Fractional Calculus

Applications

Roy Abi Zeid Daou
Xavier Moreau
Editors

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Broumi, Said

Fractional Calculus Applications Mathematics Research Developments:

Fractional Calculus Roy Abi Zeid Daou,Xavier Moreau,2014-01-12 After presenting the first volume of this two volume book presenting a lot of mathematical and theoretical studies and research related to non integer calculus the second volume illustrates applications related to this domain This volume is made up of 11 chapters The first chapter presents the heuristic power of the non integer differential operators in physics starting from the chaos to the emergence the auto organizations and the holistic rules The second chapter shows the dynamics of the fractional order chaotic systems along with some applications The third chapter represents the pressure control of gas engines by non integer order controllers by showing a novel trend in the application of the fractional calculus to automotive systems Chapter 4 shows the way to model fractional order equations using state space modeling along with some applications Another application related to this domain is the thermal diffusive interface Chapter 5 shows the analysis of a semi infinite diffuse plane medium along with the equations that model this medium and some frequency and time domain responses However Chapter 6 treats this problem by controlling this plant using the well known CRONE controller Chapter 8 presents the adaptive second order fractional sliding mode control with an application to a water tanks level system Chapter 9 treats the mechanical aspect by showing the features of the fractional operators applied to this domain Also Chapter Nine presents the theory of diffusive stresses based on the fractional advection diffusion equation The modeling of drug diffusion during general anesthesia using Fractional Calculus is shown in Chapter 10 and is considered as another application related to the biomedical field Finally Chapter 11 represents an overview of the fractional fuzzy controllers by showing the analysis the synthesis and the implementation of this module To sum up this second volume presents applications of fractional calculus in several engineering domains as the thermal the automotive the mechanical the biomedical and much more Note that this volume was preceded by a first volume that focuses on the mathematical and theoretical aspects of fractional calculus   **Recent Developments in Fractional Calculus: Theory, Applications, and Numerical Simulations** Lakhveer Kaur,Pushpendra Kumar,2025-05-30 This book discusses recent developments in fractional calculus and fractional differential equations in a very elaborative manner and is of interest to research scholars academicians and scientists who want to enhance the knowledge in the context of new insights and mathematical ideas in fractional calculus and its emerging applications in various fields It focuses on strengthening the existing results along with identifying the practical challenges encountered The purpose of this collection is to provide comprehension of articles that reflect recent mathematical results as well as some results in applied sciences untouched by the tools and techniques of fractional calculus along with their modelling and computation having applications in diverse arenas   **Fixed Point Theory and Fractional Calculus** Pradip Debnath,H. M. Srivastava,Poom Kumam,Bipan Hazarika,2022-05-10 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 <u>Recent Trends in Fractional Calculus and Its Applications</u> Praveen Agarwal,Luis Vázquez Martínez,Ervin K. Lenzi,2024-07-02 Recent Trends in Fractional Calculus and Its Applications addresses the answer to this very basic question Why is Fractional Calculus important Until recent times Fractional Calculus was considered as a rather esoteric mathematical theory without applications but in the last few decades there has been an explosion of research activities on the application of Fractional Calculus to very diverse scientific fields ranging from the physics of diffusion and advection phenomena to control systems to finance and economics An important part of mathematical modelling of objects and processes is a description of their dynamics The term Fractional Calculus is more than 300 years old It is a generalization of the ordinary differentiation and integration to noninteger arbitrary order The subject is as old as the calculus of differentiation and goes back to times when Leibniz Gauss and Newton invented this kind of calculation Several mathematicians contributed to this subject over the years People like Liouville Riemann and Weyl made major contributions to the theory of Fractional Calculus In recent decades the field of Fractional Calculus has attracted the interest of researchers in several areas including mathematics physics chemistry engineering finance and social sciences Provides the most recent and up to date developments in the Fractional Calculus and its application areas Presents pre preparation ideas to help researchers scientists clinicians face the new challenges in the application of fractional differential equations Helps researchers and scientists understand the importance of the Fractional Calculus to solve many problems in Biomedical Engineering and applied sciences *Basic Theory* Anatoly Kochubei,Yuri Luchko,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 first volume collects authoritative chapters covering the mathematical theory of fractional calculus including fractional order operators integral transforms and equations special functions calculus of variations and probabilistic and other aspects **Fractional Calculus: New Applications in Understanding Nonlinear Phenomena** Mehmet Yavuz,Necati Özdemir,2022-12-14 In the last two decades many new fractional operators have appeared often defined using integrals with special functions in the kernel as well as their extended or multivariable forms Modern operators in fractional calculus have different properties which are comparable to those of classical operators These have been intensively studied formodelling and analysing real world phenomena There is now a growing body of research on new methods to understand natural occurrences and tackle different problems This book presents ten reviews of recent fractional operators split over three sections 1 Chaotic Systems and Control covers the Caputo fractional derivative and a chaotic fractional order financial system 2 Heat Conduction covers the Duhamel theorem for time dependent source terms and the

Cattaneo Hristov model for oscillatory heat transfer 3 Computational Methods and Their Illustrative Applications covers mathematical analysis for understanding 5 real word phenomena HTLV 1 infection of CD4 T cells traveling waves rumor spreading biochemical reactions and the computational fluid dynamics of a non powered floating object navigating in an approach channel This volume is a resource for researchers in physics biology behavioral sciences and mathematics who are interested in new applications of fractional calculus in the study of nonlinear phenomena   Recent Developments in Theory and Applications of Fractional Order Systems Mehmet Yavuz,Dharmendra Kumar Singh,Stuart Townley,2025-09-01 Recent Developments in Theory and Applications of Fractional Order Systems presents a rigorous and thorough analysis of various aspects of Fractional Calculus The book provides readers with a thorough understanding of fundamental concepts and methods of applied mathematics utilized in a variety of scientific and engineering disciplines The authors present each computational modeling concept with a definition methods theorems and observations followed by typical application problems and step by step solutions Each topic is covered in detail followed typically by several meticulously worked out examples and a problem set containing many additional related problems In addition the book discusses recent developments and the latest research on Fractional Calculus and its applications demonstrating important applications in Engineering Computer Science Management Social Science and the Humanities Provides readers with a thorough understanding of fundamental concepts and methods of applied mathematics utilized in a variety of scientific and engineering disciplines Presents a systematic introduction to most of the important special functions in Fractional Calculus that commonly arise in scientific and engineering practice Explores many salient computational modeling properties Analyzes theoretical and practical problems in Fractional Calculus in fields such as Engineering Computer Science Management Social Science and the Humanities   **Fractional Calculus** Roy Abi Zeid Daou,Xavier Moreau,2014-01-11 The first volume of this two volume book presents history the mathematical modelling and the applications of fractional order systems and contains mathematical and theoretical studies and research related to this domain This volume is made up of 11 chapters The first chapter presents an analysis of the Caputo derivative and the pseudo state representation with the infinite state approach The second chapter studies the stability of a class of fractional Cauchy problems The third chapter shows how to solve fractional order differential equations and fractional order partial differential equations using modern matrix algebraic approaches Following this chapter chapter four proposes another analytical method to solve differential equations with local fractional derivative operators Concerning chapter five it presents the extended Borel transform and its related fractional analysis After presenting the analytical resolution methods for fractional calculus chapter six shows the essentials of fractional calculus on discrete settings The initialisation of such systems is shown in chapter seven In fact this chapter presents a generalised application of the Hankel operator for initialisation of fractional order systems The last four chapters show some new studies and applications of non integer calculus In fact chapter eight presents the fractional reaction transport equations and

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

Fractional Calculus Roy Abi Zeid Daou,2014 The first volume of this two volume book presents history the mathematical modeling and the applications of fractional order systems and contains mathematical and theoretical studies and research related to this domain This volume is made up of 11 chapters The first chapter presents an analysis of the Caputo derivative and the pseudo state representation with the infinite state approach The second chapter studies the stability of a class of fractional Cauchy problems The third chapter shows how to solve fractional order differential equations and fractional order partial differential equations using modern matrix algebraic approaches Following this chapter chapter four proposes another analytical method to solve differential equations with local fractional derivative operators Concerning chapter five it presents the extended Borel transform and its related fractional analysis After presenting the analytical resolution methods for fractional calculus chapter six shows the essentials of fractional calculus on discrete settings The initialization of such systems is shown in chapter seven In fact this chapter presents a generalized application of the Hankel operator for initialization of fractional order systems The last four chapters show some new studies and applications of non integer calculus In fact chapter eight presents the fractional reaction transport equations and evanescent continuous time random walks Chapter nine shows a novel approach in the exponential integrators for fractional differential equations Chapter ten presents the non fragile tuning of fractional order PD controllers for integrating time delay systems At the end chapter eleven proposes a discrete finite dimensional approximation of linear infinite dimensional systems To sum up this volume presents a mathematical and theoretical study of fractional calculus along with a stability study and some applications This volume ends up with some new techniques and methods applied in fractional calculus This volume will be followed up by a second volume that focuses on the applications of fractional calculus in several engineering domains

Fractional Calculus Behzad Ghanbari,2024-06-21 Fractional Calculus Bridging Theory with Computational and Contemporary Advances is an authoritative and comprehensive guide that delves into the world of fractional calculus offering a unique blend of theoretical foundations numerical algorithms practical applications and innovative perspectives This book explores the mathematical framework of fractional calculus and its relevance across various disciplines providing readers with a deep understanding of this rapidly growing field The author presents a rigorous yet accessible approach to fractional calculus making it suitable for mathematicians researchers academics graduate students and professionals in engineering

and applied sciences The book covers a wide range of topics including numerical methods for fractional calculus equations fractional differential equations fractal dynamics and fractional control systems It also explores applications in areas such as physics engineering signal processing and data analysis Fractional Calculus Bridging Theory with Computational and Contemporary Advances equips readers with the necessary tools to tackle challenging problems involving fractional calculus empowering them to apply these techniques in their research professional work or academic pursuits The book provides a comprehensive introduction to the fundamentals of fractional calculus explaining the theoretical concepts and key definitions in a clear and accessible manner This helps readers build a strong foundation in the subject The book then covers a range of numerical algorithms specifically designed for fractional calculus problems explaining the underlying principles step by step implementation and computational aspects of these algorithms This enables readers to apply numerical techniques to solve fractional calculus problems effectively The book also provides examples that illustrate how fractional calculus is applied to solve real world problems providing readers with insights into the wide ranging applications of the subject Provides a comprehensive introduction to the fundamentals of fractional calculus explaining the theoretical concepts and key definitions in a clear and accessible manner Covers a range of numerical algorithms specifically designed for fractional calculus problems Includes practical examples and case studies from various fields such as physics biology finance and signal processing   Handbook of Research on Advances and Applications of Fuzzy Sets and Logic Broumi, Said,2022-03-04 Fuzzy logic which is based on the concept of fuzzy set has enabled scientists to create models under conditions of imprecision vagueness or both at once As a result it has now found many important applications in almost all sectors of human activity becoming a complementary feature and supporter of probability theory which is suitable for modelling situations of uncertainty derived from randomness Fuzzy mathematics has also significantly developed at the theoretical level providing important insights into branches of traditional mathematics like algebra analysis geometry topology and more With such widespread applications fuzzy sets and logic are an important area of focus in mathematics The Handbook of Research on Advances and Applications of Fuzzy Sets and Logic studies recent theoretical advances of fuzzy sets and numbers fuzzy systems fuzzy logic and their generalizations extensions and more This book also explores the applications of fuzzy sets and logic applied to science technology and everyday life to further provide research on the subject This book is ideal for mathematicians physicists computer specialists engineers practitioners researchers academicians and students who are looking to learn more about fuzzy sets fuzzy logic and their applications   **Fractional Derivative Modeling in Mechanics and Engineering** Wen Chen,HongGuang Sun,Xicheng Li,2022-02-26 This textbook highlights the theory of fractional calculus and its wide applications in mechanics and engineering It describes in details the research findings in using fractional calculus methods for modeling and numerical simulation of complex mechanical behavior It covers the mathematical basis of fractional calculus the relationship between fractal and fractional calculus unconventional statistics

and anomalous diffusion typical applications of fractional calculus and the numerical solution of the fractional differential equation It also includes latest findings such as variable order derivative distributed order derivative and its applications Different from other textbooks in this subject the book avoids lengthy mathematical demonstrations and presents the theories in close connection to the applications in an easily readable manner This textbook is intended for students researchers and professionals in applied physics engineering mechanics and applied mathematics It is also of high reference value for those in environmental mechanics geotechnical mechanics biomechanics and rheology   Advances in Mathematics: Theory, Methods & Applications Akshay Kumar,Mangey Ram,2025-06-10 This book is an excellent collection of various topics of mathematics which include numerical methods integral equations and differential equations The book is recommended to readers to refresh their understanding of applied mathematics with theory and applications It will be useful to students researchers and practitioners working in applied and computational mathematics   *Advances in Mathematical Modelling, Applied Analysis and Computation* Jagdev Singh,George A. Anastassiou,Dumitru Baleanu,Devendra Kumar,2025-07-11 This book is a collection of research papers from the 7th International Conference on Mathematical Modelling Applied Analysis and Computation organized by Lebanese American University Beirut Lebanon from April 18 20 2024 This proceeding contains research papers related with fundamental mathematical theory and methods in a very suitable manner and useful for handling various contemporary issues of physical chemical and engineering sciences The aim of this conference is to foster cooperation among mathematicians and scientists working in these areas This book is a very useful resource for mathematicians scientists and engineers working in the field of applied mathematics analysis and computation for solving real life problems of different domains   *Advances in Applied Mathematics and Approximation Theory* George A. Anastassiou,Oktay Duman,2014-07-08 Advances in Applied Mathematics and Approximation Theory Contributions from AMAT 2012 is a collection of the best articles presented at Applied Mathematics and Approximation Theory 2012 an international conference held in Ankara Turkey May 17 20 2012 This volume brings together key work from authors in the field covering topics such as ODEs PDEs difference equations applied analysis computational analysis signal theory positive operators statistical approximation fuzzy approximation fractional analysis semigroups inequalities special functions and summability The collection will be a useful resource for researchers in applied mathematics engineering and statistics

Integral Methods in Science and Engineering Christian Constanda,Bardo E.J. Bodmann,Haroldo F. de Campos Velho,2013-08-13 Advances in science and technology are driven by the development of rigorous mathematical foundations for the study of both theoretical and experimental models With certain methodological variations this type of study always comes down to the application of analytic or computational integration procedures making such tools indispensible With a wealth of cutting edge research in the field Integral Methods in Science and Engineering Progress in Numerical and Analytic Techniques provides a detailed portrait of both the construction of theoretical integral techniques and their application to

specific problems in science and engineering The chapters in this volume are based on talks given by well known researchers at the Twelfth International Conference on Integral Methods in Science and Engineering July 23 27 2012 in Porto Alegre Brazil They address a broad range of topics from problems of existence and uniqueness for singular integral equations on domain boundaries to numerical integration via finite and boundary elements conservation laws hybrid methods and other quadrature related approaches The contributing authors bring their expertise to bear on a number of topical problems that have to date resisted solution thereby offering help and guidance to fellow professionals worldwide Integral Methods in Science and Engineering Progress in Numerical and Analytic Techniques will be a valuable resource for researchers in applied mathematics physics and mechanical and electrical engineering for graduate students in these disciplines and for various other professionals who use integration as an essential tool in their work *Advances in Complex Analysis and Operator Theory* Fabrizio Colombo,Irene Sabadini,Daniele C. Struppa,Mihaela B. Vajiac,2017-09-30 This book gathers contributions written by Daniel Alpay s friends and collaborators Several of the papers were presented at the International Conference on Complex Analysis and Operator Theory held in honor of Professor Alpay s 60th birthday at Chapman University in November 2016 The main topics covered are complex analysis operator theory and other areas of mathematics close to Alpay s primary research interests The book is recommended for mathematicians from the graduate level on working in various areas of mathematical analysis operator theory infinite dimensional analysis linear systems and stochastic processes Fractional Calculus in Analysis, Dynamics, and Optimal Control Jacky Cresson,2014 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 assymetric 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 Differential Equations* Praveen Agarwal,Carlo Cattani,Shaher Momani,2024-04-29 Fractional Differential Equations Theoretical Aspects and Applications presents the latest mathematical and conceptual developments in the field of Fractional Calculus and explores the scope of applications in research science and computational modelling Fractional derivatives arise as a generalization of integer order derivatives and have a long history their origin can be found in the work of G W Leibniz and L Euler Shortly after being introduced the new theory turned out to be very attractive for many famous mathematicians and

scientists including P S Laplace B Riemann J Liouville N H Abel and J B J Fourier due to the numerous possibilities it offered for applications Fractional Calculus the field of mathematics dealing with operators of differentiation and integration of arbitrary real or even complex order extends many of the modelling capabilities of conventional calculus and integer order differential equations and finds its application in various scientific areas such as physics mechanics engineering economics finance biology and chemistry among others However many aspects from the theoretical and practical point of view have still to be developed in relation with models based on fractional operators Efficient analytical and numerical methods have been developed but still need particular attention Fractional Differential Equations Theoretical Aspects and Applications delves into these methods and applied computational modelling techniques including analysis of equations involving fractional derivatives fractional derivatives and the wave equation analysis of FDE on groups direct and inverse problems functional inequalities and computational methods for FDEs in physics and engineering Other modelling techniques and applications explored by the authors include general fractional derivatives involving the special functions in analysis fractional derivatives with respect to another function in analysis new fractional operators in real world applications fractional order dynamical systems hidden attractors in complex systems nonlinear dynamics and chaos in engineering applications quantum chaos and self excited attractors Provides the most recent and up to date developments in the theory and scientific applications Fractional Differential Equations Includes transportable computer source codes for readers in MATLAB with code descriptions as it relates to the mathematical modelling and applications Provides readers with a comprehensive foundational reference for this key topic in computational modeling which is a mathematical underpinning for most areas of scientific and engineering research   **Recent Advances in Fractional Calculus** R. N. Kalia,1993

The Enigmatic Realm of **Fractional Calculus Applications Mathematics Research Developments**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing lacking extraordinary. Within the captivating pages of **Fractional Calculus Applications Mathematics Research Developments** a literary masterpiece penned with a renowned author, readers set about a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book is core themes, assess its distinct writing style, and delve into its lasting impact on the hearts and minds of those that partake in its reading experience.

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