

# Fractional Dynamics Applications Of Fractional Calculus To Dynamics Of Particles Fields And Media Nonlinear Physical Science

*Advances in Fractional Calculus* The Variable-Order Fractional Calculus of Variations **Handbook of Fractional Calculus for Engineering and Science** Functional Fractional Calculus for System Identification and Controls Solved Exercises in Fractional Calculus Applications of Fractional Calculus in Physics **q-Fractional Calculus and Equations** **Fractional Dynamics** **Fractional Derivatives for Physicists and Engineers** Numerical Methods for Fractional Calculus Fractional Calculus for Scientists and Engineers **Fractional Calculus and Its Applications** The Fractional Calculus Theory and Applications of Differentiation and Integration to Arbitrary Order Discrete Fractional Calculus **Stochastic Models for Fractional Calculus** **Fractional Calculus for Hydrology, Soil Science and Geomechanics** Functional Fractional Calculus Fractional Calculus Fractional Calculus with Applications in Mechanics **Fractional Order Analysis** **General Fractional Derivatives** Fractional Calculus: Theory and Applications **Fractional Calculus and Fractional Processes with Applications to Financial Economics** Univalent Functions, Fractional Calculus, and Their Applications Fractional Calculus **Fractional Calculus with Applications for Nuclear Reactor Dynamics** **Operators of Fractional Calculus and Their Applications** Applications of Fractional Calculus to Modeling in Dynamics and Chaos Mathematical Economics **Generalized Fractional Calculus** Fractional Calculus in Medical and Health Science **Fractional Differential Equations** New Trends in Nanotechnology and Fractional Calculus Applications Fractional Calculus Handbook of Fractional Calculus for Engineering and Science **Fixed Point Theory and Fractional Calculus** Fractional Dynamics **Fractional Calculus and Waves in Linear Viscoelasticity** **Fractional Calculus View of Complexity** Fractional Differential Equations

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**Fractional Calculus with Applications for Nuclear Reactor Dynamics** Sep 13 2020 Introduces Novel Applications for Solving Neutron Transport Equations While deemed nonessential in the past, fractional calculus is now gaining momentum in the science and engineering community. Various disciplines have discovered that realistic models of physical phenomenon can be achieved with fractional

calculus and are using them in numerous ways. Since fractional calculus represents a reactor more closely than classical integer order calculus, Fractional Calculus with Applications for Nuclear Reactor Dynamics focuses on the application of fractional calculus to describe the physical behavior of nuclear reactors. It applies fractional calculus to incorporate the mathematical methods used to analyze the diffusion theory model of neutron transport and

explains the role of neutron transport in reactor theory. The author discusses fractional calculus and the numerical solution for fractional neutron point kinetic equation (FNPKE), introduces the technique for efficient and accurate numerical computation for FNPKE with different values of reactivity, and analyzes the fractional neutron point kinetic (FNPKE) model for the dynamic behavior of neutron motion. The book begins with an overview of nuclear reactors, explains how nuclear energy is extracted from reactors, and explores the behavior of neutron density using reactivity functions. It also demonstrates the applicability of the Haar wavelet method and introduces the neutron diffusion concept to aid readers in understanding the complex behavior of average neutron motion. This text: Applies the effective analytical and numerical methods to obtain the solution for the NDE Determines the numerical solution for one-group delayed neutron FNPKE by the explicit finite difference method Provides the numerical solution for classical as well as fractional neutron point kinetic equations Proposes the Haar wavelet operational method (HWOM) to obtain the numerical approximate solution of the neutron point kinetic equation, and more Fractional Calculus with Applications for Nuclear Reactor Dynamics thoroughly and systematically presents the concepts of fractional calculus and emphasizes the relevance of its application to the nuclear reactor.

The Fractional Calculus Theory and Applications of Differentiation and Integration to Arbitrary Order Oct 27 2021 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

**Fractional Derivatives for Physicists and Engineers** Feb 28 2022 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.

Mathematical Economics Jun 10 2020 This book

is devoted to the application of fractional calculus in economics to describe processes with memory and non-locality. Fractional calculus is a branch of mathematics that studies the properties of differential and integral operators that are characterized by real or complex orders. Fractional calculus methods are powerful tools for describing the processes and systems with memory and nonlocality. Recently, fractional integro-differential equations have been used to describe a wide class of economical processes with power law memory and spatial nonlocality. Generalizations of basic economic concepts and notions the economic processes with memory were proposed. New mathematical models with continuous time are proposed to describe economic dynamics with long memory. This book is a collection of articles reflecting the latest mathematical and conceptual developments in mathematical economics with memory and non-locality based on applications of fractional calculus.

Univalent Functions, Fractional Calculus, and Their Applications Nov 15 2020

### **Stochastic Models for Fractional Calculus**

Aug 25 2021 Fractional calculus is a rapidly growing field of research, at the interface between probability, differential equations, and mathematical physics. It is used to model anomalous diffusion, in which a cloud of particles spreads in a different manner than traditional diffusion. This monograph develops the basic theory of fractional calculus and anomalous diffusion, from the point of view of probability. In this book, we will see how fractional calculus and anomalous diffusion can be understood at a deep and intuitive level, using ideas from probability. It covers basic limit theorems for random variables and random vectors with heavy tails. This includes regular variation, triangular arrays, infinitely divisible laws, random walks, and stochastic process convergence in the Skorokhod topology. The basic ideas of fractional calculus and anomalous diffusion are closely connected with heavy tail limit theorems. Heavy tails are applied in finance, insurance, physics, geophysics, cell biology, ecology, medicine, and computer engineering. The goal of this book is to prepare graduate students in probability for research in the area of fractional calculus, anomalous

diffusion, and heavy tails. Many interesting problems in this area remain open. This book will guide the motivated reader to understand the essential background needed to read and understand current research papers, and to gain the insights and techniques needed to begin making their own contributions to this rapidly growing field.

Fractional Calculus Jan 06 2020 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

### **Generalized Fractional Calculus** May 10 2020

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.

Handbook of Fractional Calculus for Engineering and Science Dec 05 2019 Fractional calculus is used to model many real-life situations from science and engineering. The book includes different topics associated with such equations and their relevance and significance in various scientific areas of study and research. In this book readers will find several important and useful methods and techniques for solving various types of fractional-order models in science and engineering. The book should be useful for graduate students, PhD students, researchers and educators interested in mathematical modelling, physical sciences, engineering sciences, applied mathematical sciences, applied sciences, and so on. This Handbook: Provides reliable methods for solving fractional-order models in science and engineering. Contains efficient numerical methods and algorithms for engineering-related equations. Contains comparison of various methods for accuracy and validity. Demonstrates the applicability of fractional calculus in science and engineering. Examines qualitative as well as quantitative properties of solutions of various types of science- and engineering-related equations. Readers will find this book to be useful and valuable in increasing and updating their knowledge in this field and will be it will be helpful for engineers, mathematicians, scientist and researchers working on various real-life problems.

**q-Fractional Calculus and Equations** May 02 2022 This nine-chapter monograph introduces a rigorous investigation of q-difference operators in standard and fractional settings. It starts with elementary calculus of q-differences and integration of Jackson's type before turning to q-difference equations. The existence and uniqueness theorems are derived using successive approximations, leading to systems of equations with retarded arguments. Regular q-Sturm-Liouville theory is also introduced; Green's function is constructed and the eigenfunction expansion theorem is given. The monograph also discusses some integral equations of Volterra and Abel type, as introductory material for the study of fractional q-calculi. Hence fractional q-calculi of the types Riemann-Liouville; Grünwald-Letnikov; Caputo; Erdélyi-Kober and Weyl are defined analytically. Fractional q-Leibniz rules with applications in q-series are also obtained with rigorous proofs of the formal results of Al-Salam-Verma, which remained unproved for decades. In working towards the investigation of q-fractional difference equations; families of q-Mittag-Leffler functions are defined and their properties are investigated, especially the q-Mellin-Barnes integral and Hankel contour integral representation of the q-Mittag-Leffler functions under consideration, the distribution, asymptotic and reality of their zeros, establishing q-counterparts of Wiman's results. Fractional q-difference equations are studied; existence and uniqueness theorems are given and classes of Cauchy-type problems are completely solved in terms of families of q-Mittag-Leffler functions. Among many q-analogs of classical results and concepts, q-Laplace, q-Mellin and  $q_2$ -Fourier transforms are studied and their applications are investigated.

**Fractional Calculus View of Complexity** Aug 01 2019 This book is not a text devoted to a pedagogical presentation of a specialized topic nor is it a monograph focused on the author's area of research. It accomplishes both these things while providing a rationale for why the reader ought to be interested in learning about fractional calculus. This book is for researchers who has heard about many  
*Discrete Fractional Calculus* Sep 25 2021 This text provides the first comprehensive treatment

of the discrete fractional calculus. Experienced researchers will find the text useful as a reference for discrete fractional calculus and topics of current interest. Students who are interested in learning about discrete fractional calculus will find this text to provide a useful starting point. Several exercises are offered at the end of each chapter and select answers have been provided at the end of the book. The presentation of the content is designed to give ample flexibility for potential use in a myriad of courses and for independent study. The novel approach taken by the authors includes a simultaneous treatment of the fractional- and integer-order difference calculus (on a variety of time scales, including both the usual forward and backwards difference operators). The reader will acquire a solid foundation in the classical topics of the discrete calculus while being introduced to exciting recent developments, bringing them to the frontiers of the subject. Most chapters may be covered or omitted, depending upon the background of the student. For example, the text may be used as a primary reference in an introductory course for difference equations which also includes discrete fractional calculus. Chapters 1–2 provide a basic introduction to the delta calculus including fractional calculus on the set of integers. For courses where students already have background in elementary real analysis, Chapters 1–2 may be covered quickly and readers may then skip to Chapters 6–7 which present some basic results in fractional boundary value problems (FBVPs). Chapters 6–7 in conjunction with some of the current literature listed in the Bibliography can provide a basis for a seminar in the current theory of FBVPs. For a two-semester course, Chapters 1–5 may be covered in depth, providing a very thorough introduction to both the discrete fractional calculus as well as the integer-order calculus.

*Fractional Calculus with Applications in Mechanics* Apr 20 2021 The books *Fractional Calculus with Applications in Mechanics: Vibrations and Diffusion Processes* and *Fractional Calculus with Applications in Mechanics: Wave Propagation, Impact and Variational Principles* contain various applications of fractional calculus to the fields of

classical mechanics. Namely, the books study problems in fields such as viscoelasticity of fractional order, lateral vibrations of a rod of fractional order type, lateral vibrations of a rod positioned on fractional order viscoelastic foundations, diffusion-wave phenomena, heat conduction, wave propagation, forced oscillations of a body attached to a rod, impact and variational principles of a Hamiltonian type. The books will be useful for graduate students in mechanics and applied mathematics, as well as for researchers in these fields. Part 1 of this book presents an introduction to fractional calculus. Chapter 1 briefly gives definitions and notions that are needed later in the book and Chapter 2 presents definitions and some of the properties of fractional integrals and derivatives. Part 2 is the central part of the book. Chapter 3 presents the analysis of waves in fractional viscoelastic materials in infinite and finite spatial domains. In Chapter 4, the problem of oscillations of a translatory moving rigid body, attached to a heavy, or light viscoelastic rod of fractional order type, is studied in detail. In Chapter 5, the authors analyze a specific engineering problem of the impact of a viscoelastic rod against a rigid wall. Finally, in Chapter 6, some results for the optimization of a functional containing fractional derivatives of constant and variable order are presented.

*Numerical Methods for Fractional Calculus* Jan 30 2022 *Numerical Methods for Fractional Calculus* presents numerical methods for fractional integrals and fractional derivatives, finite difference methods for fractional ordinary differential equations (FODEs) and fractional partial differential equations (FPDEs), and finite element methods for FPDEs. The book introduces the basic definitions and properties

**Fractional Dynamics** Apr 01 2022 The book is devoted to recent developments in the theory of fractional calculus and its applications.

Particular attention is paid to the applicability of this currently popular research field in various branches of pure and applied mathematics. In particular, the book focuses on the more recent results in mathematical physics, engineering applications, theoretical and applied physics as quantum mechanics, signal analysis, and in those relevant research fields where nonlinear dynamics occurs and several tools of nonlinear

analysis are required. Dynamical processes and dynamical systems of fractional order attract researchers from many areas of sciences and technologies, ranging from mathematics and physics to computer science.

Fractional Calculus May 22 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.

*Applications of Fractional Calculus in Physics* Jun 03 2022 Fractional calculus is a collection of relatively little-known mathematical results concerning generalizations of differentiation and integration to noninteger orders. While these results have been accumulated over centuries in various branches of mathematics, they have until recently found little appreciation or application in physics and other mathematically oriented sciences. This situation is beginning to change, and there are now a growing number of research areas in physics which employ fractional calculus. This volume provides an introduction to fractional calculus for physicists, and collects easily accessible review articles surveying those areas of physics in which applications of fractional calculus have recently become prominent. Contents: An Introduction to Fractional Calculus (P L Butzer & U Westphal) Fractional Time Evolution (R Hilfer) Fractional Powers of Infinitesimal Generators of Semigroups (U Westphal) Fractional Differences, Derivatives and Fractal Time Series (B J West & P Grigolini) Fractional Kinetics of Hamiltonian Chaotic Systems (G M Zaslavsky) Polymer Science Applications of Path-Integration, Integral Equations, and Fractional Calculus (J F

Douglas) Applications to Problems in Polymer Physics and Rheology (H Schiessel et al.) Applications of Fractional Calculus Techniques to Problems in Biophysics (T F Nonnenmacher & R Metzler) Fractional Calculus and Regular Variation in Thermodynamics (R Hilfer) Readership: Statistical, theoretical and mathematical physicists. Keywords: Fractional Calculus in Physics Reviews: "This monograph provides a systematic treatment of the theory and applications of fractional calculus for physicists. It contains nine review articles surveying those areas in which fractional calculus has become important. All the chapters are self-contained." Mathematics Abstracts Functional Fractional Calculus for System Identification and Controls Aug 05 2022 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.

**General Fractional Derivatives** Feb 16 2021 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*.

***Solved Exercises in Fractional Calculus*** Jul 04 2022 This book contains a brief historical introduction and state of the art in fractional calculus. The author introduces some of the so-called special functions, in particular, those which will be directly involved in calculations. The concepts of fractional integral and fractional derivative are also presented. Each chapter, except for the first one, contains a list of exercises containing suggestions for solving them and at last the resolution itself. At the end of those chapters there is a list of complementary exercises. The last chapter presents several applications of fractional calculus.

***Handbook of Fractional Calculus for Engineering and Science*** Sep 06 2022 The book includes contributions by top researchers offering topics associated with equations and their relevance and significance in various scientific areas of study and research. The readers will find several important and useful methods and techniques for solving various types of fractional-order models in engineering and science.

***Fractional Differential Equations*** Mar 08 2020 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.

***New Trends in Nanotechnology and Fractional Calculus Applications*** Feb 05 2020 In recent years fractional calculus has played an important role in various fields such as mechanics, electricity, chemistry, biology, economics, modeling, identification, control theory and signal processing. The scope of this book is to present the state of the art in the study of fractional systems and the application of fractional differentiation. Furthermore, the manufacture of nanowires is important for the design of nanosensors and the development of high-yield thin films is vital in procuring clean solar energy. This wide range of applications is of interest to engineers, physicists and mathematicians.

***Fractional Order Analysis*** Mar 20 2021 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.

**Fractional Calculus and Its Applications** Nov 27 2021

**Operators of Fractional Calculus and Their Applications** Aug 13 2020 This book is a printed edition of the Special Issue "Operators of Fractional Calculus and Their Applications" that was published in Mathematics

**Fractional Calculus and Waves in Linear Viscoelasticity** Sep 01 2019 This book is likely to be of interest to applied scientists and engineers. --Book Jacket.

**Fractional Calculus and Fractional Processes with Applications to Financial Economics** Dec 17 2020 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 Differential Equations** Jun 30 2019

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 second volume collects authoritative chapters covering the mathematical theory of fractional calculus, including ordinary and partial differential equations of fractional order, inverse problems, and evolution equations.

**Fractional Calculus in Medical and Health Science** Apr 08 2020 This book covers applications of fractional calculus used for medical and health science. It offers a collection of research articles built into chapters on classical and modern dynamical systems formulated by fractional differential equations describing human diseases and how to control them. The mathematical results included in the book will be helpful to mathematicians and doctors by enabling them to explain real-life problems accurately. The book will also offer case studies of real-life situations with an emphasis on describing the mathematical results and showing how to apply the results to medical and health science, and at the same time highlighting modeling strategies. The book will be useful to graduate level students, educators and researchers interested in mathematics and medical science.

**Fractional Calculus: Theory and Applications** Jan 18 2021

**Fixed Point Theory and Fractional Calculus** Nov 03 2019 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* Oct 15 2020 This title 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.

Fractional Calculus for Scientists and Engineers Dec 29 2021 This book gives a practical overview of Fractional Calculus as it relates to Signal Processing

*Advances in Fractional Calculus* Nov 08 2022 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.

Applications of Fractional Calculus to Modeling in Dynamics and Chaos Jul 12 2020 Applications of Fractional Calculus to Modeling in Dynamics and Chaos aims to present novel developments, trends, and applications of fractional-order derivatives with power law and Mittag-Leffler kernel in the areas of chemistry, mechanics, chaos, epidemiology, fluid mechanics, modeling, and engineering. Non-singular and non-local fractional-order derivatives have been applied in different chapters to describe complex problems. The book offers theory and practical applications for the solutions of real-life problems and will be of interest to graduate-level students, educators, researchers, and scientists interested in

mathematical modeling and its diverse applications. Features Discusses real-world problems, theory, and applications Covers new developments and advances in the various areas of nonlinear dynamics, signal processing, and chaos Suitable to teach master's and/or PhD-level graduate students, and can be used by researchers, from any field of the social, health, and physical sciences

**Fractional Calculus for Hydrology, Soil Science and Geomechanics** Jul 24 2021 This book is an unique integrated treatise, on the concepts of fractional calculus as models with applications in hydrology, soil science and geomechanics. The models are primarily fractional partial differential equations (fPDEs), and in limited cases, fractional differential equations (fDEs). It develops and applies relevant fPDEs and fDEs mainly to water flow and solute transport in porous media and overland, and in some cases, to concurrent flow and energy transfer. It is an integrated resource with theory and applications for those interested in hydrology, hydraulics and fluid mechanics. The self-contained book summarizes the fundamentals for porous media and essential mathematics with extensive references supporting the development of the model and applications.

*Functional Fractional Calculus* Jun 22 2021 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 Dynamics Oct 03 2019 "Fractional Dynamics: Applications of Fractional Calculus to Dynamics of Particles, Fields and Media"

presents applications of fractional calculus, integral and differential equations of non-integer orders in describing systems with long-time memory, non-local spatial and fractal properties. Mathematical models of fractal media and distributions, generalized dynamical systems and discrete maps, non-local statistical mechanics and kinetics, dynamics of open quantum systems, the hydrodynamics and electrodynamics of complex media with non-local properties and memory are considered. This book is intended to meet the needs of scientists and graduate students in physics, mechanics and applied mathematics who are interested in electrodynamics, statistical and condensed matter physics, quantum dynamics, complex media theories and kinetics, discrete maps and lattice models, and nonlinear dynamics and chaos. Dr. Vasily E. Tarasov is a Senior Research Associate at Nuclear Physics Institute of Moscow State University and an Associate Professor at Applied Mathematics and Physics Department of Moscow Aviation Institute.

The Variable-Order Fractional Calculus of Variations Oct 07 2022 The Variable-Order Fractional Calculus of Variations is devoted to the study of fractional operators with variable order and, in particular, variational problems involving variable-order operators. This brief presents a new numerical tool for the solution of differential equations involving Caputo derivatives of fractional variable order. Three Caputo-type fractional operators are considered, and for each one, an approximation formula is obtained in terms of standard (integer-order) derivatives only. Estimations for the error of the approximations are also provided. The contributors consider variational problems that may be subject to one or more constraints, where the functional depends on a combined Caputo derivative of variable fractional order. In particular, they establish necessary optimality conditions of Euler-Lagrange type. As the terminal point in the cost integral is free, as is the terminal state, transversality conditions are also obtained. The Variable-Order Fractional Calculus of Variations is a valuable source of information for researchers in mathematics, physics, engineering, control and optimization; it provides both analytical and numerical methods

to deal with variational problems. It is also of interest to academics and postgraduates in these

fields, as it solves multiple variational problems subject to one or more constraints in a single brief.