Partial Differential Equation Methods In Control And Shape Analysis Lecture Notes In Pure And Applied Mathematics

"Ordinary differential equations and partial differential equations form the basis for modelling many kinds of phenomena in areas such as science, engineering, computational finance and more generally, mathematical physics. There are currently no books on the market which can guide a reader with no prior knowledge of PDEs through the basics and onto advanced applications."--

This book deals with discretization techniques for partial differential equations of elliptic, parabolic and hyperbolic type. It provides an introduction to the main principles of discretization and gives a presentation of the ideas and analysis of advanced numerical methods in the area. The book is mainly dedicated to finite element methods, but it also discusses difference methods and finite volume techniques. Coverage offers analytical tools, properties of discretization techniques and hints to algorithmic aspects. It also guides readers to current developments in research.

A comprehensive guide to numerical methods for simulating physical-chemical systems This book offers a systematic, highly accessible presentation of numerical methods used to simulate the behavior of physical-chemical systems. Unlike most books on the subject, it focuses on methodology rather than specific applications. Written for students and professionals across an array of scientific and engineering disciplines and with varying levels of experience with applied mathematics, it provides comprehensive descriptions of numerical methods without requiring an advanced mathematical background. Based on its author’s more than forty years of experience teaching numerical methods to engineering students, Numerical Methods for Solving Partial Differential Equations presents the fundamentals of all of the commonly used numerical methods for solving differential equations at a level appropriate for advanced undergraduates and first-year graduate students in science and engineering. Throughout, elementary examples show how numerical methods are used to solve generic versions of equations that arise in many scientific and engineering disciplines. In writing it, the author took pains to ensure that no assumptions were made about the background discipline of the reader. Covers the spectrum of numerical methods that are used to simulate the behavior of physical-chemical systems that occur in science and engineering Written by a professor of engineering with more than forty years of experience teaching numerical methods to engineers Requires only elementary knowledge of differential equations and matrix algebra to master the material Designed to teach students to understand, appreciate and apply the basic mathematics and equations on which Mathcad and similar commercial software packages are based Comprehensive yet accessible to readers with limited mathematical knowledge, Numerical Methods for Solving Partial Differential Equations is an excellent text for advanced undergraduates and first-year graduate students in the sciences and engineering. It is also a valuable working reference for professionals in engineering, physics, chemistry, computer science, and applied mathematics.

A new class of methods, termed "group explicit methods," is introduced in this text. Their applications to solve parabolic, hyperbolic and elliptic equations are outlined, and the advantages for their implementation on parallel computers clearly portrayed. Also included are the introductory and fundamental concepts from which the new methods are derived, and on which they are dependent. With the increasing advent of parallel computing into all aspects of computational mathematics, there is no doubt that the new methods will be widely used.

This text provides an application oriented introduction to the numerical methods for partial differential equations. It covers finite difference, finite element, and finite volume methods, interweaving theory and applications throughout. The book examines modern topics such as adaptive methods, multilevel methods, and methods for convection-dominated problems and includes detailed illustrations and extensive exercises.

Substantially revised, this authoritative study covers the standard finite difference methods of parabolic, hyperbolic, and elliptic equations, and includes the concomitant theoretical work on consistency, stability, and convergence. The new edition includes revised and greatly expanded sections on stability based on the Lax-Richtmeyer definition, the application of Pade approximants to systems of ordinary differential equations for parabolic and hyperbolic equations, and a considerably improved presentation of iterative methods. A fast-paced introduction to numerical methods, this will be a useful volume for students of mathematics and engineering, and for postgraduates and professionals who need a clear, concise grounding in this discipline.

This textbook is intended for college, undergraduate and graduate students, emphasizing mainly on ordinary differential equations. However, the theory of characteristics for first order partial differential equations and the classification of second order linear partial differential operators are also included. It contains the basic material starting from elementary solution methods for ordinary differential equations to advanced methods for first order partial differential equations. In addition to the theoretical background, solution methods are strongly emphasized. Each section is completed with problems and exercises, and the solutions are also provided. There are special sections devoted to more applied tools such as implicit equations, Laplace transform, Fourier method, etc. As a novelty, a method for finding exponential polynomial solutions is presented which is based on the author's work in spectral synthesis. The presentation is self-contained, provided the reader has general undergraduate knowledge.

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Partial differential equations are used in mathematical models of a huge range of real-world phenomena, from electromagnetism to financial markets. This new edition of Applied PDEs contains many new sections and exercises Including, American options, transform methods, free surface flows, linear elasticity and complex characteristics.

"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 industryIncludes 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 codesIncludes 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

Uniquely provides fully solved problems for linear partial differential equations and boundary value problems Partial Differential Equations: Theory and Completely Solved Problems utilizes real-world physical models alongside essential theoretical concepts. With extensive examples, the book guides readers through the use of Partial Differential Equations (PDEs) for successfully solving and modeling phenomena in engineering, biology, and the applied sciences. The book focuses exclusively on linear PDEs and how they can be solved using the separation of variables technique. The authors begin by describing functions and their partial derivatives while also defining the concepts of elliptic, parabolic, and hyperbolic PDEs. Following an introduction to basic theory, subsequent chapters explore key topics including: • Classification of second-order linear PDEs • Derivation of heat, wave, and Laplace's equations • Fourier series • Separation of variables • Sturm-Liouville theory • Fourier transforms Each chapter concludes with summaries that outline key concepts. Readers are provided the opportunity to test their comprehension of the presented material through numerous problems, ranked by their level of complexity, and a related website features supplemental data and resources. Extensively class-tested to ensure an accessible presentation, Partial Differential Equations is an excellent book for engineering, mathematics, and applied science courses on the topic at the upper-undergraduate and graduate levels.

"Based on the International Federatiojn for Information Processing WG 7.2 Conference, held recently in Pisa, Italy. Provides recent results as well as entirely new material on control theory and shape analysis. Written by leading authorities from various desciplines."

An accessible introduction to the finite element method for solving numeric problems, this volume offers the keys to an important technique in computational mathematics. Suitable for advanced undergraduate and graduate courses, it outlines clear connections with applications and considers numerous examples from a variety of science- and engineering-related specialties.This text encompasses all varieties of the basic linear partial differential equations, including elliptic, parabolic and hyperbolic problems, as well as stationary and time-dependent problems. Additional topics include finite element methods for integral equations, an introduction to nonlinear problems, and considerations of unique developments of finite element techniques related to parabolic problems, including methods for automatic time step control. The relevant mathematics are expressed in non-technical terms whenever possible, in the interests of keeping the treatment accessible to a majority of students.

This latest volume in the Wavelets Analysis and Its Applications Series provides significant and up-to-date insights into recent developments in the field of wavelet constructions in connection with partial differential equations. Specialists in numerical applications and engineers in a variety of fields will find Multiscale Wavelet for Partial Differential Equations to be a valuable resource. Covers important areas of computational mechanics such as elasticity and computational fluid dynamics Includes a clear study of turbulence modeling Contains recent research on multiresolution analyses with operator-adapted wavelet discretizations Presents well-documented numerical experiments connected with the development of algorithms, useful in specific applications

This book provides an elementary yet comprehensive introduction to the numerical solution of partial differential equations (PDEs). Used to model important phenomena, such as the heating of apartments and the behavior of electromagnetic waves, these equations have applications in engineering and the life sciences, and most can only be solved approximately using computers.? Numerical Analysis of Partial Differential Equations Using Maple and MATLAB provides detailed descriptions of the four major classes of discretization methods for PDEs (finite difference method, finite volume method, spectral method, and finite element method) and runnable MATLAB? code for each of the discretization methods and exercises. It also gives self-contained convergence proofs for each method using the tools and techniques required for the general convergence analysis but adapted to the simplest setting to keep the presentation clear and complete. This book is intended for advanced undergraduate and early graduate students in numerical analysis and scientific computing and researchers in related fields. It is appropriate for a course on numerical methods for partial differential equations.

Nonlinear Partial Differential Equations in Engineering discusses methods of solution for nonlinear partial differential equations, particularly by using a unified treatment of analytic and numerical procedures. The book also explains analytic methods, approximation methods (such as asymptotic processes, perturbation procedures, weighted residual methods), and specific numerical procedures associated with these equations. The text presents exact methods of solution including the quasi-linear theory, the Poisson-Euler-Darboux equation, a general solution for anisentropic flow, and other solutions obtained from ad hoc assumptions. The book explores analytic methods such as an ad hoc solution from magneto-gas dynamics. Noh and Protter have found the Lagrange formulation to be a convenient vehicle for obtaining "soft" solutions of the equations of gas dynamics. The book notes that developing solutions in two and three dimensions can be achieved by employing Lagrangian coordinates. The book explores approximate methods that use analytical procedures to obtain solutions in the form of functions approximating solutions of nonlinear problems. Approximate methods include integral equations, boundary theory, maximum operation, and equations of elliptic types. The book can serve and benefit mathematicians, students of, and professors of calculus, statistics, or advanced mathematics.

Suitable for advanced undergraduate and graduate students, this text presents the general properties of partial differential equations, including the elementary theory of complex variables. Topics include one-dimensional wave equation, properties of elliptic and parabolic equations, separation of variables and Fourier series, nonhomogeneous problems, and analytic functions of a complex variable. Solutions. 1965 edition.

This graduate-level text opens with an elementary presentation of Hilbert space theory sufficient for understanding the rest of the book. Additional topics include boundary value problems, evolution equations, optimization, and approximation.1979 edition.

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.

This is the second edition of the well-established text in partial differential equations, emphasizing modern, practical solution techniques. This updated edition includes a new chapter on transform methods and a new section on integral equations in the numerical methods chapter. The authors have also included additional exercises.

The world of quantitative finance (QF) is one of the fastest growing areas of research and its practical applications to derivatives pricing problem. Since the discovery of the famous Black-Scholes equation in the 1970's we have seen a surge in the number of models for a wide range of products such as plain and exotic options, interest rate derivatives, real options and many others. Gone are the days when it was possible to price these derivatives analytically. For most problems we must resort to some kind of approximate method. In this book we employ partial differential equations (PDE) to describe a range of one-factor and multi-factor derivatives products such as plain European and American options, multi-asset options, Asian options, interest rate options and real options. PDE techniques allow us to create a framework for modeling complex and interesting derivatives products. Having defined the PDE problem we then approximate it using the Finite Difference Method (FDM). This method has been used for many application areas such as fluid dynamics, heat transfer, semiconductor simulation and astrophysics, to name just a few. In this book we apply the same techniques to pricing real-life derivative products. We use both traditional (or well-known) methods as well as a number of advanced schemes that are making their way into the QF literature: Crank-Nicolson, exponentially fitted and higher-order schemes for one-factor and multi-factor options Early exercise features and approximation using front-fixing, penalty and variational methods Modelling stochastic volatility models using Splitting methods Critique of ADI and Crank-Nicolson schemes; when they work and when they don't work Modelling jumps using Partial Integro Differential Equations (PIDE) Free and moving boundary value problems in QF Included with the book is a CD containing information on how to set up FDM algorithms, how to map these algorithms to C++ as well as several working programs for one-factor and two-factor models. We also provide source code so that you can customize the applications to suit your own needs.

The main theme is the integration of the theory of linear PDE and the theory of finite difference and finite element methods. For each type of PDE, elliptic, parabolic, and hyperbolic, the text contains one chapter on the mathematical theory of the differential equation, followed by one chapter on finite difference methods and one on finite element methods. The chapters on elliptic equations are preceded by a chapter on the two-point boundary value problem for ordinary differential equations. Similarly, the chapters on time-dependent problems are preceded by a chapter on the initial-value problem for ordinary differential equations. There is also one chapter on the elliptic eigenvalue problem and eigenfunction expansion. The presentation does not presume a deep knowledge of mathematical and functional analysis. The required background on linear functional analysis and Sobolev spaces is reviewed in an appendix. The book is suitable for advanced undergraduate and beginning graduate students of applied mathematics and engineering.

In this book, Professor Copson gives a rigorous account of the theory of partial differential equations of the first order and of linear partial differential equations of the second order, using the methods of classical analysis. In spite of the advent of computers and the applications of the methods of functional analysis to the theory of partial differential equations, the classical theory retains its relevance in several important respects. Many branches of classical analysing have their origins in the rigourous discussion of problems in applies mathematics and theoretical physics, and the classical treatment of the theory of partial differential equations still provides the best method of treating many physical problems. A knowledge of the classical theory is essential for pure mathematics who intend to undertake research in this field, whatever approach they ultimately adopt. The numerical analyst needs a knowledge of classical theory in order to decide whether a problem has a unique solution or not.

Solve engineering and scientific partial differential equation applications using the PDE2D software developed by the author Solving Partial Differential Equation Applications with PDE2D derives and solves a range of ordinary and partial differential equation (PDE) applications. This book describes an easy-to-use, general purpose, and time-tested PDE solver developed by the author that can be applied to a wide variety of science and engineering problems. The equations studied include many time-dependent, steady-state and eigenvalue applications such as diffusion, heat conduction and convection, image processing, math finance, fluid flow, and elasticity and quantum mechanics, in one, two, and three space dimensions. The author begins with some simple "0D" problems that give the reader an opportunity to become familiar with PDE2D before proceeding to more difficult problems. The book ends with the solution of a very difficult nonlinear problem, which requires a moving adaptive grid because the solution has sharp, moving peaks. This important book: Describes a finite-element program, PDE2D, developed by the author over the course of 40 years Derives the ordinary and partial differential equations, with appropriate initial and boundary conditions, for a wide variety of applications Offers free access to the Windows version of the PDE2D software through the author’s website at www.pde2d.com Offers free access to the Linux and MacOSX versions of the PDE2D software also, for instructors who adopt the book for their course and contact the author at www.pde2d.com Written for graduate applied mathematics or computational science classes, Solving Partial Differential Equation Applications with PDE2D offers students the opportunity to actually solve interesting engineering and scientific applications using the accessible PDE2D.

This volume is an introductory level textbook for partial differential equations (PDE's) and suitable for a one-semester undergraduate level or two-semester graduate level course in PDE's or applied mathematics. Chapters One to Five are organized according to the equations and the basic PDE's are introduced in an easy to understand manner. They include the first-order equations and the three fundamental second-order equations, i.e. the heat, wave and Laplace equations. Through these equations we learn the types of problems, how we pose the problems, and the methods of solutions such as the separation of variables and the method of characteristics. The modeling aspects are explained as well. The methods introduced in earlier chapters are developed further in Chapters Six to Twelve. They include the Fourier series, the Fourier and the Laplace transforms, and the Green's functions. The equations in higher dimensions are also discussed in detail. This volume is application-oriented and rich in examples. Going through these examples, the reader is able to easily grasp the basics of PDE's.

Differential equations, especially nonlinear, present the most effective way for describing complex physical processes. Methods for constructing exact solutions of differential equations play an important role in applied mathematics and mechanics. This book aims to provide scientists, engineers and students with an easy-to-follow, but comprehensive, description of the methods for constructing exact solutions of differential equations.

This is the practical introduction to the analytical approach taken in Volume 2. Based upon courses in partial differential equations over the last two decades, the text covers the classic canonical equations, with the method of separation of variables introduced at an early stage. The characteristic method for first order equations acts as an introduction to the classification of second order quasi-linear problems by characteristics. Attention then moves to different co-ordinate systems, primarily those with cylindrical or spherical symmetry. Hence a discussion of special functions arises quite naturally, and in each case the major properties are derived. The next section deals with the use of integral transforms and extensive methods for inverting them, and concludes with links to the use of Fourier series.

A fresh, forward-looking undergraduate textbook that treats the finite element method and classical Fourier series method with equal emphasis.

This volume is a collection of manscripts mainly originating from talks and lectures given at the Workshop on Recent Trends in Complex Methods for Par tial Differential Equations held from July 6 to 10, 1998 at the Middle East Technical University in Ankara, Turkey, sponsored by The Scientific and Tech nical Research Council of Turkey and the Middle East Technical University. This workshop is a continuation oftwo workshops from 1988 and 1993 at the In ternational Centre for Theoretical Physics in Trieste, Italy entitled Functional analytic Methods in Complex Analysis and Applications to Partial Differential Equations. Since classical complex analysis of one and several variables has a long tra dition it is of high level. But most of its basic problems are solved nowadays so that within the last few decades it has lost more and more attention. The area of complex and functional analytic methods in partial differential equations, however, is still a growing and flourishing field, in particular as these methods are not only applied. Whithin the framework of holomorphic functions but are also combined with properties of generalized analytic functions. This can be seen by the many books which recently were published in this field and also by the proceedings in this ISAAC series and the ISAAC congresses and workshops.

Partial Differential Equations: Theory and Technique provides formal definitions, notational conventions, and a systematic discussion of partial differential equations. The text emphasizes the acquisition of practical technique in the use of partial differential equations. The book contains discussions on classical second-order equations of diffusion, wave motion, first-order linear and quasi-linear equations, and potential theory. Certain chapters elaborate Green's functions, eigenvalue problems, practical approximation techniques, perturbations (regular and singular), difference equations, and numerical methods. Students of mathematics will find the book very useful.

Extensively revised edition of Computational Methods in Partial Differential Equations. A more general approach has been adopted for the splitting of operators for parabolic and hyperbolic equations to include Richtmyer and Strang type splittings in addition to alternating direction implicit and locally one dimensional methods. A description of the now standard factorization and SOR/ADI iterative techniques for solving elliptic difference equations has been supplemented with an account or preconditioned conjugate gradient methods which are currently gaining in popularity. Prominence is also given to the Galerkin method using different test and trial functions as a means of constructing difference approximations to both elliptic and time dependent problems. The applications of finite difference methods have been revised and contain examples involving the treatment of singularities in elliptic equations, free and moving boundary problems, as well as modern developments in computational fluid dynamics. Emphasis throughout is on clear exposition of the construction and solution of difference equations. Material is reinforced with theoretical results when appropriate.

This text teaches finite element methods and basic finite difference methods from a computational point of view. It emphasizes developing flexible computer programs using the numerical library Diffpack, which is detailed for problems including model equations in applied mathematics, heat transfer, elasticity, and viscous fluid flow. This edition offers new applications and projects, and all program examples are available on the Internet.

This volume is designed as an introduction to the concepts of modern numerical analysis as they apply to partial differential equations. The book contains many practical problems and their solutions, but at the same time, strives to expose the pitfalls--such as overstability, consistency requirements, and the danger of extrapolation to nonlinear problems methods used on linear problems. Numerical Methods for Partial Differential Equations, Third Edition reflects the great accomplishments that have taken place in scientific computation in the fifteen years since the Second Edition was published. This new edition is a drastic revision of the previous one, with new material on boundary elements, spectral methods, the methods of lines, and invariant methods. At the same time, the new edition retains the self-contained nature of the older version, and shares the clarity of its exposition and the integrity of its presentation. Key Features * Material on finite elements and finite differences have been merged, and now constitute equal partners * Additional material has been added on boundary elements, spectral methods, the method of lines, and invariant methods * References have been updated, and reflect the additional material * Self-contained nature of the Second Edition has been maintained * Very suitable for PDE courses

This new edition features the latest tools for modeling, characterizing, and solving partial differential equations The Third Edition of this classic text offers a comprehensive guide to modeling, characterizing, and solving partial differential equations (PDEs). The author provides all the theory and tools necessary to solve problems via exact, approximate, and numerical methods. The Third Edition retains all the hallmarks of its previous editions, including an emphasis on practical applications, clear writing style and logical organization, and extensive use of real-world examples. Among the new and revised material, the book features: * A new section at the end of each original chapter, exhibiting the use of specially constructed Maple procedures that solve PDEs via many of the methods presented in the chapters. The results can be evaluated numerically or displayed graphically. * Two new chapters that present finite difference and finite element methods for the solution of PDEs. Newly constructed Maple procedures are provided and used to carry out each of these methods. All the numerical results can be displayed graphically. * A related FTP site that includes all the Maple code used in the text. * New exercises in each chapter, and answers to many of the exercises are provided via the FTP site. A supplementary Instructor's Solutions Manual is available. The book begins with a demonstration of how the three basic types of equations-parabolic, hyperbolic, and elliptic-can be derived from random walk models. It then covers an exceptionally broad range of topics, including questions of stability, analysis of singularities, transform methods, Green's functions, and perturbation and asymptotic treatments. Approximation methods for simplifying complicated problems and solutions are described, and linear and nonlinear problems not easily solved by standard methods are examined in depth. Examples from the fields of engineering and physical sciences are used liberally throughout the text to help illustrate how theory and techniques are applied to actual problems. With its extensive use of examples and exercises, this text is recommended for advanced undergraduates and graduate students in engineering, science, and applied mathematics, as well as professionals in any of these fields. It is possible to use the text, as in the past, without use of the new Maple material.

Analytic Methods for Partial Differential EquationsSpringer Science & Business Media

This is the first book on the numerical method of lines, a relatively new method for solving partial differential equations. The Numerical Method of Lines is also the first book to accommodate all major classes of partial differential equations. This is essentially an applications book for computer scientists. The author will separately offer a disk of FORTRAN 77 programs with 250 specific applications, ranging from "Shuttle Launch Simulation" to "Temperature Control of a Nuclear Fuel Rod."