Patankar Numerical Heat Transfer Solution Manual

This book gives a systematic coverage of knowledge needed for numerical computation of fluid flows and heat transfer in five parts. Part One gives a brief history of computational machinery and a presentation of the governing equations for fluid flows and heat transfer. Part Two is devoted to the principles of the finite analytic method and its development for various types of equations. Part Three concentrates on methods of coordinate generation for applications on complex domains. Part Four presents various schemes for accomplishing the task in Part Three. Examples of a wide variety of problems are provided in Part Five.

This book describes how modeling fluid flow in chemical reactors may offer solutions that improve design, operation, and performance of reactors. Chemical reactors are any vessels, tubes, pipes, or tanks in which chemical reactions take place. Computational Flow Modeling for Chemical Reactor Engineering will show the reactor engineer how to define the specific roles of computational flow modeling, select appropriate tools, and apply these tools to link reactor hardware to reactor performance. Overall methodology is illustrated with numerous case studies. Industry has invested substantial funds in computational flow modeling which will pay off only if it can be used to realize significant performance enhancement in chemical reactors. No other single source exists which provides the information contained in this book.

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical methods to simulate heat transfer and fluid flow phenomena. These numerical simulations require the solution of large linear algebraic systems that arise from the discretization of governing equations and the number of nodes in the discretized mesh is directly related to the accuracy of the simulation. A finer mesh, one with more nodes, will result in better numerical accuracy. However, the computational resources required to solve the linear systems and the overall solution time of the simulation increases with an increased number of nodes. As practitioners continue to develop more complex simulations that require fine meshes, the need for better methods to solve linear systems becomes particularly important. In recent years, there have been significant advancements in computational hardware that have enabled massive parallelism. Multicore processors, graphics processing units, and increased memory capacity have all lead way to significant performance increases for high-performance computing (HPC) workflows that allow for faster and more accurate numerical simulations. However, many of the legacy algorithms used to solve the linear systems in CFD are not well suited to exploit the parallelism in modern computational hardware. Krylov-subspace methods are an ideal solution to this problem as the Krylov algorithms can be parallelized through single-instruction, multiple data (SIMD) operations. In the current study, the Krylov-subspace methods of Bi-Conjugate Gradients, Generalized Minimum Residual, Bi-Conjugate Gradients Stabilized, and Bi-Conjugate Gradients Stabilized (l)

are examined as potential algorithms to improve the solution time for numerical simulations of heat transfer and fluid flow. Each of the Krylov methods will be characterized against the standard, line-by-line Tri-Diagonal Matrix Algorithm using a heat conduction model and a Rayleigh-Bénard Convection model. The numerical experiments using heat conduction will examine the impact of grid size and boundary condition placement for each of the algorithms tested. The Rayleigh-Bénard Convection model will be used to determine the performance improvements of the Krylov methods in Patankar's SIMPLER algorithm. The numerical accuracies of each algorithm will be validated using analytical solutions for the heat conduction model and empirical correlations for the Rayleigh-Bénard Convection model.

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.

This Second Edition for the standard graduate level course in conduction heat transfer has been updated and oriented more to engineering applications partnered with real-world examples. New features include: numerous grid generation--for finding solutions by the finite element method--and recently developed inverse heat conduction. Every chapter and reference has been updated and new exercise problems replace the old. Advances in Heat Transfer is designed to fill the information gap between the regularly scheduled journals and university level textbooks, allowing for in-depth review articles on a broader scope than is allowable in either journals or texts. Reviews recent work on melt lubrication at the interface between two solid parts, one of which is at its melting point Employs variational principle with vanishing parameter in the study of linear and

nonlinear transient heat conduction through bodies of finite length Reviews heat transfer in porous media and its rapidly growing body of literature Emphasizes recent developments in handling complex geometry, treating wide flow speed variations, yielding accurate solutions, and producing results efficiently as illustrated throughout with many examples Discusses unsteady convective situations which are generated in response to the time-dependent boundary conditions on the surface walls of a container, and its practical industrial applications

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."

Finite Difference Methods in Heat Transfer presents a clear, step-by-step delineation of finite difference methods for solving engineering problems governed by ordinary and partial differential equations, with emphasis on heat transfer applications. The finite difference techniques presented apply to the numerical solution of problems governed by similar differential equations encountered in many other fields. Fundamental concepts are introduced in an easy-to-follow manner. Representative examples

illustrate the application of a variety of powerful and widely used finite difference techniques. The physical situations considered include the steady state and transient heat conduction, phase-change involving melting and solidification, steady and transient forced convection inside ducts, free convection over a flat plate, hyperbolic heat conduction, nonlinear diffusion, numerical grid generation techniques, and hybrid numerical-analytic solutions.

This comprehensive text provides basic fundamentals of computational theory and computational methods. The book is divided into two parts. The first part covers material fundamental to the understanding and application of finite-difference methods. The second part illustrates the use of such methods in solving different types of complex problems encountered in fluid mechanics and heat transfer. The book is replete with worked examples and problems provided at the end of each chapter.

This book is a brief introduction to the fundamental concepts of computational fluid dynamics (CFD). It is addressed to beginners, and presents the ABCs or bare essentials of CFD in their simplest and most transparent form. The approach taken is to describe the principal analytical tools required, including truncation-error and stability analyses, followed by the basic elements or building blocks of CFD, which are numerical methods for treating sources, diffusion, convection, and pressure waves. Finally, it is shown how those ingredients may be combined to obtain self-contained numerical methods for solving the full equations of fluid dynamics. The book should be suitable for self-study, as a textbook for CFD short courses, and as a supplement to more comprehensive CFD and fluid dynamics texts.

This book provides the fundamental concepts required for the development of an efficient small-scale wind turbine. For centuries, engineers and scientists have used wind turbines of all shapes and sizes to harvest wind energy. Large-scale wind turbines have been successful at producing great amounts of power when deployed in sites with vast, open space, such as in fi elds or in offshore waters. For environments with limited space, such as dense urban environments, small-scale wind turbines are an attractive alternative for taking advantage of the ubiquity of wind. However, many of today's tools for aerodynamic design and analysis were originally developed for large-scale turbines and do not scale down to these smaller devices. Arranged in a systematic and comprehensive manner, complete with supporting examples, Wind Energy Harvesting: Micro- To Small-Scale Turbines is a useful reference for undergraduate and graduate level classes on energy harvesting, sustainable energy, and fl uid dynamics, and an introduction to the field for non-technical readers.
This book presents a detailed description of a robust pseudomultigrid algorithm for solving (initial-)boundary value problems on structured grids in a black-box manner. To overcome the problem of robustness, the presented Robust Multigrid Technique (RMT) is based on the application of the essential multigrid principle in a single grid algorithm. It results in an extremely simple, very robust and highly parallel solver with close-to-optimal algorithmic complexity and the least number of problem-dependent components. Topics covered include an introduction to the mathematical principles of multigrid methods, a detailed description of RMT, results of convergence analysis and complexity, possible expansion on unstructured grids, numerical experiments and a brief description of multigrid software, parallel RMT and estimations of speed-up and efficiency of the parallel multigrid algorithms, and finally

applications of RMT for the numerical solution of the incompressible Navier Stokes equations. Potential readers are graduate students and researchers working in applied and numerical mathematics as well as multigrid practitioners and software programmers. ContentsIntroduction to multigridRobust multigrid techniqueParallel multigrid methodsApplications of multigrid methods in computational fluid dynamics

Take a train to Southern California, and you'll pass through Colton. Once the home of Gabrielino and Serrano Indians, Colton is now known as the "Hub City," the only place in the United States where the Union Pacific and the Burlington, Northern & Santa Fe railroads cross. Westward-bound rail passengers travel through the horseshoe-shaped valley along the same trails that served Spanish explorers journeying from Mexico to Monterey in the 1770s. The valley's early settlers made use of the rich soil and ready transportation, cultivating fruit trees and shipping their harvest north and east. Legendary figures have also roamed Colton's streets, including the famous Tombstone gunslingers Wyatt Earp and his brother Virgil, who was Colton's first marshal, and their father, Nicholas, who served as a justice of the peace and city recorder. Over the 150 years of the community's history, many have passed through Colton, and all have left their mark on this classically Californian town.

PC-Aided Numerical Heat Transfer and Convective Flow is intended as a graduate course textbook for Mechanical and Chemical Engineering students as well as a reference book for practitioners interested in analytical and numerical treatments in the subject. The book is written so that the reader can use the enclosed diskette, with the aid of a personal computer, to systematically learn both analytical and numerical approaches associated with fluid flow and heat transfer without resorting to complex mathematical treatments. This is the first book that

not only describes solution methodologies but also provides complete programs ranging from SOLODE to SAINTS for integration of Navier-Stokes equation. The book covers boundary layer flows to fully elliptic flows, laminar flows to turbulent flows, and free convection to forced convection. The student will learn about convection in porous media, a new field of rapid growth in contemporary heat transfer research. A basic knowledge of fluid mechanics and heat transfer is assumed. It is also assumed that the student knows the basics of Fortran and has access to a personal computer.The material can be presented in a one-semester course or with selective coverage in a seminar.

The content of this book covers several up-to-date approaches in the heat conduction theory such as inverse heat conduction problems, non-linear and non-classic heat conduction equations, coupled thermal and electromagnetic or mechanical effects and numerical methods for solving heat conduction equations as well. The book is comprised of 14 chapters divided into four sections. In the first section inverse heat conduction problems are discuss. The first two chapters of the second section are devoted to construction of analytical solutions of nonlinear heat conduction problems. In the last two chapters of this section wavelike solutions are attained.The third section is devoted to combined effects of heat conduction and electromagnetic interactions in plasmas or in pyroelectric material elastic deformations and hydrodynamics. Two chapters in the last section are dedicated to numerical methods for solving heat conduction problems.

INTERNATIONAL WORKSHOPS (at IAREC'17) (This book inclueds English (main) and Turkish languages) International Workshop on Mechanical Engineering International Workshop on Mechatronics Engineering International Workshop on Energy Systems Engineering

International Workshop on Automotive Engineering and Aerospace Engineering International Workshop on Material Engineering International Workshop on Manufacturing Engineering International Workshop on Physics Engineering International Workshop on Electrical and Electronics Engineering International Workshop on Computer Engineering and Software Engineering International Workshop on Chemical Engineering International Workshop on Textile Engineering International Workshop on Architecture International Workshop on Civil Engineering International Workshop on Geomatics Engineering International Workshop on Industrial Engineering International Workshop on Food Engineering International Workshop on Aquaculture Engineering International Workshop on Agriculture Engineering International Workshop on Mathematics Engineering International Workshop on Bioengineering Engineering International Workshop on Biomedical Engineering International Workshop on Genetic Engineering International Workshop on Environmental Engineering International Workshop on Other Engineering Science

The most comprehensive and detailed treatment of thermal radiation heat transfer available for graduate students, as well as senior undergraduate students, practicing engineers and physicists is enhanced by an excellent writing style with nice historical highlights and a clear and consistent notation throughout. Modest presents radiative heat transfer and its interactions with other modes of heat transfer in a coherent and integrated manner emphasizing the fundamentals. Numerous worked examples, a large number of problems, many based on real world situations, and an up-to-date bibliography make the book especially suitable for independent study. Most complete text in the field of radiative heat transfer Many worked examples and end-of-chapter problems Large number of computer codes (in Fortran and C++),

ranging from basic problem solving aids to sophisticated research tools Covers experimental methods

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. 'Turbulence in Porous Media' introduces the reader to the characterisation of turbulent flow, heat and mass transfer in permeable media, including analytical data and a review of available experimental data. Such transport processes occurring a relatively high velocity in permeable media are present in a number of engineering and natural flows. This new edition features a completely updated text including two new chapters exploring Turbulent Combustion and Moving Porous Media. De Lemos has expertly brought together a text that compiles, details, compares and evaluates available methodologies for modelling and simulating flow, providing an essential tour for engineering students working within the field as well as those working in chemistry, physics, applied mathematics, and geological and environmental sciences. Brings together groundbreaking and complex research on turbulence in porous media Extends the original model to situations including reactive systems Now discusses movement of the porous matrix

Presents a comprehensive, accessible and readily usable reference to the necessary

formulations, numerical schemes, and innovative solution techniques for solving problems of heat and mass transfer and related fluid flows. Grouped by major sets of methods and functions, the text describes new or improved, as well as standard, procedures. This collection of contributions from leading figures in the field covers parabolic systems, hyperbolic systems, integral and integro-differential systems, Monte Carlo and perturbation methods, inverse problems and more.

With contributions from leading experts, this second volume in the ser ies strikes a balance between generic and specific fundamentals and ge neric and specific applications. After opening with a broad overview o f the field of high-performance scientific computing and its role in f luid flow and heat transfer problems, the book goes on to cover such t opics as: unstructured meshes; spectral element method; use of the fin ite volume method for the numerical solution of radiative heat transfe r problems; heat conduction and the use of the boundary element method for both steady and unsteady problems; special numerical issues relat ed to solving microscale heat transfer problems; the Monte Carlo Metho d; flow and heat transfer in porous media; and the thermal management of electronic systems.

This work the first of two contains papers presented at an international conference on the technology of rotating machinery, which specifically address transport phenomena in terms of turbine cooling heat transfer, rotating surfaces, curved ducts and rotating channels, multiphase flow and more.

Numerical Methods for Partial Differential Equations: An Introduction Vitoriano Ruas, Sorbonne Universités, UPMC - Université Paris 6, France A comprehensive overview of techniques for the computational solution of PDE's Numerical Methods for Partial Differential Equations: An

Introduction covers the three most popular methods for solving partial differential equations: the finite difference method, the finite element method and the finite volume method. The book combines clear descriptions of the three methods, their reliability, and practical implementation aspects. Justifications for why numerical methods for the main classes of PDE's work or not, or how well they work, are supplied and exemplified. Aimed primarily at students of Engineering, Mathematics, Computer Science, Physics and Chemistry among others this book offers a substantial insight into the principles numerical methods in this class of problems are based upon. The book can also be used as a reference for research work on numerical methods for PDE's. Key features: • A balanced emphasis is given to both practical considerations and a rigorous mathematical treatment. • The reliability analyses for the three methods are carried out in a unified framework and in a structured and visible manner, for the basic types of PDE's. • Special attention is given to low order methods, as practitioner's overwhelming default options for everyday use. • New techniques are employed to derive known results, thereby simplifying their proof. • Supplementary material is available from a companion website. Finite Difference Methods in Heat Transfer, Second Edition focuses on finite difference methods and their application to the solution of heat transfer problems. Such methods are based on the discretization of governing equations, initial and boundary conditions, which then replace a continuous partial differential problem by a system of algebraic equations. Finite difference methods are a versatile tool for scientists and for engineers. This updated book serves university students taking graduate-level coursework in heat transfer, as well as being an important reference for researchers and engineering. Features Provides a self-contained approach in finite difference methods for students and professionals Covers the use of finite

difference methods in convective, conductive, and radiative heat transfer Presents numerical solution techniques to elliptic, parabolic, and hyperbolic problems Includes hybrid analytical–numerical approaches

The advent of high-speed computers has encouraged a growing demand for newly graduated engineers to possess the basic skills of computational methods for heat and mass transfer and fluid dynamics. Computational fluid dynamics and heat transfer, as well as finite element codes, are standard tools in the computer-aided design and analysis of processe

This more-of-physics, less-of-math, insightful and comprehensive book simplifies computational fluid dynamics for readers with little knowledge or experience in heat transfer, fluid dynamics or numerical methods. The novelty of this book lies in the simplification of the level of mathematics in CFD by presenting physical law (instead of the traditional differential equations) and discrete (independent of continuous) math-based algebraic formulations. Another distinguishing feature of this book is that it effectively links theory with computer program (code). This is done with pictorial as well as detailed explanations of implementation of the numerical methodology. It also includes pedagogical aspects such as end-of-chapter problems and carefully designed examples to augment learning in CFD code-development, application and analysis. This book is a valuable resource for students in the fields of mechanical, chemical or aeronautical engineering.

Single Crystal Growth of Semiconductors from Metallic Solutions covers the four principal growth techniques currently in use for the growth of semiconductor single crystals from metallic solutions. Providing an in-depth review of the state-of-the-art of each, both experimentally and by numerical simulations. The importance of a close interaction between the numerical and

experimental aspects of the processes is also emphasized. Advances in the fields of electronics and opto-electronics are hampered by the limited number of substrate materials which can be readily produced by melt-growth techniques such as the Czochralski and Bridgman methods. This can be alleviated by the use of alternative growth techniques, and in particular, growth from metallic solutions. The principal techniques currently in use are: Liquid Phase Epitaxy; Liquid Phase Electroepitaxy; the Travelling Heater Method, and; Liquid Phase Diffusion. Single Crystal Growth of Semiconductors from Metallic Solutions will serve as a valuable reference tool for researchers, and graduate and senior undergraduate students in the field of crystal growth. It covers most of the models developed in recent years. The detailed development of basic and constitutive equations and the associated interface and boundary conditions given for each technique will be very valuable to researchers for the development of their new models. * Describes the fundamentals of crystal growth modelling * Providing a state-of-the art description of the mathematical and experimental growth processes * Allows reader to gain clear insight into the practical and mathematical aspects of the topic ????:Numerical heat transfer and fluid flow

Thoroughly updated to include the latest developments in the field, this classic text on finite-difference and finite-volume computational methods maintains the fundamental concepts covered in the first edition. As an introductory text for advanced undergraduates and first-year graduate students, Computational Fluid Mechanics and Heat Transfer, Thi

This new edition updated the material by expanding coverage of certain topics, adding new examples and problems, removing outdated material, and adding a computer disk, which will be included with each book. Professor Jaluria and Torrance have structured a text addressing

both finite difference and finite element methods, comparing a number of applicable methods. "Describes the latest techniques and real-life applications of computational fluid dynamics (CFD) and heat transfer in aeronautics, materials processing and manufacturing, electronic cooling, and environmental control. Includes new material from experienced researchers in the field. Complete with detailed equations for fluid flow and heat transfer."

This extensively revised 4th edition provides an up-to-date, comprehensive single source of information on the important subjects in engineering radiative heat transfer. It presents the subject in a progressive manner that is excellent for classroom use or self-study, and also provides an annotated reference to literature and research in the field. The foundations and methods for treating radiative heat transfer are developed in detail, and the methods are demonstrated and clarified by solving example problems. The examples are especially helpful for self-study. The treatment of spectral band properties of gases has been made current and the methods are described in detail and illustrated with examples. The combination of radiation with conduction and/or convection has been given more emphasis nad has been merged with results for radiation alone that serve as a limiting case; this increases practicality for energy transfer in translucent solids and fluids. A comprehensive catalog of configuration factors on the CD that is included with each book provides over 290 factors in algebraic or graphical form. Homework problems with answers are given in each chapter, and a detailed and carefully worked solution manual is available for instructors.

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 exercise 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. "This book promotes the use of optimal modified continuous Galerkin weak form theory to generate discrete approximate solutions to incompressible-thermal Navier-Stokes equations"--
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.

Introduction to Computational Fluid Dynamics is a textbook for advanced undergraduate and first year graduate students in mechanical, aerospace and chemical engineering. The book emphasizes understanding CFD through physical principles and examples. The author follows a consistent philosophy of control volume formulation of the fundamental laws of fluid motion and energy transfer, and introduces a novel notion of 'smoothing pressure correction' for solution of flow equations on collocated grids within the framework of the well-known SIMPLE algorithm. The subject matter is developed by considering pure conduction/diffusion, convective transport in 2-dimensional boundary layers and in fully elliptic flow situations and phase-change problems in succession. The book includes chapters on discretization of equations for transport of mass, momentum and energy on Cartesian, structured curvilinear and unstructured meshes, solution of discretised equations, numerical grid generation and convergence enhancement. Practising engineers will find this particularly useful for reference and for continuing education.

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