

1. Record Nr.	UNISA996499863703316
Autore	Girin Oleksandr
Titolo	Dynamics of compressible fluids : a textbook / / Oleksandr Girin
Pubbl/distr/stampa	Cham, Switzerland : , : Springer, , [2022] ©2022
ISBN	9783031112621 9783031112614
Descrizione fisica	1 online resource (316 pages)
Disciplina	629.13232
Soggetti	Compressibility Fluid dynamics Shock waves
Lingua di pubblicazione	Inglese
Formato	Materiale a stampa
Livello bibliografico	Monografia
Nota di bibliografia	Includes bibliographical references and index.
Nota di contenuto	Intro -- Preface -- Contents -- About the Author -- Introduction -- 1. Scope of the Dynamics of Compressible Fluids -- 2. The Subject Matter of Dynamics of Compressible Fluids -- 1 General Equations of Gas Motion -- 1.1 The Thermodynamic Model of a Perfect Gas -- Adiabatic Formulae -- 1.1.1 Internal State of a Gas Particle -- Thermodynamic Variables -- 1.1.2 Perfect Gas Model -- Polytropic Gas -- 1.1.3 Adiabatic Formulae -- 1.2 Governing Equations of Gas Motion -- Mathematical Model ... -- 1.3 Speed of Propagation of Small Disturbances in Ideal Gas -- Sound Speed -- 1.4 Thermodynamics of a Moving Gas -- 1.4.1 Bernoulli-Saint-Venant Equation -- Enthalpy -- 1.4.2 Stagnation Gas State -- Isentropic Formulae -- 1.4.3 Laval's Number -- Other Characteristic States of a Moving Gas -- References -- 2 Continuous Flows -- 2.1 Equations of One-Dimensional Steady Gas Flow -- Rule of a Stream Reversal -- 2.2 Gas Outflow from Reservoir -- Saint-Venant-Vantzel Formula -- 2.3 Supersonic Outflow Mode -- Laval's Nozzle -- References -- 3 Discontinuity in a Gas Flow -- 3.1 Conservation Laws at a Strong Discontinuity Surface -- 3.2 Classification of Strong Discontinuities -- Shocks -- 3.3 Normal Shock Theory -- 3.4 Normal Shock Regularities -- 3.4.1 Velocity Jump -- 3.4.2 Pressure Jump -- 3.4.3 Density Jump -- 3.4.4 Entropy Jump --

3.5 Shock Adiabatic Curve and Its Properties -- 3.5.1 Equation of Shock Adiabatic Curve -- 3.5.2 "Asterisk" Property -- 3.5.3 Limiting Degree of Gas Compression in Shock Waves -- 3.5.4 Approximation of Strong Shocks -- 3.5.5 Approximation of Weak Shocks -- References -- 4 Governing Equations and Initial-Boundary-Value Problems -- 4.1 Geometry of One-Dimensional Flows -- 4.2 Equations of Motion in Euler's Form -- Initial and Boundary Conditions -- 4.2.1 Euler's Equations of Motion -- 4.2.2 Initial Conditions -- 4.2.3 Boundary Conditions.

4.3 Equations of Motion in Lagrange's Form -- 4.4 Equations of Motion in Characteristic Form -- the Characteristic ... -- 4.5 The Method of Characteristics -- 4.6 Generalized Cauchy Problem (Type I Problem) ... -- 4.7 The Goursat Problem (Type II Problem) -- 4.8 Combined Problem of a Special Type (Type III Problem) -- 4.9 Characteristics as Trajectories of a Possible Weak Discontinuity of a Solution -- 4.9.1 Relationships Along the Weak Discontinuity Trajectory -- 4.9.2 Breakup of Arbitrary Weak Discontinuity -- References -- 5 Isentropic Gas Flows with Plane Waves -- 5.1 Riemann Method -- 5.1.1 Riemann Invariants -- 5.1.2 Riemann Variables -- Riemann Method -- 5.1.3 The Euler-Poisson Equation -- 5.1.4 The Remarkable Case  $\gamma = 3$  -- 5.2 The Riemann Waves -- 5.2.1 Simple Waves -- 5.2.2 Adjoining Theorem -- 5.2.3 Simple Wave Equations -- 5.2.4 Properties of Simple Waves -- 5.3 Gradient Catastrophe -- 5.4 The Piston Problem -- 5.4.1 Case When the Piston Is Pulled Out from Gas -- 5.4.2 Case of Piston Moving with Constant Velocity -- 5.4.3 Gas Outflow into the Vacuum -- 5.4.4 Piston Moves into Gas -- Shock Wave Induction Time -- 5.5 Interaction of Simple Wave with a Contact Surface ... -- 5.5.1 Analysis of the Flow Structure -- 5.5.2 Qualitative Analysis of the Interaction -- 5.5.3 The Limit Cases -- References -- 6 Methods of Wave Interaction Analysis -- 6.1 Method of  $(u, p)$ -Diagrams -- 6.1.1  $(u, p)$  -Diagrams of Simple Waves -- 6.1.2  $(u, p)$  -Diagrams of Shock Waves -- 6.2 Breakup of Arbitrary Strong Discontinuity (Riemann's Problem) -- 6.2.1 The Problem Formulation -- 6.2.2 Lemma About the Disturbances -- 6.2.3 Existence and Uniqueness of the Solution -- 6.2.4 Acoustic Approximation -- References -- 7 Shock-Wave Flows -- 7.1 Shock Tube Performance -- 7.1.1 The Device Description -- 7.1.2 The Problem Formulation -- 7.1.3 Shock Tube Solution.

7.2 Piston Moving with a Constant Velocity -- 7.2.1 Piston Moves into the Gas -- 7.2.2 Piston Moves Out from the Gas -- 7.3 Shock Wave Reflection from Rigid Wall -- Amplification Factor -- 7.3.1 The Problem Formulation -- 7.3.2 The Problem Solution -- 7.3.3 Shock Wave Percussive Ability -- 7.4 Interaction of Shock Wave with Contact Surface -- 7.4.1 The Problem Formulation -- 7.4.2 Qualitative Analysis of the Flow -- 7.5 Interaction of Two Shock Waves -- 7.5.1 The Problem Formulation -- 7.5.2 Qualitative Analysis -- 7.6 Interaction of Shock Wave with Simple Wave -- Entropy Trace -- 7.6.1 The Problem Formulation -- 7.6.2 Qualitative Analysis of the Flow -- 7.7 The Problem of the Internal Ballistics (Lagrange's Problem) -- 7.7.1 The Main Assumptions -- 7.7.2 The Problem Formulation -- 7.7.3 Solution in the Domain of Simple Wave -- 7.8 Strong Point Blast in Gas -- 7.8.1 Explosion Phenomenon -- 7.8.2 The Problem Formulation -- 7.8.3 Self-similarity of the Solution -- 7.8.4 Regularities of Gas Motion at Strong Point Blast -- 7.9 Long-Range Asymptotic Behavior of Shock Waves -- References -- 8 Steady Plane Irrotational Flows -- 8.1 Theory of an Oblique Shock -- 8.1.1 Interaction of Supersonic Flow with a Wedge -- Velocity Triangle -- 8.1.2 The Properties of Shock Polar -- 8.1.3 Oblique Reflection of a Plane Shock from a Rigid Wall -- 8.2 Equations of Steady Plane Irrotational Gas Motion -- 8.2.1 Equations

and Methods -- 8.2.2 The Characteristics of Equations of Plane Irrotational Steady Flow -- 8.2.3 Simple Waves -- 8.3 Supersonic Flow Around a Convex Corner -- Prandtl-Meyer Flow -- 8.4 Plane Supersonic Outflow from a Slit -- 8.5 Elements of the Theory of Thin Aerodynamic Profile -- 8.5.1 The Main Concepts -- 8.5.2 Linearization of Equations of Motion -- 8.5.3 Thin Profile in a Subsonic Stream -- The Prandtl-Glauert Rule.

8.5.4 Thin Profile in a Supersonic Stream -- Akkeret's Formula -- Wave Drag -- References -- Appendix A Numerical Method of Characteristics for the 1-D Unsteady Flows (Massau's Scheme) -- A.1 General Features of the Method -- A.2 Algorithms of the Numerical Method of Characteristics -- A.2.1 Governing Equations of 1-D Unsteady Gas Flow in Characteristic Form -- A.2.2 Calculations in the Internal Node -- A.2.3 Implementation of Boundary Conditions -- A.2.3.1 "Rigid Wall" -- A.2.3.2 "Piston" -- A.2.3.3 "Shock Front" -- A.2.3.4 "Contact Surface" -- A.3 Reverse Method of Characteristics (Hartree Scheme) -- A.4 Scheme for Isentropic Flows with Plane Waves -- Appendix B Godunov's Method for the Calculations of 1-D Unsteady Flows -- B.1 General Properties of the Method -- B.2 Scheme of the Method -- B.2.1 Initial Data Processing -- B.2.2 Development of the Difference Scheme -- B.2.3 Searching for  $u_k$ ,  $p_k$  and Flow Configuration -- B.2.4 Determination of  $R, U, P$  -- B.2.5 Determination of the Slopes  $W_{left}$ ,  $W'_{left}$ ,  $W_k$ ,  $W'_{right}$ ,  $W_{right}$  of the Sectors' Borders -- B.2.6 Finding the Relevant Sector -- B.3 Approximate Solution of the Discontinuity Breakup Problem -- B.3.1 The Acoustic Approximation -- B.3.2 Isentropic Approximation -- B.4 Algorithms of Boundary Conditions' Fulfillment -- B.4.1 "Rigid Wall" -- B.4.2 "Piston" -- B.4.3 "Shock Front" -- B.4.4 "Contact Surface" -- B.5 Determination of a Stable Time-Step -- B.6 Example Structure and Flowchart of Program Code for Godunov's Method -- Appendix C Numerical Methods for Two-Dimensional Flows -- C.1 Method of Characteristics for 2-D Steady Supersonic Flows -- C.1.1 The Characteristic form of Equations of Gas Motion in Ehlers' Variables -- C.1.2 Calculation Scheme for an Internal Node -- C.1.3 Calculation Scheme at the Symmetry Axis. C.1.4 Calculation of the Node at the Rigid Wall -- C.1.5 Calculation of a Node at Free Surface -- C.2 Breakup-Based Scheme of the Predictor-Corrector Type for 2-D Steady Supersonic Flows -- C.2.1 Governing Equations -- C.2.2 Approximation of the Computational Domain -- C.2.3 The Corrector Stage: the Finite-Difference Scheme -- C.2.4 The Predictor Stage: Determination of  $R, U, V, P$  -- C.2.5 Boundary Condition Fulfillment -- C.2.6 Choice of Time Step -- Use of Auxiliary Variables -- C.3 Godunov's Scheme for 2-D Unsteady Flows -- C.3.1 The Case of Plane-Parallel Flow -- C.3.1.1 The "Corrector" Stage -- C.3.1.2 The Stage "Predictor" -- C.3.2 The Case of a Fixed Rectangular Grid -- References -- Index.

---