that the treatment, especially of the turbulent modeling, is too short for students to perform computer analysis of turbulent boundary layers without supporting material.

Some detailed remarks: With the many parameters appearing in the text, it would be helpful to include their definitions in the section "NOTATION" or to refer to the pages where they are introduced. Notations in figures are sometimes not defined (e.g., in Figs. 6-11 and 7-38). The notations in Figs. 1-8, C and D, are identical—what is the difference? Such shortcomings should be removed in a second edition.

In summary, the book is an excellent introduction to boundary-layer theory for those wanting information about our present knowledge of boundary-layer flow and our ability to predict its character. It can also be recommended as a textbook when additional supporting material is provided.

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Difference Methods for Initial-Boundary-Value Problems Flow Around Bodies

You-Lan Zhu, Xi-Chang Zhong, Bing-Mu Chen & Juo-Min Zhang, Springer-Verlag, New York, 1988, 600 pp., $120.00.

This book describes basic techniques for integrating hyperbolic systems of equations (specifically, Euler's equations for inviscid flows, with an emphasis on polytropic gases and some attention paid to real gases). The second part, filling about two thirds of the book, reports applications to blunt-body problems and steady, supersonic, axisymmetric flows.

In our world of glorified obsolescence, the highest merit of this book seems to be historical. Published in Chinese in 1980, it reports work done in the 1970s, when exchanges between China and the Western world practically did not exist. Therefore, the work should be judged as original, and praise is due to the choice of a technique with a sound physical background, able to generate results of the highest accuracy. (Isolation was, perhaps, a positive factor. In an aseptic environment, the basic relevant concepts of domain of dependence and shock-fitting could be analyzed and accepted with ease). My enthusiastic agreement with the authors on matters of principle does not necessarily imply that I agree with the current English translation (that only differs from the Chinese original in some Appendices), and that I consider the book a timely contribution to the state-of-the-art or a useful guide to the numerical gasdynamicist.

Regarding style, this work tends to be overly procedural in nature, a most unfortunate approach for many reasons. First, the basic ideas are drowned by meticulous but unnecesary details. For example, obsessive insistence on proof of stability does not provide a better understanding of a technique and distracts the reader from the mainstream of thought. In general, the book does not succeed in providing inspiration, as it should, but tends to enforce procedures that are not necessarily to be followed literally. In addition, the rare lines of text emerging from the algebraic sea should be completely rephrased to be comprehensible.

Second, ideas that have a right to last should be emphasized, and recipes that depend on the computer state-of-the-art should be updated, or not mentioned at all. For example, the lengthy description of three-dimensional techniques related to the method of lines and to periodical fitting of varibles in the circumferential direction in cylindrical coordinates is, by modern standards, lacking interest: even in 1965 certain simple three-dimensional, time-dependent problems had been treated without giving the circumferential variations a second-class citizenship. With the present computers, assumptions of this kind are out of the question. On the matter of shocks, shock-fitting is the technique proposed, justified, and used in this book. In principle, I agree. However, shock-fitting, using the shocks (and contact surfaces) as boundaries between regions, is the only technique described here. This was the first approach used in the 1960s for simple two-dimensional, time-dependent problems. Currently, shock-fitting can be performed leaving the shocks floating between mesh points, regardless of topological complexities. Finally, the sections on non-equilibrium gases are outdated by the new wave of papers on the subject, prompted by the novel possibilities offered by modern computers.