

Fluid Mechanics Lesson Series

Lesson 15A

One-Dimensional Compressible Flow in Ducts

Mach number, isentropic relations, stagnation properties, duct flow

Corresponding section(s) in Çengel & Cimbala textbook:

12-1, 12-2

$\rho VA = \text{constant}$

$$\frac{dV}{V} = \frac{1}{M_a^2 - 1} \frac{dA}{A}$$

• If $M_a < 1$ (subsonic flow), $M_a^2 - 1 < 0$

$$\frac{dV}{V} \approx -\frac{dA}{A} \Rightarrow \begin{cases} \text{if } A \uparrow, V \downarrow \\ \text{if } A \downarrow, V \uparrow \end{cases} \text{SUBSONIC}$$

• If $M_a > 1$ (supersonic flow), $M_a^2 - 1 > 0$

$$\frac{dV}{V} \approx \frac{dA}{A} \Rightarrow \begin{cases} \text{if } A \uparrow, V \uparrow \\ \text{if } A \downarrow, V \downarrow \end{cases} \text{SUPERSONIC}$$

Compressible Fluid Dynamics

Michel Ledoux, Abdelkhalak El Hami



Compressible Fluid Dynamics:

Introduction to Compressible Fluid Flow Patrick H. Oosthuizen, William E. Carscallen, 2013-07-22 Introduction to Compressible Fluid Flow Second Edition offers extensive coverage of the physical phenomena experienced in compressible flow Updated and revised the second edition provides a thorough explanation of the assumptions used in the analysis of compressible flows It develops in students an understanding of what causes compressible flows to differ from incompressible flows and how they can be analyzed This book also offers a strong foundation for more advanced and focused study The book begins with discussions of the analysis of isentropic flows of normal and oblique shock waves and of expansion waves The final chapters deal with nozzle characteristics friction effects heat exchange effects a hypersonic flow high temperature gas effects and low density flows This book applies real world applications and gives greater attention to the supporting software and its practical application Includes numerical results obtained using a modern commercial CFD computer fluid dynamics code to illustrate the type of results that can be obtained using such a code Replaces BASIC language programs with MATLAB routines Avails COMPROP2 software which readers can use to do compressible flow computation Additional problems have been added and non numerical problems illustrating practical applications have been included A solutions manual that contains complete solutions to all of the problems in this book is available The manual incorporates the same problem solving methodology as adopted in the worked examples in this book It also provides summaries of the major equations developed in each chapter An interactive computer program also accompanies this book

Compressible Fluid Flow Michel A. Saad, 1985 This reference develops the fundamental concepts of compressible fluid flow by clearly illustrating their applications in real world practice through the use of numerous worked out examples and problems The book covers concepts of thermodynamics and fluid mechanics which relate directly to compressible flow discusses isentropic flow through a variable area duct describes normal shock waves including moving shock waves and shock tube analysis explores the effects of friction and heat interaction on the flow of a compressible fluid covers two dimensional shock and expansion waves provides a treatment of linearized flow discusses unsteady wave propagation and computational methods in fluid dynamics provides several numerical methods for solving linear and nonlinear equations encountered in compressible flow offers modern computational methods for solving nonintegrable equations and describes methods of measurement in high speed flow Suitable for the practicing engineer engaged in compressible flow applications

Compressible Fluid Dynamics with Personal Computer Applications B. K. Hodge, Keith Koenig, 1995-01-01 This text builds from thermodynamic and conservation principles to compressible flow concepts and covers wave processes early on It introduces high temperature gas dynamics and covers distinctions in the hierarchy of compressible flow descriptions beyond the calorically perfect

Theoretical Computational Dynamics Pai, 1997-03-01 Emphasis of this text is on the basic assumptions and the formulation of the theory of compressible flow as well as on the methods of solving problems Published by Science Press Beijing distributed by

VNR in the US Annotation copyrighted by Book News Inc Portland OR *Numerical Analysis of Compressible Fluid Flows* Eduard Feireisl, Mária Lukáčová-Medvid'ová, Hana Mizerová, Bangwei She, 2022-01-01 This book is devoted to the numerical analysis of compressible fluids in the spirit of the celebrated Lax equivalence theorem The text is aimed at graduate students in mathematics and fluid dynamics researchers in applied mathematics numerical analysis and scientific computing and engineers and physicists The book contains original theoretical material based on a new approach to generalized solutions dissipative or measure valued solutions The concept of a weak strong uniqueness principle in the class of generalized solutions is used to prove the convergence of various numerical methods The problem of oscillatory solutions is solved by an original adaptation of the method of K convergence An effective method of computing the Young measures is presented Theoretical results are illustrated by a series of numerical experiments Applications of these concepts are to be expected in other problems of fluid mechanics and related fields **The Dynamics and Thermodynamics of Compressible Fluid Flow, Volume 1** Ascher H. Shapiro, 1953-05-15 Explore fluid dynamics from both a theoretical and empirical perspective The engineering science of fluid dynamics is ever changing with the very foundations of the field based on both theory and ongoing experimentation The Dynamics and Thermodynamics of Compressible Fluid Flow thoroughly addresses all topics germane to the study of fluid dynamics The book also further explores the mechanisms by which progress in the field has been driven by applying theoretical analysis to the design of new experiments and by interpreting experimental results within the framework of existing theoretical knowledge *Mathematical Theory of Compressible Fluid Flow* Richard Von Mises, Hilda Geiringer, G. S. S. Ludford, 2004-01-01 A pioneer in the fields of statistics and probability theory Richard von Mises 1883 1953 made notable advances in boundary layer flow theory and airfoil design This text on compressible flow unfinished upon his sudden death was subsequently completed in accordance with his plans and von Mises first three chapters were augmented with a survey of the theory of steady plane flow Suitable as a text for advanced undergraduate and graduate students as well as a reference for professionals Mathematical Theory of Compressible Fluid Flow examines the fundamentals of high speed flows with detailed considerations of general theorems conservation equations waves shocks and nonisentropic flows In this the final work of his distinguished career von Mises summarizes his extensive knowledge of a central branch of fluid mechanics Characteristically he pays particular attention to the basics both conceptual and mathematical The novel concept of a specifying equation clarifies the role of thermodynamics in the mechanics of compressible fluids The general theory of characteristics receives a remarkably complete and simple treatment with detailed applications and the theory of shocks as asymptotic phenomena appears within the context of rational mechanics **Theoretical and Computational Dynamics of a Compressible Flow** Shih-I Pai, Shijun Luo, 2013-05-08 The purpose of this book is to give an introduction to the theoretical and computational fluid dynamics of a compressible fluid Emphasis is laid on the basic assumptions and the formulation of the theory of compressible flow as well as on the methods of solving

problems This book is intended for the students of fluid dynamics who are interested in the essential results and the useful techniques in the theoretical analysis and numerical methods of compressible flow The authors also hope that the book may serve as a useful reference to research workers in this field After the introduction the thermodynamical and physical properties of gases are briefly reviewed These serve as a foundation for the fluid dynamics of compressible fluid In order to limit the size of this book we consider mainly the flow of an ideal compressible fluid in which the effects of transport phenomena are neglected Chapter I to XVI However the transport phenomena do have much influence on the flow of a compressible fluid Hence in Chapter XVII some basic concepts of transport phenomena are discussed which prepare the students for further study of some important aspects of a compressible fluid flow

An Introduction to Compressible Flow Forrest E. Ames, 2018-02-13 An Introduction to Compressible Flow is a concise yet comprehensive treatment of one-dimensional compressible flow designed to provide mechanical and aerospace engineering students with the background they need for aerodynamics and turbomachinery courses This book covers isentropic flow normal shock waves oblique shock waves and Prandtl-Meyer flow and their applications The first chapter reviews the physics of air control volume analysis and provides a review of thermodynamics Most textbooks provide very concise treatments of compressible flow this text will supplement that material which is often too concise to provide students with the background they need This book also supports practicing engineers who have never developed a mastery of issues related to one-dimensional compressible flow or who need to review this material at some point in their careers The appendices provide the tables and charts commonly associated with this material One new addition is an oblique shock table which tabulates the oblique shock angle for the weak shock solution as a function of Mach number and deflection angle The book includes examples of problem solutions and each chapter has a list of problems to enable students to apply their understanding

Compressible-fluid Dynamics

Philip A. THOMPSON, 1912 Non-Ideal Compressible Fluid Dynamics for Propulsion and Power Francesca di Mare, Andrea Spinelli, Matteo Pini, 2020-07-08 This book reports on advanced theories and methods aimed at characterizing the dynamics of non ideal compressible fluids A special emphasis is given to research fostering the use of non ideal compressible fluids for propulsion and power engineering Both numerical and experimental studies as well as simulations are described in the book which is based on selected contributions and keynote lectures presented at the 2nd International Seminar on Non Ideal Compressible Fluid Dynamics for Propulsion Power Held on October 4 5 in Bochum Germany the seminar aimed at fostering collaborations between academics and professionals The two perspectives have been gathered together in this book which offers a timely guide to advanced fundamentals innovative methods and current applications of non ideal compressible fluids to developing turbomachines and for propulsion and power generation

Compressible Fluid Flow P. H. Oosthuizen, William E. Carscallen, 1997 One-Dimensional Compressible Flow H. Daneshyar, 2013-10-22 One Dimensional Compressible Flow explores the physical behavior of one dimensional compressible flow Various types of flow in one dimension are considered

including isentropic flow flow through a convergent or a convergent divergent duct with varying back pressure flow with friction or heat transfer and unsteady flow This text consists of five chapters and begins with an overview of the main concepts from thermodynamics and fluid mechanics with particular emphasis on the basic conservation equations for mass momentum and energy that are derived for time dependent flow through a control volume The chapters that follow provide a basis for understanding steady flow with area change friction or heat transfer A method for solving unsteady flow problems is described in the final chapter which also discusses the propagation of small disturbances and unsteady flow with finite changes in fluid properties This book will be useful to senior students pursuing a degree course in mechanical engineering and to engineers in industry *Viscous and Compressible Fluid Dynamics* Michael Edward O'Neill, Frank Chorlton, 1989

The Dynamics and Thermodynamics of Compressible Fluid Flow Ascher H. Shapiro, 1953 *Compressible Flow Propulsion and Digital Approaches in Fluid Mechanics* Michel Ledoux, Abdelkhalak El Hami, 2017-01-19 This book aims to provide an efficient methodology of solving a fluid mechanics problem based on an awareness of the physical It meets different objectives of the student the future engineer or scientist Simple sizing calculations are required to master today's numerical approach for solving complex practical problems *The Dynamics and Thermodynamics of Compressible Fluid Flow* Ascher H. Shapiro, 1958 *The Dynamics and Thermodynamics of Compressible Fluid Flow* Ascher H. Shapiro, 1954

Loose Leaf for Modern Compressible Flow: With Historical Perspective John D. Anderson, Jr., 2020-02-03 The response to the first three editions of *Modern Compressible Flow With Historical Perspective* from students faculty and practicing professionals has been overwhelmingly favorable Therefore this new edition preserves much of this successful content while adding important new components It preserves the author's informal writing style that talks to the reader that gains the reader's interest and makes the study of compressible flow an enjoyable experience Moreover it blends the classical nature of the subject with modern aspects of computational fluid dynamics CFD and high temperature gas dynamics so important to modern applications of compressible flow In short this book is a unique teaching and learning experience

The Dynamics and Thermodynamics of Compressible Fluid Flow, 1953

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