Nonlinear Pdes Mathematical Models In Biology Chemistry And Population Genetics Springer Monographs In Mathematics

This book provides a hands-on approach to numerical continuation and bifurcation for nonlinear PDEs in 1D, 2D, and 3D. Partial differential equations (PDEs) are the main tool to describe spatially and temporally extended systems in nature. PDEs usually come with parameters, and the study of the parameter dependence of their solutions is an important task. Letting one parameter vary typically yields a branch of solutions, and at special parameter values, new branches may bifurcate. After a concise review of some analytical background and numerical methods, the author explains the free MATLAB package pde2path by using a large variety of examples with demo codes that can be easily adapted to the reader's given problem. Numerical Continuation and Bifurcation in Nonlinear PDEs will appeal to applied mathematicians and scientists from physics, chemistry, biology, and economics interested in the numerical solution of nonlinear PDEs, particularly the parameter dependence of solutions. It can be used as a supplemental text in courses on nonlinear PDEs and modeling and bifurcation.

It is well known that symmetry-based methods are very powerful tools for investigating nonlinear partial differential equations (PDEs), notably for their reduction to those of lower dimensionality (e.g. to ODEs) and constructing exact solutions. This book is devoted to (1) search Lie and conditional (non-classical) symmetries of nonlinear RDC equations, (2) constructing exact solutions using the symmetries obtained, and (3) their applications for solving some biologically and physically motivated problems. The book summarises the results derived by the authors during the last 10 years and those obtained by some other authors.

This collection covers new aspects of numerical methods in applied mathematics, engineering, and health sciences. It provides recent theoretical developments and new techniques based on optimization theory, partial differential equations (PDEs), mathematical modeling and fractional calculus that can be used to model and understand complex behavior in natural phenomena. Specific topics covered in detail include new numerical methods for nonlinear partial differential equations, global optimization, unconstrained optimization, detection of HIV- Protease, modelling with new fractional operators, analysis of biological models, and stochastic modelling.

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 ant its particular branches, such as optimal filtering and information compression. - Best operator approximation, - Non-Lagrange interpolation, - Generic Karhunen-Loeve transform - Generalised low-rank matrix approximation - Optimal data compression - Optimal nonlinear filtering

Probabilistic Models for Nonlinear Partial Differential Equations

Continuous Systems and Differential Equations

Variational and Topological Methods in the Study of Nonlinear Phenomena

The Abel Symposium 2010

Equilibrium Problems and Applications

An Introduction to Nonlinear Partial Differential Equations

The lecture courses of the CIME Summer School on Probabilistic Models for Nonlinear PDE's and their Numerical Applications (April 1995) had a three-fold emphasis: first, on the weak convergence of stochastic integrals; second, on the probabilistic interpretation and the particle approximation of equations coming from Physics (conservation laws, Boltzmann-like and Navier-Stokes equations); third, on the modelling of networks by interacting particle systems. This book, collecting the notes of these courses, will be useful to probabilists working on stochastic particle methods and on the approximation of SPDEs, in particular, to PhD students and young researchers.

The book provides a unique collection of in-depth mathematical, statistical, and modeling methods and techniques for life sciences, as well as their applications in a number of areas within life sciences. It also includes a range of new ideas that represent emerging frontiers in life sciences where the application of such quantitative methods and techniques is becoming increasingly important. The book is aimed at researchers in academia, practitioners and graduate students who want to foster interdisciplinary collaborations required to meet the challenges at the interface of modern life sciences and mathematics.

Equilibrium Problems and Applications develops a unified variational approach to deal with single-valued, set-valued and quasi-equilibrium problems. The authors promote original results in relationship with classical contributions to the field of equilibrium problems. The content evolved in the general setting of topological vector spaces and it lies at the interplay between pure and applied nonlinear analysis, mathematical economics, and mathematical physics. This abstract approach is based on tools from various fields, including set-valued analysis, variational and hemivariational inequalities, fixed point theory, and optimization. Applications include models from mathematical economics, Nash equilibrium of non-cooperative games, and Browder variational inclusions. The content is self-contained and the book is mainly addressed to researchers in mathematics, economics and mathematical physics as well as to graduate students in applied nonlinear analysis. A rigorous mathematical analysis of Nash equilibrium type problems, which play a central role to describe network traffic models, competition games or problems arising in experimental economics Develops generic models relevant to mathematical economics and quantitative modeling of game theory, aiding economists to understand vital material without having to wade through complex proofs Reveals a number of surprising interactions among various equilibria topics, enabling readers to identify a common and unified approach to analysing problem sets Illustrates the deep features shared by several types of nonlinear problems, encouraging readers to develop further this unifying approach from other viewpoints into economic models in turn

Preconditioning and the Conjugate Gradient Method in the Context of Solving PDEs?is about the interplay between modeling, analysis, discretization, matrix computation, and model reduction. The authors link PDE analysis, functional analysis, and calculus of variations with matrix iterative computation using Krylov subspace methods and address the challenges that arise during formulation of the mathematical model through to efficient numerical solution of the algebraic problem. The book?s central concept, preconditioning of the conjugate gradient method, is traditionally developed algebraically using the preconditioned finite-dimensional algebraic system. In this text, however, preconditioning is connected to the PDE analysis, and the infinite-dimensional formulation of the conjugate gradient method and its discretization and preconditioning are linked together. This text challenges commonly held views, addresses widespread misunderstandings, and formulates thought-provoking open questions for further research.?

Mechanical Vibrations, Population Dynamics, and Traffic Flow

Nonlinear PDEs: A Dynamical Systems Approach

Controllability of Partial Differential Equations Governed by Multiplicative Controls

Mathematical Models in Biology, Chemistry and Population Genetics

Proceedings of the Wisła 18 Summer School

Nonlinear PDEs

This book presents several fundamental results in solving nonlinear reaction-diffusion equations and systems using symmetry-based methods. Reaction-diffusion systems are fundamental modeling tools for mathematical biology with applications to ecology, population dynamics, pattern formation, morphogenesis, enzymatic reactions and chemotaxis. The book discusses the properties of nonlinear reaction-diffusion systems, which are relevant for biological applications, from the symmetry point of view, providing rigorous definitions and constructive algorithms to search for conditional symmetry (a nontrivial generalization of the well-known Lie symmetry) of nonlinear reaction-diffusion systems. In order to present applications to population dynamics, it focuses mainly on two- and three-component diffusive Lotka-Volterra systems. While it is primarily a valuable guide for researchers working with reaction-diffusion systems and those developing the theoretical aspects of conditional symmetry conception, parts of the book can also be used in master's level mathematical biology courses.

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.

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 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 topic of the 2010 Abel Symposium, hosted at the Norwegian Academy of Science and Letters, Oslo, was Nonlinear Partial Differential Equations, the study of which is of fundamental importance in mathematics and in almost all of natural sciences, economics, and engineering. This area of mathematics is currently in the midst of an unprecedented development worldwide. Differential equations are used to model phenomena of increasing complexity, and in areas that have traditionally been outside the realm of mathematics. New analytical tools and numerical methods are dramatically improving our understanding of nonlinear models. Nonlinearity gives rise to novel effects reflected in the appearance of shock waves, turbulence, material defects, etc., and offers challenging mathematical problems. On the other hand, new mathematical developments provide new insight in many applications. These proceedings present a selection of the latest exciting results by world leading researchers.

An Introduction

Nonlinear PDEs, Their Geometry, and Applications

The 1995 Barrett Lectures

Exact Solutions and Invariant Subspaces of Nonlinear Partial Differential Equations in Mechanics and Physics

Partial Differential Equations with Variable Exponents

Numerical Continuation and Bifurcation in Nonlinear PDEs

The subject of nonlinear partial differential equations is experiencing a period of intense activity in the study of systems underlying basic theories in geometry, topology and physics. These mathematical models share the property of being derived from variational principles. Understanding the structure of critical configurations and the dynamics of the corresponding evolution problems is of fundamental importance for the development of the physical theories and their applications. This volume contains survey lectures in four different areas, delivered by leading resarchers at the 1995 Barrett Lectures held at The University of Tennessee: nonlinear hyperbolic systems arising in field theory and relativity (S. Klainerman); harmonic maps from Minkowski spacetime (M. Struwe); dynamics of vortices in the Ginzburg-Landau model of superconductivity (F.-H. Lin); the Seiberg-Witten equations and their application to problems in four-dimensional topology (R. Fintushel). Most of this material has not previously been available in survey form. These lectures provide an up-to-date overview and an introduction to the research literature in each of these areas, which should prove useful to researchers and graduate students in mathematical physics, partial differential equations, differential geometry and topology.

This is an introductory textbook about nonlinear dynamics of PDEs, with a focus on problems over unbounded domains and modulation equations. The presentation is example-oriented, and new mathematical tools are developed step by step, giving insight into some important classes of nonlinear PDEs and nonlinear dynamics phenomena which may occur in PDEs. The book consists of four parts. Parts I and II are introductions to finite- and infinite-dimensional dynamics defined by ODEs and by PDEs over bounded domains, respectively, including the basics of bifurcation and attractor theory. Part III introduces PDEs on the real line, including the Korteweg-de Vries equation, the Nonlinear Schrödinger equation and the Ginzburg-Landau equation. These examples often occur as simplest possible models, namely as amplitude or modulation equations, for some real world phenomena such as nonlinear waves and pattern formation. Part IV explores in more detail the connections between such complicated physical systems and the reduced models. For many models, a mathematically rigorous justification by approximation results is given. The parts of the book are kept as self-contained as possible. The book is suitable for self-study, and there are various possibilities to build one- or two-semester courses from the book.

The author uses mathematical techniques to give an in-depth look at models for mechanical vibrations, population dynamics, and traffic flow.

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.

Mathematical Models of Higher Orders

A Practical Course in Differential Equations and Mathematical Modelling

Physical Mathematics and Nonlinear Partial Differential Equations

Nonlinear Reaction-Diffusion Systems

Methods of Mathematical Modelling

Nonlinear Reaction-Diffusion-Convection Equations

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).

A Practical Course in Differential Equations and Mathematical Modelling is a unique blend of the traditional methods of ordinary and partial differential equations with Lie group analysis enriched by the author?s own theoretical developments. The book ? which aims to present new mathematical curricula based on symmetry and invariance principles ? is tailored to develop analytic skills and ?working knowledge? in both classical and Lie?s methods for solving linear and nonlinear equations. This approach helps to make courses in differential equations, mathematical modelling, distributions and fundamental solution, etc. easy to follow and interesting for students. The book is based on the author?s extensive teaching experience at Novosibirsk and Moscow universities in Russia, Coll ge de France, Georgia Tech and Stanford University in the United States, universities in South Africa, Cyprus, Turkey, and Blekinge Institute of Technology (BTH) in Sweden. The new curriculum prepares students for solving modern nonlinear problems and will essentially be more appealing to students compared to the traditional way of teaching mathematics.

This book offers a valuable methodological approach to the state-of-the-art of the classical plate/shell mathematical models, exemplifying the vast range of mathematical models of nonlinear dynamics and statics of continuous mechanical structural members. The main objective highlights the need for further study of the classical problem of shell dynamics consisting of mathematical modeling, derivation of nonlinear PDEs, and of finding their solutions based on the development of new and effective numerical techniques. The book is designed for a broad readership of graduate students in mechanical and civil engineering, applied mathematics, and physics, as well as to researchers and professionals interested in a rigorous and comprehensive study of modeling non-linear phenomena governed by PDEs.

Nonlinear PDEsMathematical Models in Biology, Chemistry and Population GeneticsSpringer

Classical and New Methods, Nonlinear Mathematical Models, Symmetry and Invariance Principles

Variational Methods and Qualitative Analysis

Shells in Temperature Fields

Mathematical Models in Biology

Lectures given at the 1st Session of the Centro Internazionale Matematico Estivo (C.I.M.E.) held in Montecatini Terme, Italy, May 22-30, 1995
Lie and Conditional Symmetry, Exact Solutions and Their Applications

Partial Differential Equations with Variable Exponents: Variational Methods and Qualitative Analysis provides researchers and graduate students with a thorough introduction to the theory of nonlinear partial differential equations (PDEs) with a variable exponent, particularly those of elliptic type. The book presents the most important variational methods for elliptic PDEs described by nonhomogeneous differential operators and containing one or more power-type nonlinearities with a variable exponent. The authors give a systematic treatment of the basic mathematical theory and constructive methods for these classes of nonlinear elliptic equations as well as their applications to various processes arising in the applied sciences. The analysis developed in the book is based on the notion of a generalized or weak solution. This approach leads not only to the fundamental results of existence and multiplicity of weak solutions but also to several qualitative properties, including spectral analysis, bifurcation, and asymptotic analysis. The book examines the equations from different points of view while using the calculus of variations as the unifying theme. Readers will see how all of these diverse topics are connected to other important parts of mathematics, including topology, differential geometry, mathematical physics, and potential theory.

This volume consists of the proceedings of the conference on Physical Mathematics and Nonlinear Partial Differential Equations held at West Virginia University in Morgantown. It describes some work dealing with weak limits of solutions to nonlinear systems of partial differential equations.

"Although valuable understanding of real-world phenomena can be gained experimentally, it is often the case that experimental investigations can be found to be limited by financial, ethical or other constraints making such an approach impractical or, in some cases, even impossible. To nevertheless understand and make predictions of the natural world around us, countless processes encountered in the physical and biological sciences, engineering, economics and medicine can be efficiently described by means of mathematical models written in terms of ordinary or/and partial differential equations or their systems. Fundamental questions that arise in the modeling process need care that relies on the use of mathematical analysis. It is also the case that more realistic models directly relevant to the specific area of application are often nonlinear, calling for a robust treatment of general classes of differential equations. This thesis is devoted to developing a range of proof techniques for the mathematical analysis of general classes of both linear and nonlinear and both ordinary and partial differential equations that help in gaining an understanding of the fundamental properties of their solutions."--Boise State University ScholarWorks.

Partial Differential Equations presents a balanced and comprehensive introduction to the concepts and techniques required to solve problems containing unknown functions of multiple variables. While focusing on the three most classical partial differential equations (PDEs)—the wave, heat, and Laplace equations—this detailed text also presents a broad practical perspective that merges mathematical concepts with real-world application in diverse areas including molecular structure, photon and electron interactions, radiation of electromagnetic waves, vibrations of a solid, and many more. Rigorous pedagogical tools aid in student comprehension; advanced topics are introduced frequently, with minimal technical jargon, and a wealth of exercises reinforce vital skills and invite additional self-study. Topics are presented in a logical progression, with major concepts such as wave propagation, heat and diffusion, electrostatics, and quantum mechanics placed in contexts familiar to students of various fields in science and engineering. By understanding the properties and applications of PDEs, students will be equipped to better analyze and interpret central processes of the natural world.

Nonlinear Partial Differential Equations in Engineering by W F Ames
Solving Nonlinear Partial Differential Equations with Maple and Mathematica
Numerical Methods for Nonlinear Engineering Models
Numerical Methods for PDEs
State of the Art Techniques
Qualitative Analysis of Nonlinear Elliptic Partial Differential Equations

This volume is a collection of original research papers and expository articles stemming from the scientific program of the Nonlinear PDE Emphasis Year held at Northwestern University (Evanston, IL) in March 1998. The book offers a cross-section of the most significant recent advances and current trends and directions in nonlinear partial differential equations and related topics. The book's contributions offer two perspectives. There are papers on general analytical treatment of the theory and papers on computational methods and applications originating from significant realistic mathematical models of natural phenomena. Also included are articles that bridge the gap between these two perspectives, seeking synergistic links between theory and modeling and computation. The volume offers direct insight into recent trends in PDEs. This volume is also available on the Web. Those who purchase the print edition can gain free access by going to www.ams.org/conm/

There are many books on the use of numerical methods for solving engineering problems and for modeling of engineering artifacts. In addition there are many styles of such presentations ranging from books with a major emphasis on theory to books with an emphasis on applications. The purpose of this book is hopefully to present a somewhat different approach to the use of numerical methods for - gineering applications. Engineering models are in general nonlinear models where the response of some appropriate engineering variable depends in a nonlinear manner on the - plication of some independent parameter. It is certainly true that for many types of engineering models it is sufficient to approximate the real physical world by some linear model. However, when engineering environments are pushed to - treme conditions, nonlinear effects are always encountered. It is also such - treme conditions that are of major importance in determining the reliability or failure limits of engineering systems. Hence it is essential than engineers have a toolbox of modeling techniques that can be used to model nonlinear engineering systems. Such a set of basic numerical methods is the topic of this book. For each subject area treated, nonlinear models are incorporated into the discussion from the very beginning and linear models are simply treated as special cases of more general nonlinear models. This is a basic and fundamental difference in this book from most books on numerical methods.

This volume covers recent advances in the field of nonlinear functional analysis and its applications to nonlinear partial and ordinary differential equations, with particular emphasis on variational and topological methods. A broad range of topics is covered, including: * concentration phenomena in pdes * variational methods with applications to pdes and physics * periodic solutions of odes * computational aspects in topological methods * mathematical models in biology Though well-differentiated, the topics covered are unified through a common perspective and approach. Unique to the work are several chapters on computational aspects and applications to biology, not usually found with such basic studies on pdes and odes. The volume is an excellent reference text for researchers and graduate students in the above mentioned fields. Contributors: M. Clapp, M. Del Pino, M.J. Esteban, P. Felmer, A. Ioffe, W. Marzantowicz, M. Mrozek, M. Musso, R. Ortega, P. Pilarczyk, E. Séré, E. Schwartzman, P. Sintzoff, R. Turner , M. Willem.

This volume presents lectures given at the Summer School Wisła 18: Nonlinear PDEs, Their Geometry, and Applications, which took place from August 20 - 30th, 2018 in Wisła, Poland, and was organized by the Baltic Institute of Mathematics. The lectures in the first part of this volume were delivered by experts in nonlinear differential equations and their applications to physics. Original research articles from members of the school comprise the second part of this volume. Much of the latter half of the volume complements the methods expounded in the first half by illustrating additional applications of geometric theory of differential equations. Various subjects are covered, providing readers a glimpse of current research. Other topics covered include thermodynamics, meteorology, and the Monge–Ampère equations. Researchers interested in the applications of nonlinear differential equations to physics will find this volume particularly useful. A knowledge of differential geometry is recommended for the first portion of the book, as well as a familiarity with basic concepts in physics.

Partial Differential Equations
Numerical Solutions of Realistic Nonlinear Phenomena

Mathematical Models
Conditional Symmetry, Exact Solutions and their Applications in Biology
Nonlinear Partial Differential Equations with Applications

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

The emphasis throughout the present volume is on the practical application of theoretical mathematical models helping to unravel the underlying mechanisms involved in processes from mathematical physics and biosciences. It has been conceived as a unique collection of abstract methods dealing especially with nonlinear partial differential equations (either stationary or evolutionary) that are applied to understand concrete processes involving some important applications related to phenomena such as: boundary layer phenomena for viscous fluids, population dynamics,, dead core phenomena, etc. It addresses researchers and post-graduate students working at the interplay between mathematics and other fields of science and technology and is a comprehensive introduction to the theory of nonlinear partial differential equations and its main principles also presents their real-life applications in various contexts: mathematical physics, chemistry, mathematical biology, and population genetics. Based on the authors' original work, this volume provides an overview of the field, with examples suitable for researchers but also for graduate students entering research. The method of presentation appeals to readers with diverse backgrounds in partial differential equations and functional analysis. Each chapter includes detailed heuristic arguments, providing thorough motivation for the material developed later in the text. The content demonstrates in a firm way that partial differential equations can be used to address a large variety of phenomena occurring in and influencing our daily lives. The extensive reference list and index make this book a valuable resource for researchers working in a variety of fields and who are interested in phenomena modeled by nonlinear partial differential equations.

This book provides a comprehensive introduction to the mathematical theory of nonlinear problems described by elliptic partial differential equations. These equations can be seen as nonlinear versions of the classical Laplace equation, and they appear as mathematical models in different branches of physics, chemistry, biology, genetics, and engineering and are also relevant in differential geometry and relativistic physics. Much of the modern theory of such equations is based on the calculus of variations and functional analysis. Concentrating on single-valued or multivalued elliptic equations with nonlinearities of various types, the aim of this volume is to obtain sharp existence or nonexistence results, as well as decay rates for general classes of solutions. Many technically relevant questions are presented and analyzed in detail. A systematic picture of the most relevant phenomena is obtained for the equations under study, including bifurcation, stability, asymptotic analysis, and optimal regularity of solutions. The method of presentation should appeal to readers with different backgrounds in functional analysis and nonlinear partial differential equations. All chapters include detailed heuristic arguments providing thorough motivation of the study developed later on in the text, in relationship with concrete processes arising in applied sciences. A systematic description of the most relevant singular phenomena described in this volume includes existence (or nonexistence) of solutions, unicity or multiplicity properties, bifurcation and asymptotic analysis, and optimal regularity. The book includes an extensive bibliography and a rich index, thus allowing for quick orientation among the vast collection of literature on the mathematical theory of nonlinear phenomena described by elliptic partial differential equations.

The author uses mathematical techniques along with observations and experiments to give an in-depth look at models for mechanical vibrations, population dynamics, and traffic flow. Equal emphasis is placed on the mathematical formulation of the problem and the interpretation of the results. In the sections on mechanical vibrations and population dynamics, the author emphasizes the nonlinear aspects of ordinary differential equations and develops the concepts of equilibrium solutions and their stability. He introduces phase plane methods for the nonlinear pendulum and for predator-prey and competing species models. Haberman develops the method of characteristics to analyze the nonlinear partial differential equations that describe traffic flow. Fan-shaped characteristics describe the traffic situation that occurs when a traffic light turns green and shock waves describe the effects of a red light or traffic accident. Although it was written over 20 years ago, this book is still relevant. It is intended as an introduction to applied mathematics, but can be used for undergraduate courses in mathematical modeling or nonlinear dynamical systems or to supplement courses in ordinary or partial differential equations.

Preconditioning and the Conjugate Gradient Method in the Context of Solving PDEs
Mathematical Modelling
Nonlinear Partial Differential Equations in Geometry and Physics
International Conference on Nonlinear Partial Differential Equations and Applications, March 21-24, 1998, Northwestern University
Mathematics and Life Sciences
Mathematical Methods and Models in Biomedicine

Mathematical biomedicine is a rapidly developing interdisciplinary field of research that connects the natural and exact sciences in an attempt to respond to the modeling and simulation challenges raised by biology and medicine. There exist a large number of mathematical methods and procedures that can be brought in to meet these challenges and this book presents a palette of such tools ranging from discrete cellular automata to cell population based models described by ordinary differential equations to nonlinear partial differential equations representing complex time- and space-dependent continuous processes. Both stochastic and deterministic methods are employed to analyze biological phenomena in various temporal and spatial settings. This book illustrates the breadth and depth of research opportunities that exist in the general field of mathematical biomedicine by highlighting some of the fascinating interactions that continue to develop between the mathematical and biomedical sciences. It consists of five parts that can be read independently, but are arranged to give the reader a broader picture of specific research topics and the mathematical tools that are being applied in its modeling and analysis. The main areas covered include immune system modeling, blood vessel dynamics, cancer modeling and treatment, and epidemiology. The chapters address topics that are at the forefront of current biomedical research such as cancer stem cells, immunodominance and viral epitopes, aggressive forms of brain cancer, or gene therapy. The presentations highlight how mathematical modeling can enhance biomedical understanding and will be of interest to both the mathematical and the biomedical communities including researchers already working in the field as well as those who might consider entering it. Much of the material is presented in a way that gives graduate students and young researchers a starting point for their own work.

This volume gathers contributions from participants of the Introductory School and the IHP thematic quarter on Numerical Methods for PDE, held in 2016 in Cargese (Corsica) and Paris, providing an opportunity to disseminate the latest results and envisage fresh challenges in traditional and new application fields. Numerical analysis applied to the approximate solution of PDEs is a key discipline in applied mathematics, and over the last few years, several new paradigms have appeared, leading to entire new families of discretization methods and solution algorithms. This book is intended for researchers in the field.

Praise for the First Edition: "This book is well conceived and well written. The author has succeeded in producing a text on nonlinear PDEs that is not only quite readable but also accessible to students from diverse backgrounds." —SIAM Review A practical introduction to nonlinear PDEs and their real-world applications Now in a Second Edition, this popular book on nonlinear partial differential equations (PDEs) contains expanded coverage on the central topics of applied mathematics in an elementary, highly readable format and is accessible to students and researchers in the field of pure and applied mathematics. This book provides a new focus on the increasing use of mathematical applications in the life sciences, while also addressing key topics such as linear PDEs, first-order nonlinear PDEs, classical and weak solutions, shocks, hyperbolic systems, nonlinear diffusion, and elliptic equations. Unlike comparable books that typically only use formal proofs and theory to demonstrate results, An Introduction to Nonlinear Partial Differential Equations, Second Edition takes a more practical approach to nonlinear PDEs by emphasizing how the results are used, why they are important, and how they are applied to real problems. The intertwining relationship between mathematics and physical phenomena is discovered using detailed examples of applications across various areas such as biology, combustion, traffic flow, heat transfer, fluid mechanics, quantum mechanics, and the chemical reactor theory. New features of the Second Edition also include: Additional intermediate-level exercises that facilitate the development of advanced problem-solving skills New applications in the biological sciences, including age-structure, pattern formation, and the propagation of diseases An expanded bibliography that facilitates further investigation into specialized topics With individual, self-contained chapters and a broad scope of coverage that offers instructors the flexibility to design courses to meet specific objectives, An Introduction to Nonlinear Partial Differential Equations, Second Edition is an ideal text for applied mathematics courses at the upper-undergraduate and graduate levels. It also serves as a valuable resource for researchers and professionals in the fields of mathematics, biology, engineering, and physics who would like to further their knowledge of PDEs.

Mathematical Models in Biology is an introductory book for readers interested in biological applications of mathematics and modeling in biology. A favorite in the mathematical biology community, it shows how relatively simple mathematics can be applied to a variety of models to draw interesting conclusions. Connections are made between diverse biological examples linked by common mathematical themes. A variety of discrete and continuous ordinary and partial differential equation models are explored. Although great advances have taken place in many of the topics covered, the simple lessons contained in this book are still important and informative. Audience: the book does not assume too much background knowledge--essentially some calculus and high-school algebra. It was originally written with third- and fourth-year undergraduate mathematical-biology majors in mind; however, it was picked up by beginning graduate students as well as researchers in math (and some in biology) who wanted to learn about this field.

Nonlinear Partial Differential Equations
Concepts and Case Studies
Numerical Methods for Nonlinear Partial Differential Equations
Nonlinear Partial Differential Equations, Their Solutions, and Properties
Monotonicity, Analytic, and Variational Methods

This book presents mathematical modelling and the integrated process of formulating sets of equations to describe real-world problems. It describes methods for obtaining solutions of challenging differential equations stemming from problems in areas such as chemical reactions, population dynamics, mechanical systems, and fluid mechanics. Chapters 1 to 4 cover essential topics in ordinary differential equations, transport equations and the calculus of variations that are important for formulating models. Chapters 5 to 11 then develop more advanced techniques including similarity solutions, matched asymptotic expansions, multiple scale analysis, long-wave models, and fast/slow dynamical systems. Methods of Mathematical Modelling will be useful for advanced undergraduate or beginning graduate students in applied mathematics, engineering and other applied sciences.

This monograph addresses the global controllability of partial differential equations in the context of multiplicative (or bilinear) controls, which enter the model equations as coefficients. The methodology is illustrated with a variety of model equations.

Over the past decade there has been an increasing demand for suitable material in the area of mathematical modelling as applied to science and engineering. There has been a constant movement in the emphasis from developing proficiency in purely mathematical techniques to an approach which caters for industrial and scientific applications in emerging new technologies. In this textbook we have attempted to present the important fundamental concepts of mathematical modelling and to demonstrate their use in solving certain scientific and engineering problems. This text, which serves as a general introduction to the area of mathematical modelling, is aimed at advanced undergraduate students in mathematics or closely related disciplines, e.g., students who have some prerequisite knowledge such as one-variable calculus, linear algebra and ordinary differential equations. Some prior knowledge of computer programming would be useful but is not considered essential. The text also contains some more challenging material which could prove attractive to graduate students in engineering or science who are involved in mathematical modelling. In preparing the text we have tried to use our experience of teaching mathematical modelling to undergraduate students in a wide range of areas including mathematics and computer science and disciplines in engineering and science. An important aspect of the text is the use made of scientific computer software packages such as MAPLE for symbolic algebraic manipulations and MA TLAB for numerical simulation.