Molecular Gas Dynamics Theory Techniques And Applications Modeling And Simulation In Science Engineering And Technology

This monograph is intended to provide a comprehensive description of the rela tion between kinetic theory and fluid dynamics for a time-independent behavior of a gas in a general domain. A gas in a steady (or time-independent) state in a general domain is considered, and its asymptotic behavior for small Knudsen numbers is studied on the basis of kinetic theory. Fluid-dynamic-type equations and their associated boundary conditions, together with their Knudsen-layer corrections, describing the asymptotic behavior of the gas for small Knudsen numbers are presented. In addition, various interesting physical phenomena derived from the asymptotic theory are explained. The background of the asymptotic studies is explained in Chapter 1, accord ing to which the fluid-dynamic-type equations that describe the behavior of a gas in the continuum limit are to be studied carefully. Their detailed studies depending on physical situations are treated in the following chapters. What is striking is that the classical gas dynamic system is incomplete to describe the behavior of a gas in the continuum limit (or in the limit that the mean free path of the gas molecules vanishes). Thanks to the asymptotic theory, problems for a slightly rarefied gas can be treated with the same ease as the corresponding classical fluid-dynamic problems. In a rarefied gas, a temperature field is di rectly related to a gas flow, and there are various interesting phenomena which cannot be found in a gas in the continuum limit.

This book is a collection of carefully reviewed papers presented during the HP-SEE User Forum, the meeting of the High-Performance Computing Infrastructure for South East Europe’s (HP-SEE) Research Communities, held in October 17-19, 2012, in Belgrade, Serbia. HP-SEE aims at supporting and integrating regional HPC infrastructures; implementing solutions for HPC in the region; and making HPC resources available to research communities in SEE, region, which are working in a number of scientific fields with specific needs for massively parallel execution on powerful computing resources. HP-SEE brings together research communities and HPC operators from 14 different countries and enables them to share HPC facilities, software, tools, data and research results, thus fostering collaboration and strengthening the regional and national human network; the project specifically supports research groups in the areas of computational physics, computational chemistry and the life sciences. The contributions presented in this book are organized in four main sections: computational physics; computational chemistry; the life sciences; and scientific computing and HPC operations.

Rational extended thermodynamics (RET) is the theory that is applicable to nonequilibrium phenomena out of local equilibrium. It is expressed by the hyperbolic system of field equations with local constitutive equations and is strictly related to the kinetic theory with the closure method of the hierarchies of moment equations. The book intends to present, in a systematic way, new results obtained by RET of gases in both classical and relativistic cases, and it is a natural continuation of the book "Rational Extended Thermodynamics beyond the Monatomic Gas" by the same authors published in 2015. However, this book addresses much wider topics than those of the previous book. Its contents are as follows: RET of rarefied monatomic gases and of polyatomic gases; a simplified RET theory with 6 fields being valid far from equilibrium; RET where both molecular rotational and vibrational modes exist; mixture of gases with multi-temperature. The theory is applied to several typical topics (sound waves, shock waves, etc.) and is compared with experimental data. From a mathematical point of view, RET can be regarded as a theory of hyperbolic symmetric systems, of which it is possible to conduct a qualitative analysis. The book represents a valuable resource for applied mathematicians, physicists, and engineers, offering powerful models for many potential applications such as reentering satellites into the atmosphere, semiconductors, and nanoscale phenomena.

New edition of the popular textbook, comprehensively updated throughout and now includes a new dedicated website for gas dynamic calculations The thoroughly revised and updated third edition of Fundamentals of Gas Dynamics maintains the focus on gas flows below hypersonic. This targeted approach provides a cohesive and rigorous examination of most practical engineering problems in this gas dynamics flow regime. The conventional one-dimensional flow approach together with the role of temperature-entropy diagrams are highlighted throughout. The authors—noted experts in the field—include a modern computational aid, illustrative charts and tables, and myriad examples of varying degrees of difficulty to aid in the understanding of the material presented. The updated edition of Fundamentals of Gas Dynamics includes new sections on the shock tube, the aerospike nozzle, and the gas dynamic laser. The book contains all equations, tables, and charts necessary to work the problems and exercises in each chapter. This book’s accessible but rigorous style: Offers a comprehensively updated edition that includes new problems and examples Covers fundamentals of gas flows targeting those below hypersonic Presents the one-dimensional flow approach and highlights the role of temperature-entropy diagrams Contains new sections that examine the shock tube, the aerospike nozzle, the gas dynamic laser, and an expanded coverage of rocket propulsion Explores applications of gas dynamics to aircraft and rocket engines Includes behavioral objectives, summaries, and check tests to aid with learning Written for students in mechanical and aerospace engineering and professionals and researchers in the field, the third edition of Fundamentals of Gas Dynamics has been updated to include recent developments in the field and retains all its learning aids. The calculator for gas dynamics calculations is available at https://www.oscarbiblarz.com/gascalculator gas dynamics calculations

This self-contained book is an up-to-date description of the basic theory of molecular gas dynamics and its various applications. The book, unique in the literature, presents working knowledge, theory, techniques, and typical phenomena in rarefied gases for theoretical development and application. Basic theory is developed in a systematic way and presented in a form easily applied for practical use. In this work, the ghost effect and non-Navier–Stokes effects are demonstrated for typical examples—Bénard and Taylor–Couette problems—in the context of a new framework. A new type of ghost effect is also discussed.

Aerodynamics is a science engaged in the investigation of the motion of air and other gases and their interaction with bodies, and is one of the most important bases of the aeronautic and astronautic techniques. The continuous improvement of the configurations of the airplanes and the space vehicles aid the constant enhancement of their performances are closely related with the development of the aerodynamics. In the design of new flying vehicles the aerodynamics will play more and more important role. The undertakings of aeronautics and astronautics in our country have gained achievements of world interest, the aerodynamics community has made outstanding contributions for the development of these undertakings and the science of aerodynamics. To promote further the development of the aerodynamics, meet the challenge in the new century, summary the experience, cultivate the professional personnel and to serve better the cause of aeronautics and astronautics and the national economy, the present Series of Modern Aerodynamics is organized and published.

This open access book, published in the Soft and Biological Matter series, presents an introduction to selected research topics in the broad field of flowing matter, including the dynamics of fluids with a complex internal structure -from nematic fluids to soft glasses- as well as active matter and turbulent phenomena. Flowing matter is a subject at the crossroads between physics, mathematics, chemistry, engineering, biology and earth sciences, and relies on a multidisciplinary approach to describe the emergence of the macroscopic behaviours in a system from the coordinated dynamics of its microscopic constituents. Depending on the microscopic interactions, an assembly of molecules or of mesoscopic particles can flow like a simple Newtonian fluid, deform elastically like a solid or behave in a complex manner. When the internal constituents are active, as for biological entities, one generally observes complex large-scale collective motions. Phenomenology is further complicated by the invariable tendency of fluids to display chaos at the large scales or when stirred strongly enough. This volume presents several research topics that address these phenomena encompassing the traditional micro-, meso-, and macro-scales descriptions, and contributes to our understanding of the fundamentals of flowing matter. This book is the legacy of the COST Action MP1305 “Flowing

Matter".

This book covers classical kinetic theory of gases, presenting basic principles in a self-contained framework and from a more rigorous approach based on the Boltzmann equation. Uses methods in kinetic theory for determining the transport coefficients of gases.

This second edition of a highly regarded text covers all the recent research developments in gas dynamics including the direct simulation Monte Carlo method (DSMC).

Aimed at both researchers and professionals who deal with this topic in their routine work, this introduction provides a coherent and rigorous access to the field including relevant methods for practical applications. No preceding knowledge of gas dynamics is assumed.

This book consists of two parts, theory and applications. Part I introduces the kinetic theory of gases with relevance to molecular energies and intermolecular forces. Part II focuses on how these theories are used to explain real techniques and phenomena involving gases. By stressing the practical implications, the book explains the theory of gas dynamics in a highly readable and comprehensive manner.

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Ab initio molecular dynamics revolutionized the field of realistic computer simulation of complex molecular systems and processes, including chemical reactions, by unifying molecular dynamics and electronic structure theory. This book provides the first coherent presentation of this rapidly growing field, covering a vast range of methods and their applications, from basic theory to advanced methods. This fascinating text for graduate students and researchers contains systematic derivations of various ab initio molecular dynamics techniques to enable readers to understand and assess the merits and drawbacks of commonly used methods. It also discusses the special features of the widely used Car–Parrinello approach, correcting various misconceptions currently found in research literature. The book contains pseudo-code and program layout for typical plane wave electronic structure codes, allowing newcomers to the field to understand commonly used program packages and enabling developers to improve and add new features in their code.

The aim of this book is to present the concepts, methods and applications of kinetic theory to rarefied gas dynamics. After introducing the basic tools, problems in plane geometry are treated using approximation techniques (perturbation and numerical methods). These same techniques are later used to deal with two- and three-dimensional problems. The models include not only monatomic but also polyatomic gases, mixtures, chemical reactions. A special chapter is devoted to evaporation and condensation phenomena. Each section is accompanied by problems which are mainly intended to demonstrate the use of the material in the text and to outline additional subjects, results and equations. This will help ensure that the book can be used for a range of graduate courses in aerospace engineering or applied mathematics.

Direct Simulation Monte Carlo is a well-established method for the computer simulation of a gas flow at the molecular level. While there is a limit to the size of the flow-field with respect to the molecular mean free path, personal computers now allow solutions well into the continuum flow regime. The method can be applied to basic problems in gas dynamics and practical applications range from microelectromechanics systems (MEMS) to astrophysical flows. DSMC calculations have assisted in the design of vacuum systems, including those for semiconductor manufacture, and of many space vehicles and missions. The method was introduced by the author fifty years ago and it has been the subject of two monographs that have been published by Oxford University Press. It is now twenty years since the second of these was written and, since that time, most DSMC procedures have been superseded or significantly modified. In addition, visual interactive DSMC application programs have been developed that have proved to be readily applicable by non-specialists to a wide variety of practical problems. The computational variables are set automatically within the code and the programs report whether or not the criteria for a good calculation have been met. This book is concerned with the theory behind the current DSMC molecular models and procedures, with their integration into general purpose programs, and with the validation and demonstration of these programs. The DSMC and associated programs, including all source codes, can be freely downloaded through links that are provided in the book. The main accompanying program is simply called the "DSMC program" and, in future versions of the book, it will be applicable to homogeneous (or zero-dimensional) flows through to three-dimensional flow. All DSMC simulations are time-accurate unsteady calculations, but the flow may become steady at large times. The current version of the DSMC code is applicable only to zero and one-dimensional flows and the older DS2V code is employed for the two-dimensional validation and demonstration cases. It is because of this temporary use of the older and well-proven program that the DS2V source code is made freely available for the first time. Most of the homogeneous flow cases are validation studies, but include internal mode relaxation studies and spontaneous and forced ignition leading to combustion in an oxygen-hydrogen mixture. The one-dimensional cases include the structure of a re-entry shock wave that takes into account electronic excitation as well as dissociation, recombination and exchange reactions. They also include a spherically imploding shock wave and a spherical blast wave. The two-dimensional and axially-symmetric demonstration cases range from a typical MEMS flow to aspects of the flow around rotating planets. Intermediate cases include the formation and structure of a combustion wave, a vacuum pump driven by thermal creep, a typical vacuum processing chamber, and the flow around a typical re-entry vehicle

The book contains papers presented at the 24th International Symposium on Rarefied Gas Dynamics, a conference that is recognized as the principal forum for the presentation of recent advances in the field of rarefied gas dynamics. The topics include fundamental aspects of Boltzmann and related equations, transport theory, Monte Carlo methods, kinetic theory, gas phase molecular collision dynamics, gas surface interaction, state to state kinetics, rarefied plasmas, and non-equilibrium plasma kinetics. Applications in the fields of internal flows, vacuum systems, rarefied jets, plumes, molecular beams, scamjets and hypersonics, microflows, granular gases, electrical thrusters are discussed. Researchers in the fields of mathematics, physics, chemistry and engineering can strongly benefit from the interdisciplinary nature of the book.

Introduction to Molecular Beams Gas Dynamics is devoted to the theory and phenomenology of supersonic molecular beams. The book describes the main physical idea and mathematical methods of the gas dynamics of molecular beams, while the detailed derivation of results and equations is accompanied by an explanation of their physical meaning. Many of the applications of supersonic molecular beams are discussed, including their application to molecular spectroscopy, and the study of surface phonons by monoatomic and monokinetic beams, and the study of intermolecular potentials and the onset of condensation. The phenomenology of supersonic beams can appear complex to those not experienced in supersonic gas dynamics and, as a result, the few existing reviews on the topic generally assume a limited level of knowledge. The book begins with a quantitative description of the fundamental laws of gas dynamics and goes on to explain such phenomena. It analyzes the evolution of the gas jet from the continuum to the regime of almost free collisions between molecules, and

includes numerous figures, illustrations, tables and references.

Understanding Molecular Simulation: From Algorithms to Applications explains the physics behind the "recipes" of molecular simulation for materials science. Computer simulators are continuously confronted with questions concerning the choice of a particular technique for a given application. A wide variety of tools exist, so the choice of technique requires a good understanding of the basic principles. More importantly, such understanding may greatly improve the efficiency of a simulation program. The implementation of simulation methods is illustrated in pseudocodes and their practical use in the case studies used in the text. Since the first edition only five years ago, the simulation world has changed significantly -- current techniques have matured and new ones have appeared. This new edition deals with these new developments; in particular, there are sections on: · Transition path sampling and diffusive barrier crossing to simulaterare events · Dissipative particle dynamic as a course-grained simulation technique · Novel schemes to compute the long-ranged forces · Hamiltonian and non-Hamiltonian dynamics in the context constant-temperature and constant-pressure molecular dynamics simulations · Multiple-time step algorithms as an alternative for constraints · Defects in solids · The pruned-enriched Rosenbluth sampling, recoil-growth, and concerted rotations for complex molecules · Parallel tempering for glassy Hamiltonians Examples are included that highlight current applications and the codes of case studies are available on the World Wide Web. Several new examples have been added since the first edition to illustrate recent applications. Questions are included in this new edition. No prior knowledge of computer simulation is assumed.

Many actual technological problems require the knowledge of the physical and chemical phenomena and processes taking place in high energy gas flows. This book presents an introductory analysis, theoretical and experimental, of these media, highlighting both their fundamental characteristics and applied aspects.

Rarefied Gas Dynamics is a collection of selected papers presented at the Eighth International Symposium on Rarefied Gas Dynamics, held at Stanford University in July 1972. The book is a record of the significant advances in the broad field of Rarefied Gas Dynamics that are considered to be of general and continuing interest. The articles in this compendium are organized under 10 main topics. The text presents research papers on the kinetic theory of gases; studies and experiments on shock structures of gases; use of kinetic theory for the solution of problems in evaporation and condensation; gas expansions and jets; and techniques and methods applied to the study of rarefied gas dynamics. The book also includes works on gas-solid interactions; descriptions of basic notions of current polyatomic gas kinetics; and observation of the gas dynamic phenomena in space. Physicists, aeronautical engineers, mechanical engineers, researchers, and students in the field of aircraft design will find this book a good source of knowledge and information.

Molecular Physics and Hypersonic Flows bridges the gap between the fluid dynamics and molecular physics communities, emphasizing the role played by elementary processes in hypersonic flows. In particular, the work is primarily dedicated to filling the gap between microscopic and macroscopic treatments of the source terms to be inserted in the fluid dynamics codes. The first part of the book describes the molecular dynamics of elementary processes both in the gas phase and in the interaction with surfaces by using quantum mechanical and phenomenological approaches. A second group of contributions describes thermodynamics and transport properties of air components, with special attention to the transport of internal energy. A series of papers is devoted to the experimental and theoretical study of the flow of partially ionized gases. Subsequent contributions treat modern computational techniques for 3-D hypersonic flow. Non-equilibrium vibrational kinetics are then described, together with the coupling of vibration-dissociation processes as they affect hypersonic flows. Special emphasis is given to the interfacing of non-equilibrium models with computational fluid dynamics methods. Finally, the last part of the book deals with the application of direct Monte Carlo methods in describing rarefied flows.

"The book is divided into two parts based on the overall goals, with the first part focusing on fundamental considerations, and the second part dedicated to describing computer simulation methods. The first section covers three different areas: (1) kinetic theory, (2) quantum mechanics, and (3) statistical mechanics. Important results from these three areas are then brought together to allow analysis of nonequilibrium processes in a gas based on molecular level considerations. Chapter 1 covers kinetic theory, in which the basic idea is to develop techniques to relate the properties and behavior of particles, representing atoms and molecules, to the fluid mechanical aspects of a gas at the macroscopic level. This requires us to provide a basic definition by what is meant by a particle, and how these particles interact with one another through the mechanism of inter-molecular collisions. This leads us into a discussion of modeling of macroscopic molecular transport processes, such as viscosity and thermal conductivity, that represents one of the first key successes of kinetic theory. We will find that kinetic theory relies on the use of statistical analysis techniques, such as probability density functions, due to the very large volumes of information involved in tracking the behavior of every single particle in a real gas flow"--

In contrast to molecular gases (for example, air), the particles of granular gases, such as a cloud of dust, lose part of their kinetic energy when they collide, giving rise to many exciting physical properties. The book provides a self-contained introduction to the theory of granular gases for advanced undergraduates and beginning graduates.

This book is a superb tool in virtually all application areas involving the Kinetic Theory of Gases, Rarefied Gas Dynamics, Transport Theory, and Aerosol Mechanics. It has been especially designed to serve a dual function, both as a teaching instrument either in a classroom environment or at home, and as a reference for scientists and engineers working in the fields of Rarefied Gas Dynamics and Aerosol Mechanics.

This introduction to the molecular theory of gases and modern transport theory includes such basic concepts as distribution function, classical theory of specific heats, binary collisions, mean free path and reaction rates, as well as topics relevant to advanced transport theory.

This book is dedicated to the recent developments in RET with the aim to explore polyatomic gas, dense gas and mixture of gases in non-equilibrium. In particular we present the theory of dense gases with 14 fields, which reduces to the Navier-Stokes Fourier classical theory in the parabolic limit. Molecular RET with an arbitrary number of field-variables for polyatomic gases is also discussed and the theory is proved to be perfectly compatible with the kinetic theory in which the distribution function depends on an extra variable that takes into account a molecule’s internal degrees of freedom. Recent results on mixtures of gases with multi-temperature are presented together with a natural definition of the average temperature. The qualitative analysis and in particular, the existence of the global smooth solution and the convergence to equilibrium are also studied by taking into account the fact that the differential systems are symmetric hyperbolic. Applications to shock and sound waves are analyzed together with light scattering and heat conduction and the results are compared with experimental data. Rational extended thermodynamics (RET) is a thermodynamic theory that is applicable to non-equilibrium phenomena. It is described by differential hyperbolic systems of balance laws with local

constitutive equations. As RET has been strictly related to the kinetic theory through the closure method of moment hierarchy associated to the Boltzmann equation, the applicability range of the theory has been restricted within rarefied monatomic gases. The book represents a valuable resource for applied mathematicians, physicists and engineers, offering powerful models for potential applications like satellites reentering the atmosphere, semiconductors and nano-scale phenomena.

Good,No Highlights,No Markup,all pages are intact, Slight Shelfwear,may have the corners slightly dented, may have slight color changes/slightly damaged spine.

Physicists firmly believe that the differential equations of nature should be hyperbolic so as to exclude action at a distance; yet the equations of irreversible thermodynamics - those of Navier-Stokes and Fourier - are parabolic. This incompatibility between the expectation of physicists and the classical laws of thermodynamics has prompted the formulation of extended thermodynamics. After describing the motifs and early evolution of this new branch of irreversible thermodynamics, the authors apply the theory to mon-atomic gases, mixtures of gases, relativistic gases, and "gases" of phonons and photons. The discussion brings into perspective the various phenomena called second sound, such as heat propagation, propagation of shear stress and concentration, and the second sound in liquid helium. The formal mathematical structure of extended thermodynamics is exposed and the theory is shown to be fully compatible with the kinetic theory of gases. The study closes with the testing of extended thermodynamics through the exploitation of its predictions for measurements of light scattering and sound propagation.

The papers in these proceedings were peer reviewed. The RGD Symposia are highly inter-disciplinary and encompass all aspects of rarefaction and non-equilibrium phenomena in gases. Rarefied flow phenomena include the mechanics and physics of low density gases and the analysis of flows which take place on a spatial scale comparable to the mean free path of a gas. Topics covered include: Kinetic theory and transport theory; numerical methods including direct simulation Monte Carlo and molecular dynamics; gas-surface phenomena; nano- and microscale flows; molecular beams, atom and molecular optics; clusters and aerosols; external flows including space and vacuum technologies; plume flows; hypersonic flows; molecular collision dynamics; relaxation processes; ionized gas flows; physics of the space environment; plasma processing; experimental techniques; diagnostics including laser induced fluorescence and electron beams; applications. With the increase in space activities and microfabrication capabilities, new themes have emerged including rarefied hypersonic flows, non-equilibrium gases, plasma processing, nano- and micro-scale flows at relatively high pressures, along with parallel and hybrid computational developments. Because the RGD Symposia are recognized as the principle forum for the presentation of recent advances in this field, it is a must for engineers and scientists in a variety of specialties.

Computational fluid dynamics (CFD) studies the flow motion in a discretized space. Its basic scale resolved is the mesh size and time step. The CFD algorithm can be constructed through a direct modeling of flow motion in such a space. This book presents the principle of direct modeling for the CFD algorithm development, and the construction unified gas-kinetic scheme (UGKS). The UGKS accurately captures the gas evolution from rarefied to continuum flows. Numerically it provides a continuous spectrum of governing equation in the whole flow regimes. Contents:Direct Modeling for Computational Fluid DynamicsIntroduction to Gas Kinetic TheoryIntroduction to Nonequilibrium Flow SimulationsGas Kinetic SchemeUnified Gas Kinetic SchemeLow Speed Microflow StudiesHigh Speed Flow StudiesUnified Gas Kinetic Scheme for Diatomic GasConclusion Readership: Undergraduate and graduate students, researchers and professionals interested in computational fluid dynamics. Key Features:Direct modeling for CFD is self-contained and unified in presentationIt may be used as an advanced textbook by graduate students and even ambitious undergraduates in computational fluid dynamicsIt is also suitable for experts in CFD who wish to have a new understanding of the fundamental problems in the subject and study alternative approaches in CFD algorithm development and applicationThe explanations in the book are detailed enough to capture the interest of the curious reader, and complete enough to provide the necessary background material needed to go further into the subject and explore the research literatureKeywords:Direct Modeling;Unified Gas Kinetic Scheme;Boltzmann Equation;Kinetic Collision Model;Asymptotic Preserving Method

This current and comprehensive book provides an updated treatment of molecular gas dynamics topics for aerospace engineers, or anyone researching high-temperature gas flows for hypersonic vehicles and propulsion systems. It demonstrates how the areas of quantum mechanics, kinetic theory, and statistical mechanics can combine in order to facilitate the study of nonequilibrium processes of internal energy relaxation and chemistry. All of these theoretical ideas are used to explain the direct simulation Monte Carlo (DSMC) method, a numerical technique based on molecular simulation. Because this text provides comprehensive coverage of the physical models available for use in the DSMC method, in addition to the equations and algorithms required to implement the DSMC numerical method, readers will learn to solve nonequilibrium flow problems and perform computer simulations, and obtain a more complete understanding of various physical modeling options for DSMC than is available in other texts.

Forty-four papers (revised) from the conference held July 1988. They cover: kinetic theory, discrete kinetic theory, direct simulations, numerical techniques, and flowfields. Acidic paper; no subject index. Annotation copyright Book News, Inc. Portland, Or.

This is an introductory level textbook which explains the elements of high temperature and high-speed gas dynamics. Readers will gain an understanding how the thermodynamic and transport properties of high temperature gas are determined from a microscopic viewpoint of the molecular gas dynamics, and how such properties affect the flow features, the shock waves and the nozzle flows, from a macroscopic viewpoint. In addition, the experimental facilities for the study on the high enthalpy flows are described in a concise and easy-to-understand style. Practical examples are given throughout emphasizing the application of the theory discussed. Each chapter ends with exercises/problems and solutions to enhance the learning experience. The book begins with the basics about enthalpy, its nature and difference with internal energy and its relationship to heat. Subsequent sections in the chapter on the Basics cover the essence of the gas dynamics of perfect gas, covering all aspects of the theory, which assumes the specific heats of the gas as constants and independent of temperature. The chapter on Thermodynamics of Fluid Flow reviews the concept of energy which plays an important role in both high temperature flows and perfect gas flows. The chapter on Wave Propagation describes the waves, namely the Mach waves, compression waves and expansion waves, which prevail in all gas dynamic streams. The chapter on High Temperature Flows begins with the discussion on the difference between the perfect gas flow and high temperature flow, and proceeds to the importance of high-enthalpy flows covering the nature of high-enthalpy flows, most probable macro state, Bose-Einstein and Fermi-Dirac statistics, Boltzmann distribution, evaluation of thermodynamic properties and partition function, covering the various aspects of high-enthalpy flows with shocks. The final chapter on High Enthalpy Facilities describes the devices to provide hypersonic airflows at high enthalpy and high-pressure total conditions.