

The Finite Volume Method In Computational Fluid Dynamics An Advanced Introduction With Openfoami 1 2 And Matlab Fluid Mechanics And Its Applications

Numerical Methods for Partial Differential Equations: Finite Difference and Finite Volume Methods focuses on two popular deterministic methods for solving partial differential equations (PDEs), namely finite difference and finite volume methods. The solution of PDEs can be very challenging, depending on the type of equation, the number of independent variables, the boundary, and initial conditions, and other factors. These two methods have been traditionally used to solve problems involving fluid flow. For practical reasons, the finite element method, used more often for solving problems in solid mechanics, and covered extensively in various other texts, has been excluded. The book is intended for beginning graduate students and early career professionals, although advanced undergraduate students may find it equally useful. The material is meant to serve as a prerequisite for students who might go on to take additional courses in computational mechanics, computational fluid dynamics, or computational electromagnetics. The notations, language, and technical jargon used in the book can be easily understood by scientists and engineers who may not have had graduate-level applied mathematics or computer science courses. Presents one of the few available resources that comprehensively describes and demonstrates the finite volume method for unstructured mesh used frequently by practicing code developers in industry Includes step-by-step algorithms and code snippets in each chapter that enables the reader to make the transition from equations on the page to working codes Includes 51 worked out examples that comprehensively demonstrate important mathematical steps, algorithms, and coding practices required to numerically solve PDEs, as well as how to interpret the results from both physical and mathematic perspectives

This practical, lab-based approach to nano- and microfluidics provides readers with a wealth of practical techniques, protocols, and experiments ready to be put into practice in both research and industrial settings. The practical approach is ideally suited to researchers and R&D staff in industry; additionally the interdisciplinary approach to the science of nano- and microfluidics enables readers from a range of different academic disciplines to broaden their understanding. Dr Rapp fully engages with the multidisciplinary nature of the subject. Alongside traditional fluid/transport topics, there is a wealth of coverage of materials and manufacturing techniques, chemical modification/surface functionalization, biochemical analysis, and the biosensors involved. As well as providing a clear and concise overview to get started into the multidisciplinary field of microfluidics and practical guidance on techniques, pitfalls and troubleshooting, this book supplies: A set of hands-on experiments and protocols that will help setting up lab experiments but which will also allow a quick start into practical work. A collection of microfluidic structures, with 3D-CAD and image data that can be used directly (files provided on a companion website). A practical guide to the successful design and implementation of nano- and microfluidic processes (e.g. biosensing) and equipment (e.g., biosensors, such as diabetes blood glucose sensors). Provides techniques, experiments, and protocols ready to be put to use in the lab, in an academic, or industry setting. A collection of 3D-CAD and image files is provided on a companion website.

Examines numerical and semi-analytical methods for differential equations that can be used for solving practical ODEs and PDEs This student-friendly book deals with various approaches for solving differential equations numerically or semi-analytically depending on the type of equations and offers simple example problems to help readers along. Featuring both traditional and recent methods, Advanced Numerical and Semi Analytical Methods for Differential Equations begins with a review of basic numerical methods. It then looks at Laplace, Fourier, and weighted residual methods for solving differential equations. A new challenging method of Boundary Characteristics Orthogonal Polynomials (BCOPs) is introduced next. The book then discusses Finite Difference Method (FDM), Finite Element Method (FEM), Finite Volume Method (FVM), and Boundary Element Method (BEM). Following that, analytical/semi analytic methods like Akbari Ganji's Method (AGM) and Exp-function are used to solve nonlinear differential equations. Nonlinear differential equations using semi-analytical methods are also addressed, namely Adomian Decomposition Method (ADM), Homotopy Perturbation Method (HPM), Variational Iteration Method (VIM), and Homotopy Analysis Method (HAM). Other topics covered include: emerging areas of research related to the solution of differential equations based on differential quadrature and wavelet approach; combined and hybrid methods for solving differential equations; as well as an overview of fractal differential equations. Further, uncertainty in term of intervals and fuzzy numbers have also been included, along with the interval finite element method. This book: Discusses various methods for solving linear and nonlinear ODEs and PDEs Covers basic numerical techniques for solving differential equations along with various discretization methods Investigates nonlinear differential equations using semi-analytical methods Examines differential equations in an uncertain environment Includes a new scenario in which uncertainty (in term of intervals and fuzzy numbers) has been included in differential equations Contains solved example problems, as well as some unsolved problems for self-validation of the topics covered Advanced Numerical and Semi Analytical Methods for Differential Equations is an excellent text for graduate as well as post graduate students and researchers studying various methods for solving differential equations, numerically and semi-analytically.

This established, leading textbook, is suitable for courses in CFD. The new edition covers new techniques and methods, as well as considerable expansion of the advanced topics and applications (from one to four chapters). This book presents the fundamentals of computational fluid mechanics for the novice user. It provides a thorough yet user-friendly introduction to the governing equations and boundary conditions of viscous fluid flows, turbulence and its modelling, and the finite volume method of solving flow problems on computers.

The Control Volume Finite Element Method (CVFEM) is a hybrid numerical methods, combining the physics intuition of Control Volume Methods with the geometric flexibility of Finite Element Methods. The concept of this monograph is to introduce a common framework for the CVFEM solution so that it can be applied to both fluid flow and solid mechanics problems. To emphasize the essential ingredients, discussion focuses on the application to problems in two-dimensional domains which are discretized with linear-triangular meshes. This allows for a straightforward provision of the key information required to fully construct working CVFEM solutions of basic fluid flow and solid mechanics problems.

This text presents a comprehensive mathematical theory for elliptic, parabolic, and hyperbolic differential equations. It compares finite element and finite difference methods and illustrates applications of generalized difference methods to elastic bodies, electromagnetic fields, underground water pollution, and coupled sound-heat flows.

The finite element method (FEM) is a numerical technique for finding approximate solutions to different numerical problems. The practical applications of FEM are known as finite element analysis (FEA). FEA is a good choice for analyzing problems over complicated domains. The first three chapters of this book contribute to the development of new FE techniques by examining a few key hurdles of the FEM and proposing techniques to mitigate them. The next four chapters focus on the close connection between the development of a new technique and its implementation. Current state-of-the-art software packages for FEA allow the construction, refinement, and optimization of entire designs before manufacturing. This is convincingly demonstrated in the last three chapters of the book with examples from the field of biomechanical engineering. This book presents a current research by highlighting the vitality and potential of the finite elements for the future development of more efficient numerical techniques, new areas of application, and FEA's important role in practical engineering.

These proceedings contain the papers presented at the 4th International Symposium on Engineering Turbulence Modelling and Measurements held at Ajaccio, Corsica, France from 24-26 May 1999. It follows three previous conferences on the topic of engineering turbulence modelling and measurements. The purpose of this series of symposia is to provide a forum for presenting and discussing new developments in the area of turbulence modelling and measurements, with particular emphasis on engineering-related problems. Turbulence is still one of the key issues in tackling engineering flow problems. As powerful computers and accurate numerical methods are now available for solving the flow equations, and since engineering applications nearly always involve turbulence effects, the reliability of CFD analysis depends more and more on the performance of the turbulence models. Successful simulation of turbulence requires the understanding of the complex physical phenomena involved and suitable models for describing the turbulent momentum, heat and mass transfer. For the understanding of turbulence phenomena, experiments are indispensable, but they are equally important for providing data for the development and testing of turbulence models and hence for CFD software validation.

This book gives an introduction to the finite element method as a general computational method for solving partial differential equations approximately. Our approach is mathematical in nature with a strong focus on the underlying mathematical principles, such as approximation properties of piecewise polynomial spaces, and variational formulations of partial differential equations, but with a minimum level of advanced mathematical machinery from functional analysis and partial differential equations. In principle, the material should be accessible to students with only knowledge of calculus of several variables, basic partial differential equations, and linear algebra, as the necessary concepts from more advanced analysis are introduced when needed. Throughout the text we emphasize implementation of the involved algorithms, and have therefore mixed mathematical theory with concrete computer code using the numerical software MATLAB is and its PDE-Toolbox. We have also had the ambition to cover some of the most important applications of finite elements and the basic finite element methods developed for those applications, including diffusion and transport phenomena, solid and fluid mechanics, and also electromagnetics.?

Finite volume methods are used in numerous applications and by a broad multidisciplinary scientific community. The book communicates this important tool to students, researchers in training and academics involved in the training of students in different science and technology fields. The selection of content is based on the author's experience giving PhD and master courses in different universities. In the book the introduction of new concepts and numerical methods go together with simple exercises, examples and applications that contribute to reinforce them. In addition, some of them involve the execution of MATLAB codes. The author promotes an understanding of common terminology with a balance between mathematical rigor and physical intuition that characterizes the origin of the methods. This book aims to be a first contact with finite volume methods. Once readers have studied it, they will be able to follow more specific bibliographical references and use commercial programs or open source software within the framework of Computational Fluid Dynamics (CFD).

Matthäus Jäger examines the simulation of liquid-gas flow in fuel tank systems and its application to sloshing problems. The author focuses at first on the physical model and the assumptions necessary to derive the respective partial differential equations. The second step involves the cell-centered finite volume method and its application to fluid dynamic problems with free surfaces using a volume of fluid approach. Finally, the application of the method for different use cases is presented followed by an introduction to the methodology for the interpretation of the results achieved.

This first volume of the proceedings of the 8th conference on "Finite Volumes for Complex Applications" (Lille, June 2017) covers various topics including convergence and stability analysis, as well as investigations of these methods from the point of view of compatibility with physical principles. It collects together the focused invited papers

comparing advanced numerical methods for Stokes and Navier–Stokes equations on a benchmark, as well as reviewed contributions from internationally leading researchers in the field of analysis of finite volume and related methods, offering a comprehensive overview of the state of the art in the field. The finite volume method in its various forms is a space discretization technique for partial differential equations based on the fundamental physical principle of conservation, and recent decades have brought significant advances in the theoretical understanding of the method. Many finite volume methods preserve further qualitative or asymptotic properties, including maximum principles, dissipativity, monotone decay of free energy, and asymptotic stability. Due to these properties, finite volume methods belong to the wider class of compatible discretization methods, which preserve qualitative properties of continuous problems at the discrete level. This structural approach to the discretization of partial differential equations becomes particularly important for multiphysics and multiscale applications. The book is a valuable resource for researchers, PhD and master's level students in numerical analysis, scientific computing and related fields such as partial differential equations, as well as engineers working in numerical modeling and simulations.

This book focuses on heat and mass transfer, fluid flow, chemical reaction, and other related processes that occur in engineering equipment, the natural environment, and living organisms. Using simple algebra and elementary calculus, the author develops numerical methods for predicting these processes mainly based on physical considerations. Through this approach, readers will develop a deeper understanding of the underlying physical aspects of heat transfer and fluid flow as well as improve their ability to analyze and interpret computed results.

This textbook explores both the theoretical foundation of the Finite Volume Method (FVM) and its applications in Computational Fluid Dynamics (CFD). Readers will discover a thorough explanation of the FVM numerics and algorithms used for the simulation of incompressible and compressible fluid flows, along with a detailed examination of the components needed for the development of a collocated unstructured pressure-based CFD solver. Two particular CFD codes are explored. The first is uFVM, a three-dimensional unstructured pressure-based finite volume academic CFD code, implemented within Matlab. The second is OpenFOAM®, an open source framework used in the development of a range of CFD programs for the simulation of industrial scale flow problems. With over 220 figures, numerous examples and more than one hundred exercises on FVM numerics, programming, and applications, this textbook is suitable for use in an introductory course on the FVM, in an advanced course on numerics, and as a reference for CFD programmers and researchers.

In this text, we introduce the basic concepts for the numerical modelling of partial differential equations. We consider the classical elliptic, parabolic and hyperbolic linear equations, but also the diffusion, transport, and Navier-Stokes equations, as well as equations representing conservation laws, saddle-point problems and optimal control problems. Furthermore, we provide numerous physical examples which underline such equations. We then analyze numerical solution methods based on finite elements, finite differences, finite volumes, spectral methods and domain decomposition methods, and reduced basis methods. In particular, we discuss the algorithmic and computer implementation aspects and provide a number of easy-to-use programs. The text does not require any previous advanced mathematical knowledge of partial differential equations: the absolutely essential concepts are reported in a preliminary chapter. It is therefore suitable for students of bachelor and master courses in scientific disciplines, and recommendable to those researchers in the academic and extra-academic domain who want to approach this interesting branch of applied mathematics.

This book presents a systematic methodology for the development of parallel multi-physics models and its implementation in geophysical and biomedical applications. The methodology includes conservative discretization methods for partial differential equations on general meshes, as well as data structures and algorithms for organizing parallel simulations on general meshes. The structures and algorithms form the core of the INMOST (Integrated Numerical Modelling Object-oriented Supercomputing Technologies) platform for the development of parallel models on general meshes. The authors consider applications for addressing specific geophysical and biomedical challenges, including radioactive contaminant propagation with subsurface waters, reservoir simulation, and clot formation in blood flows. The book gathers all the components of this methodology, from algorithms and numerical methods to the open-source software, as well as examples of practical applications, in a single source, making it a valuable asset for applied mathematicians, computer scientists, and engineers alike.

The proceedings of the 9th conference on "Finite Volumes for Complex Applications" (Bergen, June 2020) are structured in two volumes. The first volume collects the focused invited papers, as well as the reviewed contributions from internationally leading researchers in the field of analysis of finite volume and related methods. Topics covered include convergence and stability analysis, as well as investigations of these methods from the point of view of compatibility with physical principles. Altogether, a rather comprehensive overview is given on the state of the art in the field. The properties of the methods considered in the conference give them distinguished advantages for a number of applications. These include fluid dynamics, magnetohydrodynamics, structural analysis, nuclear physics, semiconductor theory, carbon capture utilization and storage, geothermal energy and further topics. The second volume covers reviewed contributions reporting successful applications of finite volume and related methods in these fields. The finite volume method in its various forms is a space discretization technique for partial differential equations based on the fundamental physical principle of conservation. Many finite volume methods preserve further qualitative or asymptotic properties, including maximum principles, dissipativity, monotone decay of free energy, and asymptotic stability, making the finite volume methods compatible discretization methods, which preserve qualitative properties of continuous problems at the discrete level. This structural approach to the discretization of partial differential equations becomes particularly important for multiphysics and multiscale applications. The book is a valuable resource for researchers, PhD

and master's level students in numerical analysis, scientific computing and related fields such as partial differential equations, as well as engineers working in numerical modeling and simulations.

We hope that among these chapters you will find a topic which will raise your interest and engage you to further investigate a problem and build on the presented work. This book could serve either as a textbook or as a practical guide. It includes a wide variety of concepts in FVM, result of the efforts of scientists from all over the world. However, just to help you, all book chapters are systemized in three general groups: New techniques and algorithms in FVM; Solution of particular problems through FVM and Application of FVM in medicine and engineering. This book is for everyone who wants to grow, to improve and to investigate.

Most of the Earth's surface is covered by water. Our everyday lives and activities are affected by water waves in oceans, such as the tsunami that occurred in the Indian Ocean on 26 December 2004. This indicates how important it is for us to fully understand water waves, in particular the very large ones. One way to do so is to perform numerical simulation based on the nonlinear theory. Considerable research advances have been made in this area over the past decade by developing various numerical methods and applying them to emerging problems; however, until now there has been no comprehensive book to reflect these advances. This unique volume aims to bridge this gap. This book contains 18 self-contained chapters written by more than 50 authors from 12 different countries, many of whom are world-leading experts in the field. Each chapter is based mainly on the pioneering work of the authors and their research teams over the past decades. The chapters altogether deal with almost all numerical methods that have so far been employed to simulate nonlinear water waves and cover many important and very interesting applications, such as overturning waves, breaking waves, waves generated by landslides, freak waves, solitary waves, tsunamis, sloshing waves, interaction of extreme waves with beaches, interaction with fixed structures, and interaction with free-response floating structures. Therefore, this book provides a comprehensive overview of the state-of-the-art research and key achievements in numerical modeling of nonlinear water waves, and serves as a unique reference for postgraduates, researchers and senior engineers working in industry.

This book presents the fundamentals of computational fluid dynamics for the novice. It provides a thorough yet user-friendly introduction to the governing equations and boundary conditions of viscous fluid flows and its modelling.

This new book deals with the construction of finite-difference (FD) algorithms for three main types of equations: elliptic equations, heat equations, and gas dynamic equations in Lagrangian form. These methods can be applied to domains of arbitrary shapes. The construction of FD algorithms for all types of equations is done on the basis of the support-operators method (SOM). This method constructs the FD analogs of main invariant differential operators of first order such as the divergence, the gradient, and the curl. This book is unique because it is the first book not in Russian to present the support-operators ideas. Conservative Finite-Difference Methods on General Grids is completely self-contained, presenting all the background material necessary for understanding. The book provides the tools needed by scientists and engineers to solve a wide range of practical engineering problems. An abundance of tables and graphs support and explain methods. The book details all algorithms needed for implementation. A 3.5" IBM compatible computer diskette with the main algorithms in FORTRAN accompanies text for easy use.

Practical Finite Volume Method in OpenFOAM: Applications of CFD with Second Order FVM is the complete guide to the theory, numerical foundations, and code needed to successfully tackle a range of problems with the finite volume method in OpenFOAM. This authoritative guide will help readers to understand FVM discretisation of differential equations, as well as how to use it on an arbitrary system of equations, choose the appropriate boundary conditions and linear solvers for the system, interpret the results, and how to mesh, all in OpenFOAM. As well as building an understanding of its subject, a full coverage of the modern FVM code and its applications are provided, making this an invaluable reference for experienced practitioners and novices alike. A wide range of applications are covered, including fluid-structure interaction, naval hydrodynamics, combustion modelling, and solid mechanics. Explains how to choose and apply appropriate numerical algorithms for the system after an analysis of model equations Includes comprehensive coverage of general computational fluid dynamics principles for easy reference Demystifies the programming principles of OpenFOAM with a clear and approachable introduction to the code

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.

The content of this book covers several up-to-date topics in fluid dynamics, computational modeling and its applications, and it is intended to serve as a general reference for scientists, engineers, and graduate students. The book is comprised of 30 chapters divided into 5 parts, which include: winds, building and risk prevention; multiphase flow,

structures and gases; heat transfer, combustion and energy; medical and biomechanical applications; and other important themes. This book also provides a comprehensive overview of computational fluid dynamics and applications, without excluding experimental and theoretical aspects.

The Finite Volume Method in Computational Fluid Dynamics An Advanced Introduction with OpenFOAM® and Matlab Springer

Computational electrodynamics is a vast research field with a wide variety of tools. In physics, the principle of gauge invariance plays a pivotal role as a guide towards a sensible formulation of the laws of nature as well as for computing the properties of elementary particles using the lattice formulation of gauge theories. However, the gauge principle has played a much less pronounced role in performing computation in classical electrodynamics. In this work, the author demonstrates that starting from the gauge formulation of electrodynamics using the electromagnetic potentials leads to computational tools that can very well compete with the conventional electromagnetic field-based tools. Once accepting the formulation based on gauge fields, the computational code is very transparent due to the mimetic mapping of the electrodynamic variables on the computational grid. Although the illustrations and applications originate from microelectronic engineering, the method has a much larger range of applicability. Therefore this book will be useful to everyone having interest in computational electrodynamics. The volume is organized as follows: In part 1, a detailed introduction and overview is presented of the Maxwell equations as well as the derivation of the current and charge densities in different materials. Semiconductors are responding to electromagnetic fields in a non-linear way, and the induced complications are discussed in detail. Part 2, using the gauge potentials, presents the transition of electrodynamics theory to a formulation that can serve as the gateway to computational code. In part 3, a collection of microelectronic device designs demonstrate the feasibility and success of the methods in Part 2. Part 4 focuses on a set of topical themes that brings the reader to the frontier of research in building the simulation tools, using the gauge principle in computational electrodynamics. Technical topics discussed in the book include: - Electromagnetic Field Equations - Constitutive Relations - Discretization and Numerical Analysis - Finite Element and Finite Volume Methods - Design of Integrated Passive Components

Fluids play an important role in environmental systems appearing as surface water in rivers, lakes, and coastal regions or in the subsurface as well as in the atmosphere.

Mechanics of environmental fluids is concerned with fluid motion, associated mass and heat transport as well as deformation processes in subsurface systems. In this reference work the fundamental modelling approaches based on continuum mechanics for fluids in the environment are described, including porous media and turbulence. Numerical methods for solving the process governing equations as well as its object-oriented computer implementation are discussed and illustrated with examples. Finally, the application of computer models in civil and environmental engineering is demonstrated.

Numerical simulation methods in all engineering disciplines gains more and more importance. The successful and efficient application of such tools requires certain basic knowledge about the underlying numerical techniques. The text gives a practice-oriented introduction in modern numerical methods as they typically are applied in mechanical, chemical, or civil engineering. Problems from heat transfer, structural mechanics, and fluid mechanics constitute a thematical focus of the text. For the basic understanding of the topic aspects of numerical mathematics, natural sciences, computer science, and the corresponding engineering area are simultaneously important. Usually, the necessary information is distributed in different textbooks from the individual disciplines. In the present text the subject matter is presented in a comprehensive multidisciplinary way, where aspects from the different fields are treated insofar as it is necessary for general understanding. Overarching aspects and important questions related to accuracy, efficiency, and cost effectiveness are discussed. The topics are presented in an introductory manner, such that besides basic mathematical standard knowledge in analysis and linear algebra no further prerequisites are necessary. The book is suitable either for self-study or as an accompanying textbook for corresponding lectures. It can be useful for students of engineering disciplines as well as for computational engineers in industrial practice.

This book explores recent advances in uncertainty quantification for hyperbolic, kinetic, and related problems. The contributions address a range of different aspects, including: polynomial chaos expansions, perturbation methods, multi-level Monte Carlo methods, importance sampling, and moment methods. The interest in these topics is rapidly growing, as their applications have now expanded to many areas in engineering, physics, biology and the social sciences. Accordingly, the book provides the scientific community with a topical overview of the latest research efforts.

The principles and practice of finite volume method are highlighted in this book. In this book, readers will find a subject which will increase their interest and involve them to further explore a challenge and work further on the presented solutions. This book can serve the purposes of both; a textbook and a practical guide. It presents a vast variety of ideas in FVM which is a result of the efforts of scientists from across the world. The major topics covered in this book are novel techniques and algorithms in FVM, solution of particular problems through FVM and application of FVM in medicine and engineering. This book is for anyone who wants to grow, improve and explore.

The Finite Volume Method in Computational Rheology.

An authorised reissue of the long out of print classic textbook, Advanced Calculus by the late Dr Lynn Loomis and Dr Shlomo Sternberg both of Harvard University has been a revered but hard to find textbook for the advanced calculus course for decades. This book is based on an honors course in advanced calculus that the authors gave in the 1960's. The foundational material, presented in the unstarred sections of Chapters 1 through 11, was normally covered, but different applications of this basic material were stressed from year to year, and the book therefore contains more material than was covered in any one year. It can accordingly be used (with omissions) as a text for a year's course in advanced calculus, or as a text for a three-semester introduction to analysis. The prerequisites are a good grounding in the calculus of one variable from a mathematically rigorous point of view, together with some acquaintance with linear algebra. The reader should be familiar with limit and continuity type arguments and have a certain amount of mathematical sophistication. As possible introductory texts, we mention Differential and Integral Calculus by R Courant, Calculus by T Apostol, Calculus by M Spivak, and Pure Mathematics by G Hardy. The reader should also have some experience with partial derivatives. In overall plan the book divides roughly into a first half which develops the calculus (principally the differential calculus) in

the setting of normed vector spaces, and a second half which deals with the calculus of differentiable manifolds.

Publisher Description

Control volume finite element methods (CVFEM) bridge the gap between finite difference and finite element methods, using the advantages of both methods for simulation of multi-physics problems in complex geometries. In Hydrothermal Analysis in Engineering Using Control Volume Finite Element Method, CVFEM is covered in detail and applied to key areas of thermal engineering. Examples, exercises, and extensive references are used to show the use of the technique to model key engineering problems such as heat transfer in nanofluids (to enhance performance and compactness of energy systems), hydro-magnetic techniques in materials and bioengineering, and convective flow in fluid-saturated porous media. The topics are of practical interest to engineering, geothermal science, and medical and biomedical sciences. Introduces a detailed explanation of Control Volume Finite Element Method (CVFEM) to provide for a complete understanding of the fundamentals Demonstrates applications of this method in various fields, such as nanofluid flow and heat transfer, MHD, FHD, and porous media Offers complete familiarity with the governing equations in which nanofluid is used as a working fluid Discusses the governing equations of MHD and FHD Provides a number of extensive examples throughout the book Bonus appendix with sample computer code

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