Riemann Solvers And Numerical Methods For Fluid Dynamics

Numerical methods are indispensable tools in the analysis of complex fluid flows. This book focuses on computational techniques for high-speed gas flows, especially gas flows containing shocks and other steep gradients. The book decomposes complicated numerical methods into simple modular parts, showing how each part fits and how each method relates to or differs from others. The text begins with a review of gasdynamics and computational techniques. Next come basic principles of computational gasdynamics. The last two parts cover basic techniques and advanced techniques. Senior and graduate level students, especially in aerospace engineering, as well as researchers and practising engineers, will find a wealth of invaluable information on high-speed gas flows in this text.

This edited review book on Godunov methods contains 97 articles, all of which were presented at the international conference on Godunov Methods: Theory and Applications, held at Oxford, in October 1999, to commemorate the 70th birthday of the Russian mathematician Sergei K. Godunov. The central theme of this book is numerical methods for hyperbolic conservation laws following Godunov's key ideas contained in his celebrated paper of 1959. Hyperbolic conservation laws play a central role in mathematical modelling in several distinct disciplines of science and technology. Application areas include compressible, single (and multiple) fluid dynamics, shock waves, meteorology, elasticity, magnetohydrodynamics, relativity, and many others. The successes in the design and application of new and improved numerical methods of the Godunov type for hyperbolic conservation laws in the last twenty years have made a dramatic impact in these application areas. The 97 papers cover a very wide range of topics, such as design and analysis of numerical schemes, applications to compressible and incompressible fluid dynamics, multi-phase flows, combustion problems, astrophysics, environmental fluid dynamics, and detonation waves. This book will be a reference book on the subject of numerical methods for hyperbolic partial differential equations for many years to come. All contributions are self-contained but do contain a review element. There is a key paper by Peter Sweby in which a general overview of Godunov methods is given. This contribution is particularly suitable for beginners on the subject. This book is unique: it contains virtually everything concerned with Godunov-type methods for conservation laws. As such it will be of particular interest to academics (applied mathematicians, numerical analysts, engineers, environmental scientists, physicists, and astrophysicists) involved in research on numerical methods for partial differential equations; scientists and engineers concerned with new numerical methods and applications to scientific and engineering problems e.g., mechanical engineers, aeronautical engineers, meteorologists; and academics involved in teaching numerical methods for partial differential equations at the postgraduate

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This edited review book on Godunov methods contains 97 articles, all of which were presented at the international conference on Godunov Methods: Theory and Applications, held at Oxford in October 1999, to commemo rate the 70th birthday of the Russian mathematician Sergei K. Godunov. The meeting enjoyed the participation of 140 scientists from 20 countries; one of the participants commented: everyone is here, meaning that virtu ally everybody who had made a significant contribution to the general area of numerical methods for hyperbolic conservation laws, along the lines first proposed by Godunov in the fifties, was present at the meeting. Sadly, there were important absentees, who due to personal circumstance could not at tend this very exciting gathering. The central theme o{ the meeting, and of this book, was numerical methods for hyperbolic conservation laws fol lowing Godunov's key ideas contained in his celebrated paper of 1959. But Godunov's contributions to science are not restricted to Godunov's method.

Numerical Methods for Special Functions

Innovative Methods for Numerical Solutions of Partial Differential Equations

Numerical Methods in a Unified Object-Oriented Approach, Second Edition

Numerical Methods for Wave Propagation

Spectral and High Order Methods for Partial Differential Equations ICOSAHOM 2018

In this much-expanded second edition, author Yair Shapira presents new applications and a substantial extension of the original object-oriented framework to make this popular and comprehensive book even easier to understand and use. It not only introduces the C and C++ programming languages, but also shows how to use them in the numerical solution of partial differential equations (PDEs). The book leads readers through the entire solution process, from the original PDE, through the discretization stage, to the numerical solution of the resulting algebraic system. The high level of abstraction available in C++ is particularly useful in the implementation of complex mathematical objects, such as unstructured mesh, sparse matrix, and multigrid hierarchy, often used in numerical modeling. The well-debugged and tested code segments implement the numerical methods efficiently and transparently in a unified object-oriented approach.

In May 1995 a meeting took place at the Manchester Metropolitan Uni versity, UK, with the title International Workshop on Numerical Methods for Wave Propagation Phenomena. The Workshop, which was attended by 60 scientists from 13 countries, was preceded by a short course enti tled High-Resolution Numerical Methods for Wave Propagation Phenom ena. The course participants could then join the Workshop and listen to discussions of the latest work in the field led by experts responsible for such developments. The present volume contains written versions of their contributions from the majority of the speakers at the Workshop. Professor Amiram Harten, but for his untimely death at the age of 50 years, would have been one of the speakers at the Workshop. His remarkable contributions to Numerical Analysis of Conservation Laws are commemo rated in this volume, which includes the text of the First Harten Memorial Lecture, delivered by Professor P. L. Roe from the University of Michigan in Ann Arbour, USA.

Numerical Algorithms: Methods for Computer Vision, Machine Learning, and Graphics presents a new approach to numerical analysis for modern computer scientists. Using examples from a broad base of computational tasks, including data processing, computational photography, and animation, the textbook introduces numerical modeling and algorithmic desig

Praise for the First Edition ". . . outstandingly appealing with regard to its style, contents, considerations of requirements of practice, choice of examples, and exercises." —Zentrablatt Math ". . . carefully structured with many detailed worked

examples . . ." —The Mathematical Gazette ". . . an up-to-date and user-friendly account . . ." —Mathematika An Introduction to Numerical Methods and Analysis addresses the mathematics underlying approximation and scientific computing and successfully explains where approximation methods come from, why they sometimes work (or don't work), and when to use one of the many techniques that are available. Written in a style that emphasizes readability and usefulness for the numerical methods novice, the book begins with basic, elementary material and gradually builds up to more advanced topics. A selection of concepts required for the study of computational mathematics is introduced, and simple approximations using Taylor's Theorem are also treated in some depth. The text includes exercises that run the gamut from simple hand computations, to challenging derivations and minor proofs, to programming exercises. A greater emphasis on applied exercises as well as the cause and effect associated with numerical mathematics is featured throughout the book. An Introduction to Numerical Methods and Analysis is the ideal text for students in advanced undergraduate mathematics and engineering courses who are interested in gaining an understanding of numerical methods and numerical analysis.

An Introduction to Numerical Methods and Analysis
Solutions to ODEs and PDEs
Numerical Algorithms
Part 1: Classical Fluid Dynamics
Basic and Fundamental Issues

This open access book features a selection of high-quality papers from the presentations at the International Conference on Spectral and High-Order Methods 2018, offering an overview of the depth and breadth of the activities within this important research area. The carefully reviewed papers provide a snapshot of the state of the art, while the extensive bibliography helps initiate new research directions.

This is the first book in a four-part series designed to give a comprehensive and coherent description of Fluid Dynamics, starting with chapters on classical theory suitable for an introductory undergraduate lecture course, and then progressing through more advanced material up to the level of modern research in the field. The present Part 1 consists of four chapters. Chapter 1 begins with a discussion of Continuum Hypothesis, which is followed by an introduction to macroscopic functions, the velocity vector, pressure, density, and enthalpy. We then analyse the forces acting inside a fluid, and deduce the Navier-Stokes equations for incompressible and compressible fluids in Cartesian and curvilinear coordinates. In Chapter 2 we study the properties of a number of flows that are presented by the so-called exact solutions of the Navier-Stokes equations, including the Couette flow between two parallel plates, Hagen-Poiseuille flow through a pipe, and Karman flow above an infinite rotating disk. Chapter 3 is devoted to the inviscid incompressible flow theory, with particular focus on two-dimensional potential flows. These can be described in terms of the "complex potential", allowing the full power of the theory of functions of complex variables to be used. We discuss in detail the method of conformal mapping, which is then used to study various flows of interest, including the flows past Joukovskii aerofoils. The final Chapter 4 is concerned with compressible flows of perfect gas, including supersonic flows. Particular attention is given to the theory of characteristics, which is used, for example, to analyse the Prandtl-Meyer flow over a body surface bend and a corner. Significant attention is also devoted to the shock waves. The chapter concludes with analysis of unsteady flows, including the theory of blast waves.

Conservation laws are the mathematical expression of the principles of conservation and provide effective and accurate predictive models of our physical world. Although intense research activity during the last decades has led to substantial advances in the development of powerful computational methods for conservation laws, their solution remains a challenge and many questions are left open; thus it is an active and fruitful area of research. Numerical Methods for Conservation Laws: From Analysis to Algorithms offers the first comprehensive introduction to modern computational methods and their analysis for hyperbolic conservation laws, building on intense research activities for more than four decades of development; discusses classic results on monotone and finite difference/finite volume schemes, but emphasizes the successful development of high-order accurate methods for hyperbolic conservation laws; addresses modern concepts of TVD and entropy stability, strongly stable Runge-Kutta schemes, and limiter-based methods before discussing essentially nonoscillatory schemes, discontinuous Galerkin methods, and spectral methods; explores algorithmic aspects of these methods, emphasizing one- and two-dimensional problems and the development and analysis of an extensive range of methods; includes MATLAB software with which all main methods and computational results in the book can be reproduced; and demonstrates the performance of many methods on a set of benchmark problems to allow direct comparisons. Code and other supplemental material will be available online at publication.

This book is concerned with mathematical and numerical methods for compressible flow. It aims to provide the reader with a sufficiently detailed and extensive, mathematically precise, but comprehensible guide, through a wide spectrum of mathematical and computational methods used in Computational Fluid Dynamics (CFD) for the numerical simulation of compressible flow. Up-to-date techniques applied in the numerical solution of inviscid as well as viscous compressible flow on unstructured meshes are explained, thus allowing the simulation of complex three-dimensional technically relevant problems. Among some of the methods addressed are finite volume methods using approximate Riemann solvers, finite element techniques, such as the streamline diffusion and the discontinuous Galerkin methods, and combined finite volume - finite element schemes. The book gives a complex insight into the numerics of compressible flow, covering the development of numerical schemes and their theoretical mathematical analysis, their verification on test problems and use in solving practical engineering problems. The book will be helpful to specialists coming into contact with CFD - pure and applied mathematicians, aerodynamists, engineers, physicists and natural scientists. It will also be suitable for advanced undergraduate, graduate and postgraduate students of mathematics and technical sciences.

Upwind and High-Resolution Schemes

Computational Methods for Astrophysical Fluid Flow

Godunov Methods

Relativistic Hydrodynamics

Computational Gasdynamics

These notes developed from a course on the numerical solution of conservation laws first taught at the University of Washington in the fall of 1988 and then at ETH during the following spring. The overall emphasis is on studying the mathematical tools that are essential in de veloping, analyzing, and successfully using numerical methods for nonlinear systems of conservation laws, particularly for problems involving shock waves. A reasonable un derstanding of the mathematical structure of these equations and their solutions is first required, and Part I of these notes deals with this theory. Part II deals more directly with numerical methods, again with the emphasis on general tools that are of broad use. I have stressed the underlying ideas used in various classes of methods rather than present ing the most sophisticated methods in great detail. My aim was to provide a sufficient background that students could then approach the current research literature with the necessary tools and understanding. vVithout the wonders of TeX and LaTeX, these notes would never have been put together. The professional-looking results perhaps obscure the fact that these are indeed lecture notes. Some sections have been reworked several times by now, but others are still preliminary. I can only hope that the errors are not too blatant. Moreover, the breadth and depth of coverage was limited by the length of these courses, and some parts are rather sketchy.

The Riemann problem is the most fundamental problem in the entire field of non-linear hyperbolic conservation laws. Since first posed and solved in 1860, great progress has been achieved in the one-dimensional case. However, the two-dimensional case is substantially different. Although research interest in it has lasted more than a century, it has yielded almost no analytical demonstration. It remains a great challenge for mathematicians. This volume presents work on the two-dimensional Riemann problem carried out over the last 20 years by a Chinese group. The authors explore four models: scalar conservation laws, compressible Euler equations, zero-pressure gas dynamics, and pressure-gradient equations. They use the method of generalized characteristic analysis plus numerical experiments to demonstrate the elementary field interaction patterns of shocks, rarefaction waves, and slip lines. They also discover a most interesting feature for zero-pressure gas dynamics: a new kind of elementary wave appearing in the interaction of slip lines-a

weighted Dirac delta shock of the density function. The Two-Dimensional Riemann Problem in Gas Dynamics establishes the rigorous mathematical theory of delta-shocks and Mach reflection-like patterns for zero-pressure gas dynamics, clarifies the boundaries of interaction of elementary waves, demonstrates the interesting spatial interaction of slip lines, and proposes a series of open problems. With applications ranging from engineering to astrophysics, and as the first book to examine the two-dimensional Riemann problem, this volume will prove fascinating to mathematicians and hold great interest for physicists and engineers.

Handbook of Numerical Methods for Hyperbolic Problems explores the changes that have taken place in the past few decades regarding literature in the design, analysis and application of various numerical algorithms for solving hyperbolic equations. This volume provides concise summaries from experts in different types of algorithms, so that readers can find a variety of algorithms under different situations and readily understand their relative advantages and limitations. Provides detailed, cutting-edge background explanations of existing algorithms and their analysis Ideal for readers working on the theoretical aspects of algorithm development and its numerical analysis Presents a method of different algorithms for specific applications and the relative advantages and limitations of different algorithms for engineers or readers involved in applications Written by leading subject experts in each field who provide breadth and depth of content coverage

This scholarly text provides an introduction to the numerical methods used to model partial differential equations, with focus on atmospheric and oceanic flows. The book covers both the essentials of building a numerical model and the more sophisticated techniques that are now available. Finite difference methods, spectral methods, finite element method, flux-corrected methods and TVC schemes are all discussed. Throughout, the author keeps to a middle ground between the theorem-proof formalism of a mathematical text and the highly empirical approach found in some engineering publications. The book establishes a concrete link between theory and practice using an extensive range of test problems to illustrate the theoretically derived properties of various methods. From the reviews: "...the books unquestionable advantage is the clarity and simplicity in presenting virtually all basic ideas and methods of numerical analysis currently actively used in geophysical fluid dynamics." Physics of Atmosphere and Ocean

Numerical Analysis Using R

Python Programming and Numerical Methods

Principles of Computational Fluid Dynamics

Solving PDEs in C++

Numerical Methods for Fluid Dynamics

Python Programming and Numerical Methods: A Guide for Engineers and Scientists introduces programming tools and numerical methods to engineering and science students, with the goal of helping the students to develop good computational problem-solving techniques through the use of numerical methods and the Python programming language. Part One introduces fundamental programming concepts, using simple examples to put new concepts quickly into practice. Part Two covers the fundamentals of algorithms and numerical analysis at a level that allows students to quickly apply results in practical settings. Includes tips, warnings and "try this" features within each chapter to help the reader develop good programming practice

Summaries at the end of each chapter allow for quick access to important information Includes code in Jupyter notebook format that can be directly run online

This book, first published in 2002, contains an introduction to hyperbolic partial differential equations and a powerful class of numerical methods for approximating their solution, including both linear problems and nonlinear conservation laws. These equations describe a wide range of wave propagation and transport phenomena arising in nearly every scientific and engineering discipline. Several applications are described in a self-contained manner, along with much of the mathematical theory of hyperbolic problems. High-resolution versions of Godunov's method are developed, in which Riemann problems are solved to determine the local wave structure and limiters are then applied to eliminate numerical oscillations. These methods were originally designed to capture shock waves accurately, but are also useful tools for studying linear wave-propagation problems, particularly in heterogenous material. The methods studied are implemented in the CLAWPACK software package and source code for all the examples presented can be found on the web, along with animations of many of the simulations. This provides an excellent learning environment for understanding wave propagation phenomena and finite volume methods.

Computational science is fundamentally changing how technological questions are addressed. The design of aircraft, automobiles, and even racing sailboats is now done by computational simulation. The mathematical foundation of this new approach is numerical analysis, which studies algorithms for computing expressions defined with real numbers. Emphasizing the theory behind the computation, this book provides a rigorous and self-contained introduction to numerical analysis and presents the advanced mathematics that underpin industrial software, including complete details that are missing from most textbooks. Using an inquiry-based learning approach, Numerical Analysis is written in a narrative style, provides historical background, and includes many of the proofs and technical details in exercises. Students will be able to go beyond an elementary understanding of numerical simulation and develop deep insights into the foundations of the subject. They will no longer have to accept the mathematical gaps that exist in current textbooks. For example, both necessary and sufficient conditions for convergence of basic iterative methods are covered, and proofs are given in full generality, not just based on special cases. The book is accessible to undergraduate mathematics majors as well as computational scientists wanting to learn the foundations of the subject. Presents the mathematical foundations of numerical analysis Explains the mathematical details behind simulation software Introduces many advanced concepts in modern analysis Self-contained and mathematically rigorous Contains problems and solutions in each chapter Excellent follow-up course to Principles of Mathematical Analysis by Rudin

This book addresses an important class of mathematical problems (the Riemann problem) for first-order hyperbolic partial differential equations (PDEs), which arise when modeling wave propagation in applications such as fluid dynamics, traffic flow, acoustics, and elasticity. The solution of the Riemann problem captures essential information about these models and is the key ingredient in modern numerical methods for their solution. This book covers the fundamental ideas related to classical Riemann solutions, including their special structure and the types of waves that arise, as well as the ideas behind fast approximate solvers for the Riemann problem. The emphasis is on the general ideas, but each chapter delves into a particular application. Riemann Problems and Jupyter Solutions is available in electronic form as a collection of Jupyter notebooks that contain executable computer code and interactive figures and animations, allowing readers to grasp how the concepts presented are affected by important parameters and to experiment by varying those parameters themselves. The only interactive book focused entirely on the Riemann problem, it develops each concept in the context of a specific physical application, helping readers apply physical intuition in learning mathematical concepts. Graduate students and researchers working in the analysis and/or numerical solution of hyperbolic PDEs will find this book of interest. This includes mathematicians, as well as scientists and engineers, working on wave propagation problems. Educators interested in developing instructional materials using Jupyter notebooks will also find

this book useful. The book is appropriate for courses in Numerical Methods for Hyperbolic PDEs and Analysis of Hyperbolic PDEs, and it can be a great supplement for courses in computational fluid dynamics, acoustics, and gas dynamics.

Analytical and Numerical Methods for Wave Propagation in Fluid Media

With Applications to Geophysics

Mathematical and Computational Methods for Compressible Flow

Saas-Fee Advanced Course 27. Lecture Notes 1997 Swiss Society for Astrophysics and Astronomy

Riemann Problems and Jupyter Solutions

This book consists of 20 review articles dedicated to Prof. Philip Roe on the occasion of his 60th birthday and in appreciation of his original contributions to computational fluid dynamics. The articles, written by leading researchers in the field, cover many topics, including theory and applications, algorithm developments and modern computational techniques for industry. Contents: OC A One-Sided ViewOCO: The Real Story (B van Leer); Collocated Upwind Schemes for Ideal MHD (K G Powell); The Penultimate Scheme for Systems of Conservation Laws: Finite Difference ENO with Marquina's Flux Splitting (R P Fedkiw et al.); A Finite Element Based Level-Set Method for Multiphase Flows (B Engquist & A-K Tornberg); The GHOST Fluid Method for Viscous Flows (R P Fedkiw & X-D Liu); Factorizable Schemes for the Equations of Fluid Flow (D Sidilkover); Evolution Galerkin Methods as Finite Difference Schemes (K W Morton); Fluctuation Distribution Schemes on Adjustable Meshes for Scalar Hyperbolic Equations (M J Baines); Superconvergent Lift Estimates Through Adjoint Error Analysis (M B Giles & N A Pierce); Somewhere between the LaxOCoWendroff and Roe Schemes for Calculating Multidimensional Compressible Flows (A Lerat et al.); Flux Schemes for Solving Nonlinear Systems of Conservation Laws (J M Ghidaglia); A LaxOCoWendroff Type Theorem for Residual Schemes (R Abgrall et al.); Kinetic Schemes for Solving SaintOCoVenant Equations on Unstructured Grids (M O Bristeau & B Perthame); Nonlinear Projection Methods for Multi-Entropies NavierOCoStokes Systems (C Berthon & F Coquel); A Hybrid Fluctuation Splitting Scheme for Two-Dimensional Compressible Steady Flows (P De Palma et al.); Some Recent Developments in Kinetic Schemes Based on Least Squares and Entropy Variables (S M Deshpande); Difference Approximation for Scalar Conservation Law. Consistency with Entropy Condition from the Viewpoint of Oleinik's E-Condition (H Aiso); Lessons Learned from the Blast Wave Computation Using Overset Moving Grids: Grid Motion Improves the Resolution (K Fujii). Readership: Researchers and graduate students in numerical and computational mathematics in engineering."

Special functions arise in many problems of pure and applied mathematics, mathematical statistics, physics, and engineering. This book provides an up-to-date overview of numerical methods for computing special functions and discusses when to use these methods depending on the function and the range of parameters. Not only are standard and simple parameter domains considered, but methods valid for large and complex parameters are described as well. The first part of the book (basic methods) covers convergent and divergent series, Chebyshev expansions, numerical quadrature, and recurrence relations. Its focus is on the computation of special functions; however, it is suitable for general numerical courses. Pseudoalgorithms are given to help students write their own algorithms. In addition to these basic tools, the authors discuss other useful and efficient methods, such as methods for computing zeros of special functions, uniform asymptotic expansions, Padé approximations, and sequence transformations. The book also provides specific algorithms for computing several special functions (like Airy functions and parabolic cylinder functions, among others).

Numerical Methods for Hyperbolic Equations is a collection of 49 articles presented at the International Conference on Numerical Methods for Hyperbolic Equations: Theory and Applications (Santiago de Compostela, Spain, 4-8 July 2011). The conference was organized to honour Professor Eleuterio Toro in the month of his 65th birthday. The topics cover

This book leads directly to the most modern numerical techniques for compressible fluid flow, with special consideration given to astrophysical applications. Emphasis is put on high-resolution shock-capturing finite-volume schemes based on Riemann solvers. The applications of such schemes, in particular the PPM method, are given and include large-scale simulations of supernova explosions by core collapse and thermonuclear burning and astrophysical jets. Parts two and three treat radiation hydrodynamics. The power of adaptive (moving) grids is demonstrated with a number of stellar-physical simulations showing very crispy shock-front structures.

From Analysis to Algorithms

Handbook of Numerical Methods for Hyperbolic Problems

Generalized Riemann Problems in Computational Fluid Dynamics

Methods for Computer Vision, Machine Learning, and Graphics

Numerical Methods for Stochastic Partial Differential Equations with White Noise

High resolution upwind and centered methods are a mature generation of computational techniques. They are applicable to a wide range of engineering and scientific disciplines, Computational Fluid Dynamics (CFD) being the most prominent up to now. This textbook gives a comprehensive, coherent and practical presentation of this class of techniques. For its third edition the book has been thoroughly revised to contain new material.

One of the major achievements in computational fluid dynamics has been the development of numerical methods for simulating compressible flows, combining higher-order accuracy in smooth regions with a sharp, oscillation-free representation of embedded shocks methods and now known as "high-resolution schemes". Together with introductions from the editors written from the modern vantage point this volume collects in one place many of the most significant papers in the development of high-resolution schemes as occured at ICASE.

Relativistic hydrodynamics is a very successful theoretical framework to describe the dynamics of matter from scales as small as those of colliding elementary particles, up to the largest scales in the universe. This book provides an up-to-date, lively, and approachable introduction to the mathematical formalism, numerical techniques, and applications of relativistic hydrodynamics. The topic is typically covered either by very formal or by very phenomenological books, but is instead presented here in a form that will be appreciated both by students and researchers in the field. The topics covered in the book are the results of work carried out over the last 40 years, which can be found in rather technical research articles with dissimilar notations and styles. The book is not just a collection of scattered information, but a well-organized description of relativistic hydrodynamics, from the basic principles of statistical kinetic theory, down to the technical aspects of numerical methods devised for the solution of the equations, and over to the applications in modern physics and astrophysics. Numerous figures, diagrams, and a variety of exercises aid the material in the book. The most obvious applications of this work range from astrophysics (black holes, neutron stars, gamma-ray bursts, and active galaxies) to cosmology (early-universe hydrodynamics and phase transitions) and particle physics (heavy-ion collisions). It is often said that fluids are either seen as solutions of partial differential equations or as "wet". Fluids in this book are definitely wet, but the mathematical beauty of differential equations is not washed out.

Numerical Solution of Hyperbolic Partial Differential Equations is a new type of graduate textbook, with both print and interactive electronic components (on CD). It is a comprehensive presentation of modern shock-capturing methods, including both finite volume and finite element methods, covering the theory of hyperbolic conservation laws and the theory of the numerical methods. The range of applications is broad enough to engage most engineering disciplines and many areas of applied mathematics. Classical techniques for judging the qualitative performance of the schemes are used to motivate the development of classical higher-order methods. The interactive CD gives access to the computer code used to create all of the text's figures, and lets readers run simulations, choosing their own input parameters; the CD displays the results of the experiments as movies. Consequently, students can gain an appreciation for both the dynamics of the problem application, and the growth of numerical errors.

A Practical Introduction

Approximate Riemann Solvers and Numerical Flux Functions

A Guide for Engineers and Scientists

Numerical Methods in Scientific Computing:

The Two-Dimensional Riemann Problem in Gas Dynamics

This book surveys analytical and numerical techniques appropriate to the description of fluid motion with an emphasis on the most widely used techniques exhibiting the best performance. Analytical and numerical solutions to hyperbolic systems of wave equations are the primary focus of the book. In addition, many interesting wave phenomena in fluids are considered using examples such as acoustic waves, the emission of air pollutants, magnetohydrodynamic waves in the solar corona, solar wind interaction with the planet venus, and ion-acoustic solitons.

The first of its kind in the field, this title examines the use of modern, shock-capturing finite volume numerical methods, in the solution of partial differential equations associated with free-surface flows, which satisfy the shallow-water type assumption (including shallow water flows, dense gases and mixtures of materials as special samples). Starting with a general presentation of the governing equations for free-surface shallow flows and a discussion of their physical applicability, the book goes on to analyse the mathematical properties of the equations, in preparation for the presentation of the exact solution of the Riemann problem for wet and dry beds. After a general introduction to the finite volume approach, several chapters are then devoted to describing a variety of modern shock-capturing finite volume numerical methods, including Godunov methods of the upwind and centred type.

Approximate Riemann solvers following various approaches are studied in detail as is their use in the Godunov approach for constructing low and high-order upwind TVD methods. Centred TVD schemes are also presented. Two chapters are then devoted to practical applications. The book finishes with an overview of potential practical applications of the methods studied, along with appropriate reference to sources of further information. Features include: * Algorithmic and practical presentation of the methods * Practical applications such as dam-break modelling and the study of bore reflection patterns in two space dimensions * Sample computer programs and accompanying numerical software (details available at www.numeritek.com) The book is suitable for teaching postgraduate students of civil, mechanical, hydraulic and environmental engineering, meteorology, oceanography, fluid mechanics and applied mathematics. Selected portions of the material may also be useful in teaching final year undergraduate students in the above disciplines. The contents will also be of interest to research scientists and engineers in academia and research and consultancy laboratories.

In 1917, the British scientist L. F. Richardson made the first reported attempt to predict the weather by solving partial differential equations numerically, by hand! It is generally accepted that Richardson's work, though unsuccess ful, marked the beginning of Computational Fluid Dynamics (CFD), a large branch of Scientific Computing today. His work had the four distinguishing characteristics of CFD: a PRACTICAL PROBLEM to solve, a MATHEMATICAL MODEL to represent the problem in the form of a set of partial differen tial equations, a NUMERICAL METHOD and a COMPUTER, human beings in Richardson's case. Eighty years on and these four elements remain the pillars of modern CFD. It is therefore not surprising that the generally accepted definition of CFD as the science of computing numerical solutions to Partial Differential or Integral Equations that are models for fluid flow phenomena, closely embodies Richardson's work. COMPUTERS have, since Richardson's era, developed to unprecedented levels and at an ever decreasing cost. PRACTICAL PROBLEMS to solved nu merically have increased dramatically. In addition to the traditional demands from Meteorology, Oceanography, some branches of Physics and from a range of Engineering Disciplines, there are at present fresh demands from a dynamic and fast-moving manufacturing industry, whose traditional build-test-fix approach is rapidly being replaced by the use of quantitative methods, at all levels. The need for new materials and for decision-making under envi ronmental constraints are increasing sources of demands for mathematical modelling, numerical algorithms and high-performance computing.

This book covers numerical methods for stochastic partial differential equations with white noise using the framework of Wong-Zakai approximation. The book begins with some motivational and background material in the introductory chapters and is divided into three parts. Part I covers numerical stochastic ordinary differential equations. Here the authors start with numerical methods for SDEs with delay using the Wong-Zakai approximation and finite difference in time. Part II covers temporal white noise. Here the authors consider SPDEs as PDEs driven by white noise, where discretization of white noise (Brownian motion) leads to PDEs with smooth noise, which can then be treated by numerical methods for PDEs. In this part, recursive algorithms based on Wiener chaos expansion and stochastic collocation methods are presented for linear stochastic advection-diffusion-reaction equations. In addition, stochastic Euler equations are exploited as an application of stochastic collocation methods, where a numerical comparison with other integration methods in random space is made. Part III covers spatial white noise. Here the authors discuss numerical methods for nonlinear elliptic equations as well as other equations with additive noise. Numerical methods for SPDEs with multiplicative noise are also discussed using the Wiener chaos expansion method. In addition, some SPDEs driven by non-Gaussian white noise are discussed and some model reduction methods (based on Wick-Malliavin calculus) are presented for generalized polynomial chaos expansion methods. Powerful techniques are provided for solving stochastic partial differential equations. This book can be considered as self-contained. Necessary background knowledge is presented in the appendices. Basic knowledge of probability theory and stochastic calculus is presented in Appendix A. In Appendix B some semi-analytical methods for SPDEs are presented. In Appendix C an introduction to Gauss quadrature is provided. In Appendix D, all the conclusions which are needed for proofs are presented, and in Appendix E a method to compute the convergence rate empirically is included. In addition, the authors provide a thorough review of the topics, both theoretical and computational exercises in the book with practical discussion of the effectiveness of the methods. Supporting Matlab files are made available to help illustrate some of the concepts further. Bibliographic notes are included at the end of each chapter. This book serves as a reference for graduate students and researchers in the mathematical sciences who would like to understand state-of-the-art numerical methods for stochastic partial differential equations with white noise.

Finite Volume Methods for Hyperbolic Problems

Shock-Capturing Methods for Free-Surface Shallow Flows

Riemann Solvers and Numerical Methods for Fluid Dynamics

Theory and Applications ; [proceedings of an International Conference on Godunov Methods: Theory and Applications, Held October 18 - 22, 1999, in Oxford, UK ...]

Numerical Methods for Conservation Laws

This book presents the latest numerical solutions to initial value problems and boundary value problems described by ODEs and PDEs. The author offers practical methods that can be adapted to solve wide ranges of problems and illustrates them in the increasingly popular open source computer language R, allowing integration with more statistically based methods. The book begins with standard techniques, followed by an overview of 'high resolution' flux limiters and WENO to solve problems with solutions exhibiting high gradient phenomena. Meshless methods using radial basis functions are then discussed in the context of scattered data interpolation and the solution of PDEs on irregular grids. Three detailed case studies demonstrate how numerical methods can be used to tackle very different complex problems. With its focus on practical solutions to real-world problems, this book will be useful to students and practitioners in all areas of science and engineering, especially those using R.

High resolution upwind and centered methods are today a mature generation of computational techniques applicable to a wide range of engineering and scientific disciplines, Computational Fluid Dynamics (CFD) being the most prominent up to now. This textbook gives a comprehensive, coherent and practical presentation of this class of techniques. The book is designed to provide readers with an understanding of the basic concepts, some of the underlying theory, the ability to critically use the current research papers on the subject, and, above all, with the required information for the practical implementation of the methods. Applications include: compressible, steady, unsteady, reactive, viscous, non-viscous and free surface flows.

This up-to-date book gives an account of the present state of the art of numerical methods employed in computational fluid dynamics. The underlying numerical principles are treated in some detail, using elementary methods. The author gives many pointers to the current literature, facilitating further study. This book will become the standard reference for CFD for the next 20 years.

This work addresses the increasingly important role of numerical methods in science and engineering. It combines traditional and well-developed topics with other material such as interval arithmetic, elementary functions, operator series, convergence acceleration, and continued fractions.

Volume 1

Selected Papers from the ICOSAHOM Conference, London, UK, July 9-13, 2018

Numerical Analysis

Selected Contributions from the Workshop held in Manchester, U.K., Containing the Harten Memorial Lecture

Theory and Applications