

Nonlinear Partial Differential Equations In Engineering And Applied Science Lecture Notes In Pure And Applied Mathematics

This book primarily concerns quasilinear and semilinear elliptic and parabolic partial differential equations, inequalities, and systems. The exposition quickly leads general theory to analysis of concrete equations, which have specific applications in such areas as electrically (semi-) conductive media, modeling of biological systems, and mechanical engineering. Methods of Galerkin or of Rothe are exposed in a large generality.

Addresses a class of equations central to many areas of mathematics and its applications. This book addresses a general approach that consists of the following: choose an appropriate function space, define a family of mappings, prove this family has a fixed point, and study various properties of the solution.

New to the Second Edition More than 1,000 pages with over 1,500 new first-, second-, third-, fourth-, and higher-order nonlinear equations with solutions Parabolic, hyperbolic, elliptic, and other systems of equations with solutions Some exact methods and transformations Symbolic and numerical methods for solving nonlinear PDEs with Maple™, Mathematica®, and MATLAB® Many new illustrative examples and tables A large list of references consisting of over 1,300 sources To accommodate different mathematical backgrounds, the authors avoid wherever possible the use of special terminology. They outline the methods in a schematic,

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simplified manner and arrange the material in increasing order of complexity.

This volume presents the proceedings of a series of lectures hosted by the Mathematics Department of The University of Tennessee, Knoxville, March 22-24, 1995, under the title "Nonlinear Partial Differential Equations in Geometry and Physics". While the relevance of partial differential equations to problems in differential geometry has been recognized since the early days of the latter subject, the idea that differential equations of differential-geometric origin can be useful in the formulation of physical theories is a much more recent one. Perhaps the earliest emergence of systems of nonlinear partial differential equations having deep geometric and physical importance were the Einstein equations of general relativity (1915). Several basic aspects of the initial value problem for the Einstein equations, such as existence, regularity and stability of solutions remain prime research areas today, eighty years after Einstein's work. An even more recent development is the realization that structures originally the context of models in theoretical physics may turn out to have introduced in important geometric or topological applications. Perhaps its emergence can be traced back to 1954, with the introduction of a non-abelian version of Maxwell's equations as a model in elementary-particle physics, by the physicists C.N. Yang and R. Mills. The rich geometric structure of the Yang-Mills equations was brought to the attention of mathematicians through work of M.F. Atiyah, J. Hitchin, I.

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

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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 anisotropic 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.

What distinguishes differential geometry in the last half of the twentieth century from its earlier history is the use of nonlinear partial differential equations in the study of curved manifolds, submanifolds, mapping problems, and function theory on manifolds, among other topics. The differential equations appear as tools and as objects of study, with analytic and geometric advances fueling each other in the current explosion of progress in this area of geometry in the last twenty years. This book contains lecture notes of minicourses at the Regional Geometry Institute at Park City, Utah, in July 1992. Presented here are surveys of breaking developments in a number of areas of nonlinear partial differential equations in differential geometry. The authors of the articles are not only excellent expositors, but are also leaders in this field of research. All of the articles provide in-depth treatment of the topics and require few

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prerequisites and less background than current research articles.

This book presents a comprehensive and systematic treatment of nonlinear partial differential equations and their varied applications. It contains methods and properties of solutions along with their physical significance. In an effort to make the book useful for a diverse readership, modern examples of applications are chosen from areas of fluid dynamics, gas dynamics, plasma physics, nonlinear dynamics, quantum mechanics, nonlinear optics, acoustics, and wave propagation. Nonlinear Partial Differential Equations for Scientists and Engineers is an exceptionally complete and accessible text/reference for graduates and professionals in mathematics, physics, science, and engineering. It is also suitable as a self-study/reference guide.

The book covers several topics of current interest in the field of nonlinear partial differential equations and their applications to the physics of continuous media and particle interactions. It treats the quasigeostrophic equation, integral diffusions, periodic Lorentz gas, Boltzmann equation, and critical dispersive nonlinear Schrödinger and wave equations. The book describes in a careful and expository manner several powerful methods from recent top research articles.

Exact Solutions and Invariant Subspaces of Nonlinear Partial Differential Equations in Mechanics and Physics is the first book to provide a systematic construction of exact solutions via linear invariant subspaces for nonlinear differential operators. Acting as a guide to nonlinear evolution equations and

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models from physics and mechanics, the book focuses on the existence of new exact solutions on linear invariant subspaces for nonlinear operators and their crucial new properties. This practical reference deals with various partial differential equations (PDEs) and models that exhibit some common nonlinear invariant features. It begins with classical as well as more recent examples of solutions on invariant subspaces. In the remainder of the book, the authors develop several techniques for constructing exact solutions of various nonlinear PDEs, including reaction-diffusion and gas dynamics models, thin-film and Kuramoto-Sivashinsky equations, nonlinear dispersion (compacton) equations, KdV-type and Harry Dym models, quasilinear magma equations, and Green-Naghdi equations. Using exact solutions, they describe the evolution properties of blow-up or extinction phenomena, finite interface propagation, and the oscillatory, changing sign behavior of weak solutions near interfaces for nonlinear PDEs of various types and orders. The techniques surveyed in *Exact Solutions and Invariant Subspaces of Nonlinear Partial Differential Equations in Mechanics and Physics* serve as a preliminary introduction to the general theory of nonlinear evolution PDEs of different orders and types.

The third of three volumes on partial differential equations, this is devoted to nonlinear PDE. It treats a number of equations of classical continuum mechanics,

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including relativistic versions, as well as various equations arising in differential geometry, such as in the study of minimal surfaces, isometric imbedding, conformal deformation, harmonic maps, and prescribed Gauss curvature. In addition, some nonlinear diffusion problems are studied. It also introduces such analytical tools as the theory of L^p Sobolev spaces, H^1 spaces, Hardy spaces, and Morrey spaces, and also a development of Calderon-Zygmund theory and paradifferential operator calculus. The book is aimed at graduate students in mathematics, and at professional mathematicians with an interest in partial differential equations, mathematical physics, differential geometry, harmonic analysis and complex analysis

This book is not a textbook, but rather a coherent collection of papers from the field of partial differential equations. Nevertheless we believe that it may very well serve as a good introduction into some topics of this classical field of analysis which, despite of its long history, is highly modern and well prospering. Richard Courant wrote in 1950: "It has always been a temptation for mathematicians to present the crystallized product of their thought as a deductive general theory and to relegate the individual mathematical phenomenon into the role of an example. The reader who submits to the dogmatic form will be easily indoctrinated. Enlightenment, however, must come from an understanding of

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motives; live mathematical development springs from specific natural problems which can be easily understood, but whose solutions are difficult and demand new methods or more general significance. " We think that many, if not all, papers of this book are written in this spirit and will give the reader access to an important branch of analysis by exhibiting interesting problems worth to be studied. Most of the collected articles have an extensive introductory part describing the history of the presented problems as well as the state of the art and offer a well chosen guide to the literature. This way the papers became lengthier than customary these days, but the level of presentation is such that an advanced graduate student should find the various articles both readable and stimulating.

Nonlinear Partial Differential Equations

This book contains a collection of twelve papers that reflect the state of the art of nonlinear differential equations in modern geometrical theory. It comprises miscellaneous topics of the local and nonlocal geometry of differential equations and the applications of the corresponding methods in hydrodynamics, symplectic geometry, optimal investment theory, etc. The contents will be useful for all the readers whose professional interests are related to nonlinear PDEs and differential geometry, both in theoretical and applied aspects.

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This book primarily concerns quasilinear and semilinear elliptic and parabolic partial differential equations, inequalities, and systems. The exposition leads the reader through the general theory based on abstract (pseudo-) monotone or accretive operators as fast as possible towards the analysis of concrete differential equations, which have specific applications in continuum (thermo-) mechanics of solids and fluids, electrically (semi-) conductive media, modelling of biological systems, or in mechanical engineering. Selected parts are mainly an introduction into the subject while some others form an advanced textbook. The second edition simplifies and extends the exposition at particular spots and augments the applications especially towards thermally coupled systems, magnetism, and more. The intended audience is graduate and PhD students as well as researchers in the theory of partial differential equations or in mathematical modelling of distributed parameter systems. ----- The monograph contains a wealth of material in both the abstract theory of steady-state or evolution equations of monotone and accretive type and concrete applications to nonlinear partial differential equations from mathematical modeling. The organization of the material is well done, and the presentation, although concise, is clear, elegant and rigorous. (...) this book is a notable addition to the existing literature. Also, it certainly will prove useful to engineers, physicists, biologists

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and other scientists interested in the analysis of (...) nonlinear differential models of the real world. (Mathematical Reviews)

This textbook presents the essential parts of the modern theory of nonlinear partial differential equations, including the calculus of variations. After a short review of results in real and functional analysis, the author introduces the main mathematical techniques for solving both semilinear and quasilinear elliptic PDEs, and the associated boundary value problems. Key topics include infinite dimensional fixed point methods, the Galerkin method, the maximum principle, elliptic regularity, and the calculus of variations. Aimed at graduate students and researchers, this textbook contains numerous examples and exercises and provides several comments and suggestions for further study.

This work will serve as an excellent first course in modern analysis. The main focus is on showing how self-similar solutions are useful in studying the behavior of solutions of nonlinear partial differential equations, especially those of parabolic type. This textbook will be an excellent resource for self-study or classroom use.

The aim of this book is to put together all the results that are known about the existence of formal, holomorphic and singular solutions of singular non linear partial differential equations. The aim of this work is to present research workers and graduate students in numerical analysis with a state-of-the-art survey of some of the most active areas of numerical analysis. This volume covers research in the numerical analysis of nonlinear phenomena.

The purpose of this book is to explain systematically and clearly many of the most important techniques set forth in recent years for using weak convergence methods to study nonlinear

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partial differential equations. This work represents an expanded version of a series of ten talks presented by the author at Loyola University of Chicago in the summer of 1988. The author surveys a wide collection of techniques for showing the existence of solutions to various nonlinear partial differential equations, especially when strong analytic estimates are unavailable. The overall guiding viewpoint is that when a sequence of approximate solutions converges only weakly, one must exploit the nonlinear structure of the PDE to justify passing to limits. The author concentrates on several areas that are rapidly developing and points to some underlying viewpoints common to them all. Among the several themes in the book are the primary role of measure theory and real analysis (as opposed to functional analysis) and the continual use in diverse settings of low-amplitude, high-frequency periodic test functions to extract useful information. The author uses the simplest problems possible to illustrate various key techniques. Aimed at research mathematicians in the field of nonlinear PDEs, this book should prove an important resource for understanding the techniques being used in this important area of research.

In recent years, the Fourier analysis methods have experienced a growing interest in the study of partial differential equations. In particular, those techniques based on the Littlewood-Paley decomposition have proved to be very efficient for the study of evolution equations. The present book aims at presenting self-contained, state-of-the-art models of those techniques with applications to different classes of partial differential equations: transport, heat, wave and Schrödinger equations. It also offers more sophisticated models originating from fluid mechanics (in particular the incompressible and compressible Navier-Stokes equations) or general relativity. It is either directed to anyone with a good undergraduate level of knowledge

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in analysis or useful for experts who are eager to know the benefit that one might gain from Fourier analysis when dealing with nonlinear partial differential equations.

A large number of physical phenomena are modeled by nonlinear partial differential equations, subject to appropriate initial/ boundary conditions; these equations, in general, do not admit exact solution. The present monograph gives constructive mathematical techniques which bring out large time behavior of solutions of these model equations. These approaches, in conjunction with modern computational methods, help solve physical problems in a satisfactory manner. The asymptotic methods dealt with here include self-similarity, balancing argument, and matched asymptotic expansions. The physical models discussed in some detail here relate to porous media equation, heat equation with absorption, generalized Fisher's equation, Burgers equation and its generalizations. A chapter each is devoted to nonlinear diffusion and fluid mechanics. The present book will be found useful by applied mathematicians, physicists, engineers and biologists, and would considerably help understand diverse natural phenomena. During the last few years, several fairly systematic nonlinear theories of generalized solutions of rather arbitrary nonlinear partial differential equations have emerged. The aim of this volume is to offer the reader a sufficiently detailed introduction to two of these recent nonlinear theories which have so far contributed most to the study of generalized solutions of nonlinear partial differential equations, bringing the reader to the level of ongoing research. The essence of the two nonlinear theories presented in this volume is the observation that much of the mathematics concerning existence, uniqueness regularity, etc., of generalized solutions for nonlinear partial differential equations can be reduced to elementary calculus in Euclidean spaces, combined with elementary algebra in quotient rings of families of smooth functions on

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through interactive advances that such rapid progress has occurred. These papers require a good background in partial differential equations. Many of the contributors are mathematical physicists, and the papers are addressed to mathematical physicists (particularly in perturbed integrable systems), as well as to PDE specialists and applied mathematicians in general. The emphasis of the book is given in how to construct different types of solutions (exact, approximate analytical, numerical, graphical) of numerous nonlinear PDEs correctly, easily, and quickly. The reader can learn a wide variety of techniques and solve numerous nonlinear PDEs included and many other differential equations, simplifying and transforming the equations and solutions, arbitrary functions and parameters, presented in the book). Numerous comparisons and relationships between various types of solutions, different methods and approaches are provided, the results obtained in Maple and Mathematica, facilitates a deeper understanding of the subject. Among a big number of CAS, we choose the two systems, Maple and Mathematica, that are used worldwide by students, research mathematicians, scientists, and engineers. As in the our previous books, we propose the idea to use in parallel both systems, Maple and Mathematica, since in many research problems frequently it is required to compare independent results obtained by using different computer algebra systems, Maple and/or Mathematica, at all stages of the solution process. One of the main points (related to CAS) is based on the implementation of a whole solution method (e.g. starting from an analytical derivation of exact governing equations, constructing discretizations and analytical formulas of a numerical method, performing numerical procedure, obtaining various visualizations, and comparing the numerical solution obtained with other types of solutions considered in the book, e.g. with asymptotic solution).

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The description of many interesting phenomena in science and engineering leads to infinite-dimensional minimization or evolution problems that define nonlinear partial differential equations. While the development and analysis of numerical methods for linear partial differential equations is nearly complete, only few results are available in the case of nonlinear equations. This monograph devises numerical methods for nonlinear model problems arising in the mathematical description of phase transitions, large bending problems, image processing, and inelastic material behavior. For each of these problems the underlying mathematical model is discussed, the essential analytical properties are explained, and the proposed numerical method is rigorously analyzed. The practicality of the algorithms is illustrated by means of short implementations.

This book contains the written versions of lectures delivered since 1997 in the well-known weekly seminar on Applied Mathematics at the Collège de France in Paris, directed by Jacques-Louis Lions. It is the 14th and last of the series, due to the recent and untimely death of Professor Lions. The texts in this volume deal mostly with various aspects of the theory of nonlinear partial differential equations. They present both theoretical and applied results in many fields of growing importance such as Calculus of variations and optimal control, optimization, system theory and control, operations research, fluids and continuum mechanics, nonlinear dynamics, meteorology and climate, homogenization and material science, numerical analysis and scientific computations. The book is of interest to everyone from postgraduate, who wishes to follow the most recent progress in these fields.

It would be hopeless to attempt to give a complete account of the history of the

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calculus of variations. The interest of Greek philosophers in isoperimetric problems underscores the importance of "optimal form" in ancient cultures, see Hildebrandt-Tromba [1] for a beautiful treatise of this subject. While variational problems thus are part of our classical cultural heritage, the first modern treatment of a variational problem is attributed to Fermat (see Goldstine [1; p.1]). Postulating that light follows a path of least possible time, in 1662 Fermat was able to derive the laws of refraction, thereby using methods which may already be termed analytic. With the development of the Calculus by Newton and Leibniz, the basis was laid for a more systematic development of the calculus of variations. The brothers Johann and Jakob Bernoulli and Johann's student Leonhard Euler, all from the city of Basel in Switzerland, were to become the "founding fathers" (Hildebrandt-Tromba [1; p.21]) of this new discipline. In 1743 Euler [1] submitted "A method for finding curves enjoying certain maximum or minimum properties", published 1744, the first textbook on the calculus of variations.

An Introduction to Nonlinear Partial Differential Equations is a textbook on nonlinear partial differential equations. It is technique oriented with an emphasis on applications and is designed to build a foundation for studying advanced treatises in the field. The Second Edition features an updated bibliography as

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well as an increase in the number of exercises. All software references have been updated with the latest version of MATLAB®, the corresponding graphics have also been updated using MATLAB®. An increased focus on hydrogeology...

In this book, we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems. A number of computing techniques are considered, such as methods of operator approximation with any given accuracy; operator interpolation techniques including a non-Lagrange interpolation; methods of system representation subject to constraints associated with concepts of causality, memory and stationarity; methods of system representation with an accuracy that is the best within a given class of models; methods of covariance matrix estimation; methods for low-rank matrix approximations; hybrid methods based on a combination of iterative procedures and best operator approximation; and methods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory. As a result, the book represents a blend of new methods in general computational analysis, and specific, but also generic, techniques for study of systems theory and its particular branches, such as optimal filtering and information compression. - Best operator approximation, -

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Non-Lagrange interpolation, - Generic Karhunen-Loeve transform - Generalised low-rank matrix approximation - Optimal data compression - Optimal nonlinear filtering

Nonlinear Partial Differential Equations in Applied Science

This book consists almost entirely of papers delivered at the Seminar on partial differential equations held at Max-Planck-Institut in the spring of 1984. They give an insight into important recent research activities. Some further developments are also included.

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