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The Fractional Calculus Theory and Applications of Differentiation and Integration to Arbitrary Order Advances in Fractional Calculus Fractional Calculus: Theory and Applications Basic Theory Of Fractional Differential Equations (Third Edition) Fractional Calculus Fractional Calculus Theory and Numerical Approximations of Fractional Integrals and Derivatives Fractional Order Analysis Fractional differential calculus via fractional difference theory and applications : a non-standard fractional calculus and its applications Functional Fractional Calculus Fractional Calculus Fractional Equations and Models Time-Fractional Differential Equations Theory And Applications of Fractional Differential Equations Basic Theory Fractional

Calculus: Theory and Applications General Fractional Derivatives Fractional Calculus: Theory and Applications Applied Fractional Calculus in Identification and Control Fractional Differential Equations Theory and Numerical Approximations of Fractional Integrals and Derivatives Fractional Calculus: An Introduction For Physicists (2nd Edition) Fractional Differential Equations Discrete Fractional Calculus and Fractional Difference Equations Theory and Applications of Fractional Differential Equations Fixed Point Theory and Fractional Calculus Fractional Differential Equations Theory and Applications of Non-integer Order Systems An Introduction to the Fractional Calculus and Fractional Differential Equations Generalized Fractional Calculus Fractional Derivatives for Physicists and Engineers Fractional Calculus and Fractional Differential Equations Fractional Calculus Fractional Calculus Theory of Fractional Evolution Equations Fractional Calculus Functional Fractional Calculus for System Identification and Controls Fractional Calculus and Fractional Processes with Applications to Financial Economics Discrete Fractional Calculus Fractional Calculus and Its Applications

Time-Fractional Differential Equations Jun 10 2023 This book aims to establish a foundation for fractional derivatives and fractional differential equations. The theory of fractional derivatives enables considering any positive order of differentiation. The history of research in this field is very long, with its origins dating back to Leibniz. Since then, many great mathematicians, such as Abel, have made contributions that cover not only theoretical aspects but also physical applications of fractional calculus. The fractional partial differential equations govern phenomena depending both on spatial and time variables and require more subtle treatments.

Moreover, fractional partial differential equations are highly demanded model equations for solving real-world problems such as the anomalous diffusion in heterogeneous media. The studies of fractional partial differential equations have continued to expand explosively. However we observe that available mathematical theory for fractional partial differential equations is not still complete. In particular, operator-theoretical approaches are indispensable for some generalized categories of solutions such as weak solutions, but feasible operator-theoretic foundations for wide applications are not available in monographs. To make this monograph more readable, we are restricting it to a few fundamental types of time-fractional partial differential equations, forgoing many other important and exciting topics such as stability for nonlinear problems. However, we believe that this book works well as an introduction to mathematical research in such vast fields.

Basic Theory Apr 08 2023 This multi-volume handbook is the most up-to-date and comprehensive reference work in the field of fractional calculus and its numerous applications. This first volume collects authoritative chapters covering the mathematical theory of fractional calculus, including fractional-order operators, integral transforms and equations, special functions, calculus of variations, and probabilistic and other aspects.

Fractional Order Analysis Nov 15 2023 A guide to the new research in the field of fractional order analysis *Fractional Order Analysis* contains the most recent research findings in fractional order analysis and its applications. The authors—noted experts on the topic—offer an examination of the theory, methods, applications, and the modern tools and techniques in the field of fractional order analysis. The information, tools, and applications presented can help

develop mathematical methods and models with better accuracy. Comprehensive in scope, the book covers a range of topics including: new fractional operators, fractional derivatives, fractional differential equations, inequalities for different fractional derivatives and fractional integrals, fractional modeling related to transmission of Malaria, and dynamics of Zika virus with various fractional derivatives, and more. Designed to be an accessible text, several useful, relevant and connected topics can be found in one place, which is crucial for an understanding of the research problems of an applied nature. This book: Contains recent development in fractional calculus Offers a balance of theory, methods, and applications Puts the focus on fractional analysis and its interdisciplinary applications, such as fractional models for biological models Helps make research more relevant to real-life applications Written for researchers, professionals and practitioners, Fractional Order Analysis offers a comprehensive resource to fractional analysis and its many applications as well as information on the newest research.

Theory and Numerical Approximations of Fractional Integrals and Derivatives Oct 02 2022

"This book provides a comprehensive review of fractional calculus, covering both theory and numerical methods, and presents recent results on the subject"--

Fractional Equations and Models Jul 11 2023 Fractional equations and models play an essential part in the description of anomalous dynamics in complex systems. Recent developments in the modeling of various physical, chemical and biological systems have clearly shown that fractional calculus is not just an exotic mathematical theory, as it might have once seemed. The present book seeks to demonstrate this using various examples of equations and models with fractional and generalized operators. Intended for students and researchers in mathematics, physics,

chemistry, biology and engineering, it systematically offers a wealth of useful tools for fractional calculus.

Discrete Fractional Calculus Mar 15 2021 The main subject of the monograph is the fractional calculus in the discrete version. The volume is divided into three main parts. Part one contains a theoretical introduction to the classical and fractional-order discrete calculus where the fundamental role is played by the backward difference and sum. In the second part, selected applications of the discrete fractional calculus in the discrete system control theory are presented. In the discrete system identification, analysis and synthesis, one can consider integer or fractional models based on the fractional-order difference equations. The third part of the book is devoted to digital image processing.

Fractional Differential Equations Nov 03 2022 Fractional calculus provides the possibility of introducing integrals and derivatives of an arbitrary order in the mathematical modelling of physical processes, and it has become a relevant subject with applications to various fields, such as anomalous diffusion, propagation in different media, and propagation in relation to materials with different properties. However, many aspects from theoretical and practical points of view have still to be developed in relation to models based on fractional operators. This Special Issue is related to new developments on different aspects of fractional differential equations, both from a theoretical point of view and in terms of applications in different fields such as physics, chemistry, or control theory, for instance. The topics of the Issue include fractional calculus, the mathematical analysis of the properties of the solutions to fractional equations, the extension of classical approaches, or applications of fractional equations to several fields.

Fractional Derivatives for Physicists and Engineers Nov 22 2021 The first derivative of a particle coordinate means its velocity, the second means its acceleration, but what does a fractional order derivative mean? Where does it come from, how does it work, where does it lead to? The two-volume book written on high didactic level answers these questions. Fractional Derivatives for Physicists and Engineers— The first volume contains a clear introduction into such a modern branch of analysis as the fractional calculus. The second develops a wide panorama of applications of the fractional calculus to various physical problems. This book recovers new perspectives in front of the reader dealing with turbulence and semiconductors, plasma and thermodynamics, mechanics and quantum optics, nanophysics and astrophysics. The book is addressed to students, engineers and physicists, specialists in theory of probability and statistics, in mathematical modeling and numerical simulations, to everybody who doesn't wish to stay apart from the new mathematical methods becoming more and more popular. Prof. Vladimir V. UCHAIKIN is a known Russian scientist and pedagogue, a Honored Worker of Russian High School, a member of the Russian Academy of Natural Sciences. He is the author of about three hundreds articles and more than a dozen books (mostly in Russian) in Cosmic ray physics, Mathematical physics, Levy stable statistics, Monte Carlo methods with applications to anomalous processes in complex systems of various levels: from quantum dots to the Milky Way galaxy.

Advances in Fractional Calculus May 21 2024 In the last two decades, fractional (or non integer) differentiation has played a very important role in various fields such as mechanics, electricity, chemistry, biology, economics, control theory and signal and image processing. For example, in

the last three fields, some important considerations such as modelling, curve fitting, filtering, pattern recognition, edge detection, identification, stability, controllability, observability and robustness are now linked to long-range dependence phenomena. Similar progress has been made in other fields listed here. The scope of the book is thus to present the state of the art in the study of fractional systems and the application of fractional differentiation. As this volume covers recent applications of fractional calculus, it will be of interest to engineers, scientists, and applied mathematicians.

Functional Fractional Calculus Sep 13 2023 When a new extraordinary and outstanding theory is stated, it has to face criticism and skepticism, because it is beyond the usual concept. The fractional calculus though not new, was not discussed or developed for a long time, particularly for lack of its application to real life problems. It is extraordinary because it does not deal with 'ordinary' differential calculus. It is outstanding because it can now be applied to situations where existing theories fail to give satisfactory results. In this book not only mathematical abstractions are discussed in a lucid manner, with physical mathematical and geometrical explanations, but also several practical applications are given particularly for system identification, description and then efficient controls. The normal physical laws like, transport theory, electrodynamics, equation of motions, elasticity, viscosity, and several others of are based on 'ordinary' calculus. In this book these physical laws are generalized in fractional calculus contexts; taking, heterogeneity effect in transport background, the space having traps or islands, irregular distribution of charges, non-ideal spring with mass connected to a pointless-mass ball, material behaving with viscous as well as elastic properties, system relaxation with

and without memory, physics of random delay in computer network; and several others; mapping the reality of nature closely. The concept of fractional and complex order differentiation and integration are elaborated mathematically, physically and geometrically with examples. The practical utility of local fractional differentiation for enhancing the character of singularity at phase transition or characterizing the irregularity measure of response function is deliberated. Practical results of viscoelastic experiments, fractional order controls experiments, design of fractional controller and practical circuit synthesis for fractional order elements are elaborated in this book. The book also maps theory of classical integer order differential equations to fractional calculus contexts, and deals in details with conflicting and demanding initialization issues, required in classical techniques. The book presents a modern approach to solve the ‘solvable’ system of fractional and other differential equations, linear, non-linear; without perturbation or transformations, but by applying physical principle of action-and-opposite-reaction, giving ‘approximately exact’ series solutions. Historically, Sir Isaac Newton and Gottfried Wilhelm Leibniz independently discovered calculus in the middle of the 17th century. In recognition to this remarkable discovery, J.von Neumann remarked, “...the calculus was the first achievement of modern mathematics and it is difficult to overestimate its importance. I think it defines more equivocally than anything else the inception of modern mathematical analysis which is logical development, still constitute the greatest technical advance in exact thinking.” This XXI century has thus started to ‘think-exactly’ for advancement in science & technology by growing application of fractional calculus, and this century has started speaking the language which nature understands the best.

Fractional Calculus: Theory and Applications Mar 07 2023

Theory And Applications of Fractional Differential Equations May 09 2023 This monograph provides the most recent and up-to-date developments on fractional differential and fractional integro-differential equations involving many different potentially useful operators of fractional calculus. The subject of fractional calculus and its applications (that is, calculus of integrals and derivatives of any arbitrary real or complex order) has gained considerable popularity and importance during the past three decades or so, due mainly to its demonstrated applications in numerous seemingly diverse and widespread fields of science and engineering. Some of the areas of present-day applications of fractional models include Fluid Flow, Solute Transport or Dynamical Processes in Self-Similar and Porous Structures, Diffusive Transport akin to Diffusion, Material Viscoelastic Theory, Electromagnetic Theory, Dynamics of Earthquakes, Control Theory of Dynamical Systems, Optics and Signal Processing, Bio-Sciences, Economics, Geology, Astrophysics, Probability and Statistics, Chemical Physics, and so on. In the above-mentioned areas, there are phenomena with strange kinetics which have a microscopic complex behaviour, and their macroscopic dynamics can not be characterized by classical derivative models. The fractional modelling is an emergent tool which use fractional differential equations including derivatives of fractional order, that is, we can speak about a derivative of order $1/3$, or square root of 2, and so on. Some of such fractional models can have solutions which are non-differentiable but continuous functions, such as Weierstrass type functions. Such kinds of properties are, obviously, impossible for the ordinary models. What are the useful properties of these fractional operators which help in the modelling of so many anomalous processes? From

the point of view of the authors and from known experimental results, most of the processes associated with complex systems have non-local dynamics involving long-memory in time, and the fractional integral and fractional derivative operators do have some of those characteristics. This book is written primarily for the graduate students and researchers in many different disciplines in the mathematical, physical, engineering and so many others sciences, who are interested not only in learning about the various mathematical tools and techniques used in the theory and widespread applications of fractional differential equations, but also in further investigations which emerge naturally from (or which are motivated substantially by) the physical situations modelled mathematically in the book. This monograph consists of a total of eight chapters and a very extensive bibliography. The main objective of it is to complement the contents of the other books dedicated to the study and the applications of fractional differential equations. The aim of the book is to present, in a systematic manner, results including the existence and uniqueness of solutions for the Cauchy type problems involving nonlinear ordinary fractional differential equations, explicit solutions of linear differential equations and of the corresponding initial-value problems through different methods, closed-form solutions of ordinary and partial differential equations, and a theory of the so-called sequential linear fractional differential equations including a generalization of the classical Frobenius method, and also to include an interesting set of applications of the developed theory. Key features: - It is mainly application oriented. - It contains a complete theory of Fractional Differential Equations. - It can be used as a postgraduate-level textbook in many different disciplines within science and engineering. - It contains an up-to-date bibliography. - It provides problems and directions for

further investigations. - Fractional Modelling is an emergent tool with demonstrated applications in numerous seemingly diverse and widespread fields of science and engineering. - It contains many examples. - and so on!

Theory of Fractional Evolution Equations Jul 19 2021 Fractional evolution equations provide a unifying framework to investigate wellposedness of complex systems with fractional order derivatives. This monograph presents the existence, attractivity, stability, periodic solutions and control theory for time fractional evolution equations. The book contains an up-to-date and comprehensive stuff on the topic.

Generalized Fractional Calculus Dec 24 2021 This book applies generalized fractional differentiation techniques of Caputo, Canavati and Conformable types to a great variety of integral inequalities e.g. of Ostrowski and Opial types, etc. Some of these are extended to Banach space valued functions. These inequalities have also great impact in numerical analysis, stochastics and fractional differential equations. The book continues with generalized fractional approximations by positive sublinear operators which derive from the presented Korovkin type inequalities and also includes abstract cases. It presents also multivariate complex Korovkin quantitative approximation theory. It follows M-fractional integral inequalities of Ostrowski and Polya types. The results are weighted so they provide a great variety of cases and applications. The second part of the book deals with the quantitative fractional Korovkin type approximation of stochastic processes and lays there the foundations of stochastic fractional calculus. The book considers both Caputo and Conformable fractional directions and derives regular and trigonometric results. The positive linear operators can be expectation operator commutative or

not. This book results are expected to find applications in many areas of pure and applied mathematics and stochastics. As such this monograph is suitable for researchers, graduate students, and seminars of the above disciplines, also to be in all science and engineering libraries.

Applied Fractional Calculus in Identification and Control Dec 04 2022 The book investigates the fractional calculus-based approaches and their benefits to adopting in complex real-time areas. Another objective is to provide initial solutions for new areas where fractional theory has yet to verify the expertise. The book focuses on the latest scientific interest and illustrates the basic idea of general fractional calculus with MATLAB codes. This book is ideal for researchers working on fractional calculus theory both in simulation and hardware. Researchers from academia and industry working or starting research in applied fractional calculus methods will find the book most useful. The scope of this book covers most of the theoretical and practical studies on linear and nonlinear systems using fractional-order integro-differential operators.

Fractional Calculus and Fractional Processes with Applications to Financial Economics Apr 15 2021 Fractional Calculus and Fractional Processes with Applications to Financial Economics presents the theory and application of fractional calculus and fractional processes to financial data. Fractional calculus dates back to 1695 when Gottfried Wilhelm Leibniz first suggested the possibility of fractional derivatives. Research on fractional calculus started in full earnest in the second half of the twentieth century. The fractional paradigm applies not only to calculus, but also to stochastic processes, used in many applications in financial economics such as modelling volatility, interest rates, and modelling high-frequency data. The key features of fractional processes that make them interesting are long-range memory, path-dependence, non-Markovian

properties, self-similarity, fractal paths, and anomalous diffusion behaviour. In this book, the authors discuss how fractional calculus and fractional processes are used in financial modelling and finance economic theory. It provides a practical guide that can be useful for students, researchers, and quantitative asset and risk managers interested in applying fractional calculus and fractional processes to asset pricing, financial time-series analysis, stochastic volatility modelling, and portfolio optimization. Provides the necessary background for the book's content as applied to financial economics Analyzes the application of fractional calculus and fractional processes from deterministic and stochastic perspectives

Fractional Calculus Aug 12 2023 The first volume of this two-volume book, presents history, the mathematical modeling and the applications of fractional order systems, and contains mathematical and theoretical studies and research related to this domain. This volume is made up of 11 chapters. The first chapter presents an analysis of the Caputo derivative and the pseudo state representation with the infinite state approach. The second chapter studies the stability of a class of fractional Cauchy problems. The third chapter shows how to solve fractional order differential equations and fractional order partial differential equations using modern matrix algebraic approaches. Following this chapter, chapter four proposes another analytical method to solve differential equations with local fractional derivative operators. Concerning chapter five, it presents the extended Borel transform and its related fractional analysis. After presenting the analytical resolution methods for fractional calculus, chapter six shows the essentials of fractional calculus on discrete settings. The initialization of such systems is shown in chapter seven. In fact, this chapter presents a generalized application of the Hankel operator for

initialization of fractional order systems. The last four chapters show some new studies and applications of non-integer calculus. In fact, chapter eight presents the fractional reaction-transport equations and evanescent continuous time random walks. Chapter nine shows a novel approach in the exponential integrators for fractional differential equations. Chapter ten presents the non-fragile tuning of fractional order PD controllers for integrating time delay systems. At the end, chapter eleven proposes a discrete finite-dimensional approximation of linear infinite dimensional systems. To sum up, this volume presents a mathematical and theoretical study of fractional calculus along with a stability study and some applications. This volume ends up with some new techniques and methods applied in fractional calculus. This volume will be followed up by a second volume that focuses on the applications of fractional calculus in several engineering domains.

Fractional Calculus: Theory and Applications Jan 05 2023 Fractional calculus falls under the domain of mathematical analysis. It focuses on the study of the differentiation operator in terms of real and complex number powers. Fractional calculus has various applications across other scientific fields such as polymer chemistry through structural damping models, in quantum theory through the analysis of Schrödinger's equation, etc. This book elucidates new techniques and their applications in a multidisciplinary manner. The chapters provide significant information of this field to help develop a good understanding of fractional calculus and related fields. It also attempts to understand the multiple branches that fall under this discipline and how such concepts have practical applications. It aims to serve as a resource guide for students and experts alike as well as contribute to the growth of the discipline.

General Fractional Derivatives Feb 06 2023 *General Fractional Derivatives: Theory, Methods and Applications* provides knowledge of the special functions with respect to another function, and the integro-differential operators where the integrals are of the convolution type and exist the singular, weakly singular and nonsingular kernels, which exhibit the fractional derivatives, fractional integrals, general fractional derivatives, and general fractional integrals of the constant and variable order without and with respect to another function due to the appearance of the power-law and complex herbivores to figure out the modern developments in theoretical and applied science. Features: Give some new results for fractional calculus of constant and variable orders. Discuss some new definitions for fractional calculus with respect to another function. Provide definitions for general fractional calculus of constant and variable orders. Report new results of general fractional calculus with respect to another function. Propose news special functions with respect to another function and their applications. Present new models for the anomalous relaxation and rheological behaviors. This book serves as a reference book and textbook for scientists and engineers in the fields of mathematics, physics, chemistry and engineering, senior undergraduate and graduate students. Dr. Xiao-Jun Yang is a full professor of Applied Mathematics and Mechanics, at China University of Mining and Technology, China. He is currently an editor of several scientific journals, such as *Fractals*, *Applied Numerical Mathematics*, *Mathematical Modelling and Analysis*, *International Journal of Numerical Methods for Heat & Fluid Flow*, and *Thermal Science*.

An Introduction to the Fractional Calculus and Fractional Differential Equations Jan 25 2022
Commences with the historical development of fractional calculus, its mathematical

theory—particularly the Riemann-Liouville version. Numerous examples and theoretical applications of the theory are presented. Features topics associated with fractional differential equations. Discusses Weyl fractional calculus and some of its uses. Includes selected physical problems which lead to fractional differential or integral equations.

Fractional Differential Equations Mar 27 2022 This book is a landmark title in the continuous move from integer to non-integer in mathematics: from integer numbers to real numbers, from factorials to the gamma function, from integer-order models to models of an arbitrary order. For historical reasons, the word 'fractional' is used instead of the word 'arbitrary'. This book is written for readers who are new to the fields of fractional derivatives and fractional-order mathematical models, and feel that they need them for developing more adequate mathematical models. In this book, not only applied scientists, but also pure mathematicians will find fresh motivation for developing new methods and approaches in their fields of research. A reader will find in this book everything necessary for the initial study and immediate application of fractional derivatives fractional differential equations, including several necessary special functions, basic theory of fractional differentiation, uniqueness and existence theorems, analytical numerical methods of solution of fractional differential equations, and many inspiring examples of applications. A unique survey of many applications of fractional calculus Presents basic theory Includes a unified presentation of selected classical results, which are important for applications Provides many examples Contains a separate chapter of fractional order control systems, which opens new perspectives in control theory The first systematic consideration of Caputo's fractional derivative in comparison with other selected approaches Includes tables of fractional derivatives,

which can be used for evaluation of all considered types of fractional derivatives

Fractional Calculus Jun 17 2021 Fractional calculus is undergoing rapidly and ongoing development. We can already recognize, that within its framework new concepts and strategies emerge, which lead to new challenging insights and surprising correlations between different branches of physics. This book is an invitation both to the interested student and the professional researcher. It presents a thorough introduction to the basics of fractional calculus and guides the reader directly to the current state-of-the-art physical interpretation. It is also devoted to the application of fractional calculus on physical problems, in the subjects of classical mechanics, friction, damping, oscillations, group theory, quantum mechanics, nuclear physics, and hadron spectroscopy up to quantum field theory.

Fractional Calculus and Fractional Differential Equations Oct 22 2021 This book provides a broad overview of the latest developments in fractional calculus and fractional differential equations (FDEs) with an aim to motivate the readers to venture into these areas. It also presents original research describing the fractional operators of variable order, fractional-order delay differential equations, chaos and related phenomena in detail. Selected results on the stability of solutions of nonlinear dynamical systems of the non-commensurate fractional order have also been included. Furthermore, artificial neural network and fractional differential equations are elaborated on; and new transform methods (for example, Sumudu methods) and how they can be employed to solve fractional partial differential equations are discussed. The book covers the latest research on a variety of topics, including: comparison of various numerical methods for solving FDEs, the Adomian decomposition method and its applications to fractional versions of

the classical Poisson processes, variable-order fractional operators, fractional variational principles, fractional delay differential equations, fractional-order dynamical systems and stability analysis, inequalities and comparison theorems in FDEs, artificial neural network approximation for fractional operators, and new transform methods for solving partial FDEs. Given its scope and level of detail, the book will be an invaluable asset for researchers working in these areas.

Fractional differential calculus via fractional difference theory and applications : a non-standard fractional calculus and its applications Oct 14 2023 Contrary to most books on fractional calculus which start with definitions of fractional derivatives in terms of integrals, here one uses a definition expressed as the limit of fractional difference, what allows us to expand the theory step by step exactly like with Leibniz calculus, by handling infinitely small increments. It follows that the physical significance of this calculus sticks to real problems and that, as a result, it is quite suitable (perhaps excellent) in systems modeling. Physical increments have a parlance in modeling which one can find in our fractional calculus, but is nowhere in the definition of fractional derivative via integrals. Last but not least, the book deals with non-differentiable functions, whilst most classical approaches to fractional calculus refer to the Caputo definition which deals with differentiable functions.

Fractional Calculus: An Introduction For Physicists (2nd Edition) Sep 01 2022 The book presents a concise introduction to the basic methods and strategies in fractional calculus and enables the reader to catch up with the state of the art in this field as well as to participate and contribute in the development of this exciting research area. The contents are devoted to the

application of fractional calculus to physical problems. The fractional concept is applied to subjects in classical mechanics, group theory, quantum mechanics, nuclear physics, hadron spectroscopy and quantum field theory and it will surprise the reader with new intriguing insights. This new, extended edition now also covers additional chapters about image processing, folded potentials in cluster physics, infrared spectroscopy and local aspects of fractional calculus. A new feature is exercises with elaborated solutions, which significantly supports a deeper understanding of general aspects of the theory. As a result, this book should also be useful as a supporting medium for teachers and courses devoted to this subject.

Fixed Point Theory and Fractional Calculus Apr 27 2022 This book collects chapters on fixed-point theory and fractional calculus and their applications in science and engineering. It discusses state-of-the-art developments in these two areas through original new contributions from scientists across the world. It contains several useful tools and techniques to develop their skills and expertise in fixed-point theory and fractional calculus. New research directions are also indicated in chapters. This book is meant for graduate students and researchers willing to expand their knowledge in these areas. The minimum prerequisite for readers is the graduate-level knowledge of analysis, topology and functional analysis.

Fractional Calculus and Its Applications Feb 11 2021

Theory and Applications of Fractional Differential Equations May 29 2022 This work aims to present, in a systematic manner, results including the existence and uniqueness of solutions for the Cauchy Type and Cauchy problems involving nonlinear ordinary fractional differential equations.

Fractional Calculus Jan 17 2024 FRACTIONAL CALCULUS: Theory and Applications deals with differentiation and integration of arbitrary order. The origin of this subject can be traced back to the end of seventeenth century, the time when Newton and Leibniz developed foundations of differential and integral calculus. Nonetheless, utility and applicability of FC to various branches of science and engineering have been realized only in last few decades. Recent years have witnessed tremendous upsurge in research activities related to the applications of FC in modeling of real-world systems. Unlike the derivatives of integral order, the non-local nature of fractional derivatives correctly models many natural phenomena containing long memory and give more accurate description than their integer counterparts. The present book comprises of contributions from academicians and leading researchers and gives a panoramic overview of various aspects of this subject: Introduction to Fractional Calculus Fractional Differential Equations Fractional Ordered Dynamical Systems Fractional Operators on Fractals Local Fractional Derivatives Fractional Control Systems Fractional Operators and Statistical Distributions Applications to Engineering

Fractional Calculus Feb 18 2024 The first volume of this two-volume book, presents history, the mathematical modelling and the applications of fractional order systems, and contains mathematical and theoretical studies and research related to this domain. This volume is made up of 11 chapters. The first chapter presents an analysis of the Caputo derivative and the pseudo state representation with the infinite state approach. The second chapter studies the stability of a class of fractional Cauchy problems. The third chapter shows how to solve fractional order differential equations and fractional order partial differential equations using modern matrix

algebraic approaches. Following this chapter, chapter four proposes another analytical method to solve differential equations with local fractional derivative operators. Concerning chapter five, it presents the extended Borel transform and its related fractional analysis. After presenting the analytical resolution methods for fractional calculus, chapter six shows the essentials of fractional calculus on discrete settings. The initialisation of such systems is shown in chapter seven. In fact, this chapter presents a generalised application of the Hankel operator for initialisation of fractional order systems. The last four chapters show some new studies and applications of non-integer calculus. In fact, chapter eight presents the fractional reaction-transport equations and evanescent continuous time random walks. Chapter nine shows a novel approach in the exponential integrators for fractional differential equations. Chapter ten presents the non-fragile tuning of fractional order PD controllers for integrating time delay systems. At the end, chapter eleven proposes a discrete finite-dimensional approximation of linear infinite dimensional systems. To sum up, this volume presents a mathematical and theoretical study of fractional calculus along with a stability study and some applications. This volume ends up with some new techniques and methods applied in fractional calculus. This volume will be followed up by a second volume that focuses on the applications of fractional calculus in several engineering domains.

Fractional Differential Equations Jul 31 2022 Fractional Differential Equations: Theoretical Aspects and Applications presents the latest mathematical and conceptual developments in the field of Fractional Calculus and explores the scope of applications in research science and computational modelling. Fractional derivatives arise as a generalization of integer order

derivatives and have a long history: their origin can be found in the work of G. W. Leibniz and L. Euler. Shortly after being introduced, the new theory turned out to be very attractive for many famous mathematicians and scientists, including P. S. Laplace, B. Riemann, J. Liouville, N. H. Abel, and J. B. J. Fourier, due to the numerous possibilities it offered for applications. Fractional Calculus, the field of mathematics dealing with operators of differentiation and integration of arbitrary real or even complex order, extends many of the modelling capabilities of conventional calculus and integer-order differential equations and finds its application in various scientific areas, such as physics, mechanics, engineering, economics, finance, biology, and chemistry, among others. However, many aspects from the theoretical and practical point of view have still to be developed in relation with models based on fractional operators. Efficient analytical and numerical methods have been developed but still need particular attention. Fractional Differential Equations: Theoretical Aspects and Applications delves into these methods and applied computational modelling techniques, including analysis of equations involving fractional derivatives, fractional derivatives and the wave equation, analysis of FDE on groups, direct and inverse problems, functional inequalities, and computational methods for FDEs in physics and engineering. Other modelling techniques and applications explored by the authors include general fractional derivatives involving the special functions in analysis, fractional derivatives with respect to another function in analysis, new fractional operators in real-world applications, fractional order dynamical systems, hidden attractors in complex systems, nonlinear dynamics and chaos in engineering applications, quantum chaos, and self-excited attractors. Provides the most recent and up-to-date developments in the theory and scientific applications Fractional

Differential Equations Includes transportable computer source codes for readers in MATLAB, with code descriptions as it relates to the mathematical modelling and applications Provides readers with a comprehensive foundational reference for this key topic in computational modeling, which is a mathematical underpinning for most areas of scientific and engineering research

The Fractional Calculus Theory and Applications of Differentiation and Integration to Arbitrary Order Jun 22 2024 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, - Non-Lagrange interpolation, - Generic Karhunen-Loeve transform - Generalised low-rank matrix approximation - Optimal data compression - Optimal nonlinear filtering

Theory and Numerical Approximations of Fractional Integrals and Derivatives Dec 16

2023 Due to its ubiquity across a variety of fields in science and engineering, fractional calculus has gained momentum in industry and academia. While a number of books and papers introduce either fractional calculus or numerical approximations, no current literature provides a comprehensive collection of both topics. This monograph introduces fundamental information on fractional calculus, provides a detailed treatment of existing numerical approximations, and presents an inclusive review of fractional calculus in terms of theory and numerical methods and systematically examines almost all existing numerical approximations for fractional integrals and derivatives. The authors consider the relationship between the fractional Laplacian and the Riesz derivative, a key component absent from other related texts, and highlight recent developments, including their own research and results. The core audience spans several fractional communities, including those interested in fractional partial differential equations, the fractional Laplacian, and applied and computational mathematics. Advanced undergraduate and graduate students will find the material suitable as a primary or supplementary resource for their studies.

Fractional Calculus: Theory and Applications Apr 20 2024 This book is a printed edition of the Special Issue "Fractional Calculus: Theory and Applications" that was published in *Mathematics*

Functional Fractional Calculus for System Identification and Controls May 17 2021 In this

book, not only are mathematical abstractions discussed in a lucid manner, but also several practical applications are given particularly for system identification, description and then efficient controls. The reader gets a feeling of the wide applicability of fractional calculus in the field of science and engineering. With this book, a starter can understand the concepts of this

emerging field with a minimal effort and basic mathematics.

Discrete Fractional Calculus and Fractional Difference Equations Jun 29 2022 This brief aims to merge the theories of fractional calculus and discrete calculus in a concise but comprehensive manner. It is designed for graduate students, but will be useful for any researcher interested in the theory of discrete fractional calculus and fractional difference equations.

Theory and Applications of Non-integer Order Systems Feb 23 2022 This book collects papers from the 8th Conference on Non-Integer Order Calculus and Its Applications that have been held on September 20-21, 2016 in Zakopane, Poland. The preceding two conferences were held in Szczecin, Poland in 2015, and in Opole, Poland, in 2014. This conference provides a platform for academic exchange on the theory and application of fractional calculus between domestic and international universities, research institutes, corporate experts and scholars. The Proceedings of the 8th Conference on Non-Integer Order Calculus and Its Applications 2016 brings together rigorously reviewed contributions from leading international experts. The included papers cover novel various important aspects of mathematical foundations of fractional calculus, modeling and control of fractional systems as well as controllability, detectability, observability and stability problems for this systems.

Basic Theory Of Fractional Differential Equations (Third Edition) Mar 19 2024 This accessible monograph is devoted to a rapidly developing area on the research of qualitative theory of fractional ordinary differential equations and evolution equations. It is self-contained and unified in presentation, and provides the readers the necessary background material required to go further into the subject and explore the rich research literature. The tools used include many

classical and modern nonlinear analysis methods such as fixed point theory, measure of noncompactness method, topological degree method, Picard operators technique, critical point theory and semigroups theory. This book is based on the research work done so far by the author and other experts, and contains comprehensive up-to-date materials on the topic. In this third edition, four new topics have been added: Hilfer fractional evolution equations and infinite interval problems, oscillations and nonoscillations, fractional Hamiltonian systems, fractional Rayleigh-Stokes equations, and wave equations. The bibliography has also been updated and expanded. This book is useful to researchers, graduate or PhD students dealing with fractional calculus and applied analysis, differential equations, and related areas of research.

Fractional Calculus Sep 20 2021 Deals with differentiation and integration of arbitrary order. The book comprises contributions from academics and leading researchers and gives a panoramic overview of various aspects of the subject.

Fractional Calculus Aug 20 2021 This book will give readers the possibility of finding very important mathematical tools for working with fractional models and solving fractional differential equations, such as a generalization of Stirling numbers in the framework of fractional calculus and a set of efficient numerical methods. Moreover, we will introduce some applied topics, in particular fractional variational methods which are used in physics, engineering or economics. We will also discuss the relationship between semi-Markov continuous-time random walks and the space-time fractional diffusion equation, which generalizes the usual theory relating random walks to the diffusion equation. These methods can be applied in finance, to model tick-by-tick (log)-price fluctuations, in insurance theory, to study ruin, as well as in

macroeconomics as prototypical growth models. All these topics are complementary to what is dealt with in existing books on fractional calculus and its applications. This book will keep in mind the trade-off between full mathematical rigor and the needs of readers coming from different applied areas of science and engineering. In particular, the numerical methods listed in the book are presented in a readily accessible way that immediately allows the readers to implement them on a computer in a programming language of their choice. The second edition of the book has been expanded and now includes a discussion of additional, newly developed numerical methods for fractional calculus and a chapter on the application of fractional calculus for modeling processes in the life sciences.

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