

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

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Fractional Dynamics Carlo Cattani 2015-01-01 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 Dynamics Carlo Cattani 2015-12 This title 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.

New Trends in Nanotechnology and Fractional Calculus Applications Dumitru Baleanu 2010-03-14 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 Modeling of Dynamic Systems with Applications in Optimization, Signal Processing, and Control Ahmed G. Radwan 2021-10-29 Fractional-order Modelling of Dynamic Systems with Applications in Optimization, Signal Processing and Control introduces applications from a design perspective, helping readers plan and design their own applications. The book includes the different techniques employed to design fractional-order systems/devices comprehensively and straightforwardly. Furthermore, mathematics is available in the literature on how to solve fractional-order calculus for system applications. This book introduces the mathematics that has been employed explicitly for fractional-order systems. It will prove an excellent material for students and scholars who want to quickly understand the field of fractional-order systems and contribute to its different domains and applications. Fractional-order systems are believed to play an essential role in our day-to-day activities. Therefore, several researchers around the globe endeavor to work in the different domains of fractional-order systems. The efforts include developing the mathematics to solve fractional-order calculus/systems and to achieve the feasible designs for various applications of fractional-order systems. Presents a simple and comprehensive understanding of the field of fractional-order systems Offers practical knowledge on the design of fractional-order systems for different applications Exposes users to possible new applications for fractional-order systems

Fractional Calculus and its Applications in Physics Dumitru Baleanu 2019-11-15

Fractional Calculus and Its Applications B. Ross 2006-11-15

Fractional Calculus Roy Abi Zeid Daou 2014-11-15 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 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.

Economic Dynamics with Memory Vasily E. Tarasov 2021-01-18 This book presents the applications of fractional calculus, fractional operators of non-integer orders and fractional differential equations in describing economic dynamics with long memory. Generalizations of basic economic concepts, notions and methods for the economic processes with memory are suggested. New micro and macroeconomic models with continuous time are proposed to describe the fractional economic dynamics with long memory as well.

Fractional Differential Equations Anatoly Kochubei 2019-03-27 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 Devendra Kumar 2020-06-25 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.

The Fractional Calculus Theory and Applications of Differentiation and Integration to Arbitrary Order 1974-09-05 In this book, we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems. A number of computing techniques are considered, such as methods of operator approximation with any given accuracy; operator interpolation techniques including a non-Lagrange interpolation; methods of system representation subject to constraints associated with concepts of causality, memory and stationarity; methods of system representation with an accuracy that is the best within a given class of models; methods of covariance matrix estimation; methods for low-rank matrix approximations; hybrid methods based on a combination of iterative procedures and best operator approximation; and methods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory. As a result, the book represents a blend of new methods in general computational analysis, and specific, but also generic, techniques for study of systems theory ant its particular branches, such as optimal filtering and information compression. - Best operator approximation, - Non-Lagrange interpolation, - Generic Karhunen-Loeve transform - Generalised low-rank matrix approximation - Optimal data compression - Optimal nonlinear filtering

Theory and Applications of Fractional Differential Equations A.A. Kilbas 2006-03-02 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.

Applications in Physics Vasily E. Tarasov 2019-02-19 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 fourth volume collects authoritative chapters covering several applications of fractional calculus in physics, including classical and continuum mechanics.

Fractional Calculus Dumitru Baleanu 2016-09-15 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.

Fractional Order Analysis Hemen Dutta 2020-09-01 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 Dynamics and Control Dumitru Baleanu 2011-11-19 Fractional Dynamics and Control provides a comprehensive overview of recent advances in the areas of nonlinear dynamics, vibration and control with analytical, numerical, and experimental results. This book provides an overview of recent discoveries in fractional control, delves into fractional variational principles and differential equations, and applies advanced techniques in fractional calculus to solving complicated mathematical and physical problems. Finally, this book also discusses the role that fractional order modeling can play in complex systems for engineering and science.

Applications of Fractional Calculus to Modeling in Dynamics and Chaos Taylor & Francis Group 2022-06-21 This book 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.

Handbook of Fractional Calculus for Engineering and Science Taylor & Francis Group 2022-02-17 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.

Mathematical Economics Vasily E. Tarasov 2020-06-03 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.

Theory And Applications of Fractional Differential Equations A. Anatoli Aleksandrovich Kilbas 2006 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 uses 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!

New Trends in Fractional Differential Equations with Real-World Applications in Physics Jagdev Singh 2020-12-30

Intelligent Numerical Methods: Applications to Fractional Calculus George A. Anastassiou 2015-12-07 In this monograph the authors present Newton-type, Newton-like and other numerical methods, which involve fractional derivatives and fractional integral operators, for the first time studied in the literature. All for the purpose to solve numerically equations whose associated functions can be also non-differentiable in the ordinary sense. That is among others extending the classical Newton method theory which requires usual differentiability of function. Chapters are self-contained and can be read independently and several advanced courses can be taught out of this book. An extensive list of references is given per chapter. The book's results are expected to find applications in many areas of applied mathematics, stochastics, computer science and engineering. As such this monograph is suitable for researchers, graduate students, and seminars of the above subjects, also to be in all science and engineering libraries.

Advanced Applications of Fractional Differential Operators to Science and Technology Matouk, Ahmed Ezzat 2020-04-24 Fractional-order calculus dates to the 19th century but has been resurrected as a prevalent research subject due to its provision of more adequate and realistic descriptions of physical aspects within the science and engineering fields. What was once a classical form of mathematics is currently being reintroduced as a new modeling technique that engineers and scientists are finding modern uses for. There is a need for research on all facets of these fractional-order systems and studies of its potential applications. Advanced Applications of Fractional Differential Operators to Science and Technology provides emerging research exploring the theoretical and practical aspects of novel fractional modeling and related dynamical behaviors as well as its applications within the fields of physical sciences and engineering. Featuring coverage on a broad range of topics such as chaotic dynamics, ecological models, and bifurcation control, this book is ideally designed for engineering professionals, mathematicians, physicists, analysts, researchers, educators, and students seeking current research on fractional calculus and other applied mathematical modeling techniques.

Fractional Calculus Dumitru Baleanu 2012 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 with Applications in Mechanics Teodor M. Atanackovic 2014-02-19 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.

Advances on Fractional Inequalities George A. Anastassiou 2011-07-25 Advances on Fractional Inequalities use primarily the Caputo fractional derivative, as the most important in applications, and presents the first fractional differentiation inequalities of Opial type which involves the balanced fractional derivatives. The book continues with right and mixed fractional differentiation Ostrowski inequalities in the univariate and multivariate cases. Next the right and left, as well as mixed, Landau fractional differentiation inequalities in the univariate and multivariate cases are illustrated. Throughout the book many applications are given. Fractional differentiation inequalities are by themselves an important and great mathematical topic for research. Furthermore they have many applications, the most important ones are in establishing uniqueness of solution in fractional differential equations and systems and in fractional partial differential equations. Also they provide upper bounds to the solutions of the above equations. Fractional Calculus has emerged as very useful over the last forty years due to its many applications in almost all applied sciences. This is currently seen in applications in acoustic wave propagation in inhomogeneous porous material, diffusive transport, fluid flow, dynamical processes in self-similar structures, dynamics of earthquakes, optics, geology, viscoelastic materials, bio-sciences, bioengineering, medicine, economics, probability and statistics, astrophysics, chemical engineering, physics, splines, tomography, fluid mechanics, electromagnetic waves, nonlinear control, signal processing, control of power electronic, converters, chaotic dynamics, polymer science, proteins, polymer physics, electrochemistry, statistical physics, rheology, thermodynamics, neural networks, etc. Almost all fields of research in science and engineering use fractional calculus in order to describe results. This book is a part of Fractional Calculus, therefore it is useful for researchers and graduate students for research, seminars and advanced graduate courses, in pure and applied mathematics, engineering and all other applied sciences.

Applications of Fractional Calculus in Physics Rudolf Hilfer 2000 Nine independent treatments that have been only lightly edited to retain the diverse styles and levels of formalization in the different areas of application. A unifying theme is that fractional derivatives arise as the infinitesimal generators of a class of translation-invariant convolution semigroups, which appear universally as attractors for coarse graining procedures or scale change, and are parametrized by a number in the unit interval corresponding to the order of the fractional derivative. After an introduction to fractional calculus, the topics include fractional time evolution, the fractional kinetics of Hamiltonian chaotic systems, and applications to problems in polymer physics and rheology.

Functional Fractional Calculus Shantanu Das 2011-06-01 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 Modeling and Controller Design of Robotic Manipulators Abhaya Pal Singh 2020-10-15 This book at hand is an appropriate addition to the field of fractional calculus applied to control systems. If an engineer or a researcher wishes to delve into fractional-order systems, then this book has many collections of such systems to work upon, and this book also tells the reader about how one can convert an integer-order system into an appropriate fractional-order one through an efficient and simple algorithm. If the reader further wants to explore the controller design for the fractional-order systems, then for them, this book provides a variety of controller design strategies. The use of fractional-order derivatives and integrals in control theory leads to better results than integer-order approaches and hence provides solid motivation for further development of control theory. Fractional-order models are more useful than the integer-order models when accuracy is of paramount importance. Real-time experimental validation of controller design strategies for the fractional-order plants is available. This book is beneficial to the academic institutes for postgraduate and advanced research-level that need a specific textbook on fractional control and its applications in robotic manipulators. The book is also a valuable teaching and learning resource for undergraduate and postgraduate students.

General Fractional Derivatives Xiao-Jun Yang 2019-05-10 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 new 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.

Fractional Calculus and Fractional Differential Equations Varsha Daftardar-Gejji 2019-08-10 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 Calculus in Analysis, Dynamics, and Optimal Control Jacky Cresson 2014-01-01 This book is devoted to applications of fractional calculus in classical fields of mathematics like analysis, dynamics, partial differential equations and optimal control. The first chapter deals with the notion of local fractional derivatives and its applications to the study of regularity and geometry of curves. The second chapter develops the notion of fractional embedding and fractional asymmetric calculus of variations in order to find fractional Lagrangian variational structures for classical dissipative partial differential equations. In continuation of this chapter, a fractional analogue of the classical Pontryagin maximum principle is proved for discrete and continuous fractional optimal control problems. The fourth chapter gives a first mathematical model that allows a rigorous connection to be made between the dynamics of chaotic Hamiltonian systems and fractional dynamics, mixing the previous approaches of G Zaslavsky and R Hilfer. Finally, numerical methods to deal with fractional optimal control problems are discussed and implemented. All the chapters are self-contained and complete proofs are given.

Fractional Dynamics Vasily E. Tarasov 2011-01-04 "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.

Fractional Derivatives with Mittag-Leffler Kernel José Francisco Gómez 2019-02-13 This book offers a timely overview of fractional calculus applications, with a

special emphasis on fractional derivatives with Mittag-Leffler kernel. The different contributions, written by applied mathematicians, physicists and engineers, offers a snapshot of recent research in the field, highlighting the current methodological frameworks together with applications in different fields of science and engineering, such as chemistry, mechanics, epidemiology and more. It is intended as a timely guide and source of inspiration for graduate students and researchers in the above-mentioned areas.

Advances in Synchronization of Coupled Fractional Order Systems Rafael Martínez-Guerra 2018-07-23 After a short introduction to the fundamentals, this book provides a detailed account of major advances in applying fractional calculus to dynamical systems. Fractional order dynamical systems currently continue to gain further importance in many areas of science and engineering. As with many other approaches to mathematical modeling, the first issue to be addressed is the need to couple a definition of the fractional differentiation or integration operator with the types of dynamical systems that are analyzed. As such, for the fundamentals the focus is on basic aspects of fractional calculus, in particular stability analysis, which is required to tackle synchronization in coupled fractional order systems, to understand the essence of estimators for related integer order systems, and to keep track of the interplay between synchronization and parameter observation. This serves as the common basis for the more advanced topics and applications presented in the subsequent chapters, which include an introduction to the 'Immersion and Invariance' (I&I) methodology, the masterslave synchronization scheme for partially known nonlinear fractional order systems, Fractional Algebraic Observability (FAO) and Fractional Generalized quasi-Synchronization (FGqS) to name but a few. This book is intended not only for applied mathematicians and theoretical physicists, but also for anyone in applied science dealing with complex nonlinear systems.

Applications of Fractional Calculus in Physics R Hilfer 2000-03-02 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

Fault-tolerant Control and Diagnosis for Integer and Fractional-order Systems Rafael Martínez-Guerra 2020-12-14 This book is about algebraic and differential methods, as well as fractional calculus, applied to diagnose and reject faults in nonlinear systems, which are of integer or fractional order. This represents an extension of a very important and widely studied problem in control theory, namely fault diagnosis and rejection (using differential algebraic approaches), to systems presenting fractional dynamics, i.e. systems whose dynamics are represented by derivatives and integrals of non-integer order. The authors offer a thorough overview devoted to fault diagnosis and fault-tolerant control applied to fractional-order and integer-order dynamical systems, and they introduce new methodologies for control and observation described by fractional and integer models, together with successful simulations and real-time applications. The basic concepts and tools of mathematics required to understand the methodologies proposed are all clearly introduced and explained. Consequently, the book is useful as supplementary reading in courses of applied mathematics and nonlinear control theory. This book is meant for engineers, mathematicians, physicists and, in general, to researchers and postgraduate students in diverse areas who have a minimum knowledge of calculus. It also contains advanced topics for researchers and professionals interested in the area of states and faults estimation.

Fractional Calculus with Applications for Nuclear Reactor Dynamics Santanu Saha Ray 2015-07-29 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 Trigonometry Carl F. Lorenzo 2016-11-14 Addresses the rapidly growing field of fractional calculus and provides simplified solutions for linear commensurate-order fractional differential equations The Fractional Trigonometry: With Applications to Fractional Differential Equations and Science is the result of the authors' work in fractional calculus, and more particularly, in functions for the solutions of fractional differential equations, which is fostered in the behavior of generalized exponential functions. The authors discuss how fractional trigonometry plays a role analogous to the classical trigonometry for the fractional calculus by providing solutions to linear fractional differential equations. The book begins with an introductory chapter that offers insight into the fundamentals of fractional calculus, and topical coverage is then organized in two main parts. Part One develops the definitions and theories of fractional exponentials and fractional trigonometry. Part Two provides insight into various areas of potential application within the sciences. The fractional exponential function via the fundamental fractional differential equation, the generalized exponential function, and R-function relationships are discussed in addition to the fractional hyperboletry, the R1-fractional trigonometry, the R2-fractional trigonometry, and the R3-trigonometric functions. The Fractional Trigonometry: With Applications to Fractional Differential Equations and Science also: Presents fractional trigonometry as a tool for scientists and engineers and discusses how to apply fractional-order methods to the current toolbox of mathematical modelers Employs a mathematically clear presentation in an effort to make the topic broadly accessible Includes solutions to linear fractional differential equations and generously features graphical forms of functions to help readers visualize the presented concepts Provides effective and efficient methods to describe complex structures The Fractional Trigonometry: With Applications to Fractional Differential Equations and Science is an ideal reference for academic researchers, research engineers, research scientists, mathematicians, physicists, biologists, and chemists who need to apply new fractional calculus methods to a variety of disciplines. The book is also appropriate as a textbook for graduate- and PhD-level courses in fractional calculus. Carl F. Lorenzo is Distinguished Research Associate at the NASA Glenn Research Center in Cleveland, Ohio. His past positions include chief engineer of the Instrumentation and Controls Division and chief of the Advanced Controls Technology and Systems Dynamics branches at NASA. He is internationally recognized for his work in the development and application of the fractional calculus and fractional trigonometry. Tom T. Hartley, PhD, is Emeritus Professor in the Department of Electrical and Computer Engineering at The University of Akron. Dr Hartley is a recognized expert in fractional-order systems, and together with Carl Lorenzo, has solved fundamental problems in the area including Riemann's complementary-function initialization function problem. He received his PhD in Electrical Engineering from Vanderbilt University.

Fractional Order Systems Ahmed G. Radwan 2021-10-13 Fractional Order Systems: An Overview of Mathematics, Design, and Applications for Engineers introduces applications from a design perspective, helping readers plan and design their own applications. The book includes the different techniques employed to design fractional-order systems/devices comprehensively and straightforwardly. Furthermore, mathematics is available in the literature on how to solve fractional-order calculus for system applications. This book introduces the mathematics that has been employed explicitly for fractional-order systems. It will prove an excellent material for students and scholars who want to quickly understand the field of fractional-order systems and contribute to its different domains and applications. Fractional-order systems are believed to play an essential role in our day-to-day activities. Therefore, several researchers around the globe endeavor to work in the different domains of fractional-order systems. The efforts include developing the mathematics to solve fractional-order calculus/systems and to achieve the feasible designs for various applications of fractional-order systems. Presents a simple and comprehensive understanding of the field of fractional-order systems Offers practical knowledge on the design of fractional-order systems for different applications Exposes users to possible new applications for fractional-order systems