is an interaction of aerodynamic, elastic, and inertial forces. The stability of a system is judged by the balance of energy in a cycle of oscillation, and can be classified broadly as static or dynamic in nature. The authors highlight various types of instabilities with a reference to the aeroelastic triangle used by Prof. Collar. In the first few sections an excellent introduction to the characteristics of steady and unsteady flows and the work done by the air loads is presented. Subsequently, classical two-dimensional aeroelastic problems, such as divergence, aileron effectiveness, aileron reversal speed, and flutter are presented. Linear and nonlinear panel flutter solution methods in supersonic flow, and the application of finite-element methods to determine unsteady air loads are also outlined. The reader will find some interesting discussions on nonlinear characteristics of stall flutter, both in bending and torsion modes.

Following the introduction to flutter mechanisms, practical flutter solution methods such as V-g method and the CT method of Wittmeyer are described. In the next section, the authors introduce some advanced topics in active flutter suppression and optimum design with some examples.

Finally, the authors conclude this chapter with some valuable outlines on computational fluid dynamics (CFD) by finite-element methods (FEM). In published articles, the authors have demonstrated the feasibility of applying finite-element methods for determining transient aerodynamic loads for applications in flutter analyses. They employ the Navier-Stokes equations for incompressible and compressible fluid media including hypersonic flow regimes. It appears from these discussions that CFD analysis by the FEM may have distinct advantages over other methods.

Each chapter in this book contains extensive literature references, lucid mathematical developments, and intriguing examples. The reader will appreciate the authors' efforts in maintaining systematic definitions, symbols, and notations for easy reading. This book will serve the engineering community as a valuable reference text. Therefore, the reviewer not only recommends the addition of this book (in three volumes) to every engineering library, but also as a personal copy for every practicing engineer, researcher, and student.

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Hypersonic and High Temperature Gas Dynamics

J. D. Anderson Jr., McGraw-Hill, NY 1989, 680 pp., $49.95.

Recent vehicle concepts involving high Mach-number cruise and aero-assisted orbital transfer are driving renewed interest in hypersonics, an area that had not attracted much attention since the end of the 1960s. Several texts/monographs on hypersonic flow and high-temperature gasdynamics were published before 1966,[1-7] but the present book by John D. Anderson Jr. is the first basic text to become available since then. The text was designed, as the Preface indicates, to be a *self-contained teaching instrument* for a new generation of engineers and scientists interested in learning the fundamentals of hypersonic flows and high-temperature gasdynamics, as well as certain "modern perspectives" gained from space-shuttle program developments. Thus, the work is intended to make up for this 20-year hiatus, while at the same time furnishing the needed fundamentals on the subject matter. A basic knowledge of fluid mechanics and compressible flow at the undergraduate level is assumed for the readers. The book was to play two roles: (1) a textbook to be used by senior undergraduate and first-year graduate students, and (2) a viable, working tool for engineers and program managers on jobs related to hypersonics. Of these ends, the first was achieved admirably well and the second may also be considered successful, with more specific qualifications given below.

Several textbooks written earlier by Anderson[8-11] have enjoyed great popularity among students in aerospace engineering for their lively presentation and clear exposition, and this one should not be an exception. The numerous AIAA-sponsored workshops on hypersonic flows organized and led by the author also proved to be successful. The book in fact represents a physically more attractive, compact form of his workshop lecture notes. The content falls into three distinct parts: 1) Inviscid Hypersonic Flow, 2) Viscous Hypersonic Flow, and 3) High-Temperature Gasdynamics. With the expressed goals of the book, issues on the flow physics and fluid mechanic modeling and related theoretical works, as well as some of the important advances in computation methods, cannot be critically addressed at the same level achieved by Hayes and Probstein's scholarly monograph.[1,7] However, the materials presented obviously offer a wider and more up-to-date coverage in a user-friendly format, serving well the goals set for a "modern education in hypersonics and high-temperature gasdynamics."

Much of the fundamental aspects in Parts I and II are identifiable with the more elementary treatises and equations for the classical theory[1-3,5,7] and gasdynamics,[4,6] which are interspersed with examples of computations and their comparison with flight measurements. The latter were generated partly from the author's own research in the past, but mostly from research and development in support of the space-shuttle program, unavailable two decades earlier. Although the level of sophistication in numerical methods has been kept low, to be consistent with the book's objectives, uninitiated readers are exposed progressively to the basic ideas and principles in numerical solutions to the Euler and Navier-Stokes equations by finite differences. In introducing the subjects of shock fitting, shock capturing, and thin-layer approximations, McCormack's explicit, predictor-corrector method and its variants have been extensively used. The adherence to the predictor-corrector method, however, does not represent a restriction or limitation. The author should, in fact, be congratulated for having not only invested in an approach of proven robustness and utility, but also for his wisdom of adhering to a procedure of relative simplicity, which fits well with the chosen level and tone of the book.

Readers unfamiliar with statistical thermodynamics may feel grateful toward the author for a masterful presentation of the subject in Part III, which calls for an exercise of good judgement in deciding on the materials to be included and the issues to be addressed. A reader familiar with Anderson's "Modern Compressible Flow" may find this part to be a repetition, but it is justifiable in the quest of being "a self-contained teaching instrument." An inquisitive student should consult Vincenti and Kruger[6] for a more comprehensive discourse; a very similar account may be found, but the deletion of a number of more sophisticated issues and cumbersome qualifiers from Ref. 6 appear to have succeeded here in bringing out the essence more vividly. The presentations on the harmonic oscillator model for vibrational nonequilibrium and on the chemical kinetics models for diatomic gas and air again run parallel to those in Vincenti and Kruger but with a more extensive study on concrete examples of inviscid nonequilibrium air flows in divergent nozzles and about smooth, blunt bodies[14,15] as well as the stagnation-point boundary layer.[16] The study brings out quite well concepts and ideas such as chemical freezing, binary scaling, frozen and equilibrium boundary layers, wall catalyticity, etc., familiar from earlier works. There are sections under Part III introducing elementary concepts of gas kinetic theory and gas cap radiation, as well as molecular transport properties. Compared with the corresponding treatises in Vincenti & Kruger, however, one may find the present work on the sketchy side and even confusing in some instances. Again these weaknesses can be excused for the need to observe page limitations and for the topics' relative unimportance. An interesting discussion of the results of viscous shock layer (VSL) model[17] and of parabolized Navier-Stokes (PNS) solutions, which takes into account nonequilibrium air chemistry, is presented.

As a course text on hypersonic flow and related subjects, the reviewer finds the book extremely helpful; it frees the instructor from the routine and drudgery of covering a number of topics that may be difficult to present in a classroom but better said and done by the book. He can well devote the precious lecturing hours in amplifying more on the essentials and expounding on critical issues of flow physics and formulations. Obviously, it may not be fair to view this work as a *monograph* to which more stringent standards in originality, completeness, and scholarship would have to be brought to bear. This work may still fare well and merit recommendation in many respects, even if taken as a monograph. To be used as a stop-gap on hypersonics for engineers, program managers and applied mathematicians, the content may appear to be a little short on turbulent boundary layers and transition, but so is the state of the art itself. Scientists and engineers seriously involved with highly nonequilibrium flows bordering on rarefied gasdynamics will be disappointed not only with the scanty passages on gas kinetic concepts and on the transport coefficients but with the omission of Direct Simulation Monte-Carlo (DSMC) calculations[18] and their comparisons with a corresponding continuum model,[19] which was based on the VSL discussed at length in Part III. It is regrettable indeed that the author's talent has not been used for a masterful discourse on the fundamentals of the DSMC method, which represents an area badly in need of a clear and lively exposition for nonexperts. Critical readers familiar with existing treatises on hypersonic flow may find some of the presentations unpalatable not because of the lack in depth of the enquiries, but in the explanation of certain crucial details. For example, while Maslen's version of the thin (inviscid) shock layer as described on pages 138-148 proves to be successful, the assumption of a uniform velocity profile $u = u_s(x)$ in Eqs. (4.176) and (4.177) needs an explanation—it does not follow directly from the thin shock layer assumption. A weak spot of the text is found with the hypersonic boundary-layer interaction for its lack of a clear distinction between a global interaction and one of a shorter scale which permits upstream influence and local flow separation. On the other hand, the discussion on the inviscid/viscous interaction from the experimental point of view, including Stollery's turbulent interaction parameter,[20] is rather comprehensive.

More disappointing is a protracted argument on pages 223-226 leading to the assertation that "for very large hypersonic Mach number (at the outer edge), the assumption that p is constant in the normal direction throughout a boundary layer is not always valid." Departing from the less theoretical tone maintained throughout the book, the author applies a formal scale analysis to the boundary-layer equations which reveals explicitly the influence of (outer-edge) Mach number "M_∞" and Reynolds number. Regrettably, the most important feature in the boundary layer with a hypersonic outer flow, namely, the extremely low density level brought about by the high temperature recovery, was overlooked, which led to the erroneous belief that most existing theories of hypersonic boundary layers are suspect. Curiously, the same statement and argument were presented in an earlier text by the author.[11] This and other weaknesses mentioned may nevertheless be regarded as isolated singularities in a otherwise well-written text. Indeed, the book scores highly as a basic text with adequate depth on the gasdynamic fundamentals, and as a useful treatise on hypersonics with sufficient coverage to entice readers to more advanced study and research.

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