



# **FRACTIONAL CALCULUS WITH APPLICATIONS FOR NUCLEAR REACTOR DYNAMICS**

**Santanu Saha Ray**



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# Fractional Calculus With Applications For Nuclear Reactor Dynamics

**Yijin Wang**

A decorative graphic element consisting of a light blue horizontal bar with a rounded right end, and a red circular gradient shape partially visible behind it.

## **Fractional Calculus With Applications For Nuclear Reactor Dynamics:**

**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 way **Fractional-Order Models for Nuclear Reactor Analysis** Gilberto Espinosa Paredes, 2020-10-22 Fractional Order Models for Nuclear Reactor Analysis presents fractional modeling issues in the context of anomalous diffusion processes in an accessible and practical way The book emphasizes the importance of non Fickian diffusion in heterogeneous systems as the core of the nuclear reactor as well as different variations of diffusion processes in nuclear reactors which are presented to establish the importance of nuclear and thermohydraulic phenomena and the physical side effects of feedback In addition the book analyzes core issues in fractional modeling in nuclear reactors surrounding phenomenological description and important analytical sub diffusive processes in the transport neutron Users will find the most innovative modeling techniques of nuclear reactors using operator differentials of fractional order and applications in nuclear design and reactor dynamics Proposed methods are tested with Boltzmann equations and non linear order models alongside real data from nuclear power plants making this a valuable resource for nuclear professionals researchers and graduate students as well as those working in nuclear research centers with expertise in mathematical modeling physics and control Presents and analyzes a new paradigm of nuclear reactor phenomena with fractional modeling Considers principles of fractional calculation methods of solving differential equations of fractional order and their applications Includes methodologies of linear and nonlinear analysis along with design and dynamic analyses **Fractional Order Control and Synchronization of Chaotic Systems** Ahmad Taher Azar, Sundarapandian Vaidyanathan, Adel Ouannas, 2017-02-27 The book reports on the latest advances in and applications of fractional order control and synchronization of chaotic systems explaining the concepts involved in a clear matter of fact style It consists of 30 original contributions written by eminent scientists and active researchers in the field that address theories methods and applications in a number of research areas related to fractional order control and synchronization of chaotic systems such as fractional chaotic systems hyperchaotic systems complex systems fractional order discrete chaotic systems chaos control chaos synchronization jerk circuits fractional chaotic systems with hidden attractors neural network fuzzy logic controllers behavioral modeling robust and adaptive control sliding mode control different types of synchronization circuit realization of chaotic systems etc In addition to providing readers extensive information on chaos fundamentals fractional calculus fractional differential equations fractional control and stability the book also discusses key applications of fractional order chaotic systems as well as multidisciplinary solutions developed via control modeling As such it offers the perfect reference guide for graduate students researchers and practitioners in the areas of fractional order control systems and

fractional order chaotic systems      **Analog/Digital Implementation of Fractional Order Chaotic Circuits and Applications** Esteban Tlelo-Cuautle, Ana Dalia Pano-Azucena, Omar Guillén-Fernández, Alejandro Silva-Juárez, 2019-11-11

This book details the simulation and optimization of integer and fractional order chaotic systems and how they can be implemented in the analog and digital domains using FPAA and FPGAs. Design guidelines are provided to use commercially available electronic devices and to perform hardware descriptions of integer fractional order chaotic systems programming in VHDL. Finally, several engineering applications oriented to cryptography, internet of things, robotics, and chaotic communications are detailed to highlight the usefulness of FPAA/FPGA based integer fractional order chaotic systems. Provides guidelines to implement fractional order derivatives using commercially available devices. Describes details on using FPAA to approach fractional order chaotic systems. Includes details on using FPGAs to approach fractional order chaotic systems programming in VHDL and reducing hardware resources. Discusses applications to cryptography, internet of things, robotics, and chaotic communications.

**Introduction to Fractional Differential Equations** Constantin Milici, Gheorghe Drăgănescu, J. Tenreiro Machado, 2018-10-28 This book introduces a series of problems and methods insufficiently discussed in the field of Fractional Calculus, a major emerging tool relevant to all areas of scientific inquiry. The authors present examples based on symbolic computation written in Maple and Mathematica and address both mathematical and computational areas in the context of mathematical modeling and the generalization of classical integer order methods. Distinct from most books, the present volume fills the gap between mathematics and computer fields and the transition from integer to fractional order methods.

**Generalized Fractional Order Differential Equations Arising in Physical Models** Santanu Saha Ray, Subhadarshan Sahoo, 2018-11-13 This book analyzes the various semi-analytical and analytical methods for finding approximate and exact solutions of fractional order partial differential equations. It explores approximate and exact solutions obtained by various analytical methods for fractional order partial differential equations arising in physical models.

**Nonlinear Differential Equations in Physics** Santanu Saha Ray, 2019-12-28 This book discusses various novel analytical and numerical methods for solving partial and fractional differential equations. Moreover, it presents selected numerical methods for solving stochastic point kinetic equations in nuclear reactor dynamics by using Euler-Maruyama and strong order Taylor numerical methods. The book also shows how to arrive at new exact solutions to various fractional differential equations such as the time fractional Burgers-Hopf equation, the 3D time fractional Khokhlov-Zabolotskaya-Kuznetsov equation, the 3D time fractional KdV-Khokhlov-Zabolotskaya-Kuznetsov equation, the fractional 2D Davey-Stewartson equation, and the integrable Davey-Stewartson type equation. Many of the methods discussed are analytical-numerical, namely the modified decomposition method, a new two-step Adomian decomposition method, a new approach to the Adomian decomposition method, modified homotopy analysis method with Fourier transform, modified fractional reduced differential transform method, MFRDTM, coupled fractional reduced differential transform method.

CFRDTM optimal homotopy asymptotic method first integral method and a solution procedure based on Haar wavelets and the operational matrices with function approximation The book proposes for the first time a generalized order operational matrix of Haar wavelets as well as new techniques MFRDTM and CFRDTM for solving fractional differential equations Numerical methods used to solve stochastic point kinetic equations like the Wiener process Euler Maruyama and order 1 5 strong Taylor methods are also discussed 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 **Advances in Memristors, Memristive Devices and Systems** Sundarapandian Vaidyanathan, Christos Volos, 2017-02-15 This book reports on the latest advances in and applications of memristors memristive devices and systems It gathers 20 contributed chapters by subject experts including pioneers in the field such as Leon Chua UC Berkeley USA and R S Williams HP Labs USA who are specialized in the various topics addressed in this book and covers broad areas of memristors and memristive devices such as memristor emulators oscillators chaotic and hyperchaotic memristive systems control of memristive systems memristor based min max circuits canonic memristors memristive based neuromorphic applications implementation of memristor based chaotic oscillators inverse memristors linear memristor devices delayed memristive systems flux controlled memristive emulators etc Throughout the book special emphasis is given to papers offering practical solutions and design modeling and implementation insights to address current research problems in memristors memristive devices and systems As such it offers a valuable reference book on memristors and memristive devices for graduate students and researchers with a basic knowledge of electrical and control systems engineering *Numerical Analysis with Algorithms and Programming* Santanu Saha Ray, 2018-09-03 Numerical Analysis with Algorithms and Programming is the first comprehensive textbook to provide detailed coverage of numerical methods their algorithms and corresponding computer programs It presents many techniques for the efficient numerical solution of problems in science and engineering Along with numerous worked out examples end of chapter exercises and Mathematica programs the book includes the standard algorithms for numerical computation Root finding for nonlinear equations Interpolation and approximation of functions by simpler computational building blocks such as polynomials and splines The solution of systems of linear equations and triangularization Approximation of functions and least square approximation Numerical differentiation and divided differences Numerical quadrature and integration Numerical solutions of ordinary differential equations ODEs and boundary value problems Numerical solution of partial differential equations PDEs The text develops students understanding of the construction of numerical algorithms and the applicability of the methods By thoroughly studying the algorithms students will discover how various methods provide accuracy efficiency scalability and

stability for large scale systems      **Novel Methods for Solving Linear and Nonlinear Integral Equations** Santanu Saha Ray,Prakash Kumar Sahu,2018-12-07 This book deals with the numerical solution of integral equations based on approximation of functions and the authors apply wavelet approximation to the unknown function of integral equations The book s goal is to categorize the selected methods and assess their accuracy and efficiency      *Stochastic Integral And Differential Equations In Mathematical Modelling* Santanu Saha Ray,2023-04-25 The modelling of systems by differential equations usually requires that the parameters involved be completely known Such models often originate from problems in physics or economics where we have insufficient information on parameter values One important class of stochastic mathematical models is stochastic partial differential equations SPDEs which can be seen as deterministic partial differential equations PDEs with finite or infinite dimensional stochastic processes either with colour noise or white noise Though white noise is a purely mathematical construction it can be a good model for rapid random fluctuations Stochastic Integral and Differential Equations in Mathematical Modelling concerns the analysis of discrete time approximations for stochastic differential equations SDEs driven by Wiener processes It also provides a theoretical basis for working with SDEs and stochastic processes This book is written in a simple and clear mathematical logical language with basic definitions and theorems on stochastic calculus provided from the outset Each chapter contains illustrated examples via figures and tables The reader can also construct new wavelets by using the procedure presented in the book Stochastic Integral and Differential Equations in Mathematical Modelling fulfils the existing gap in the literature for a comprehensive account of this subject area      **Fractional-order Modeling of Nuclear Reactor: From Subdiffusive Neutron Transport to Control-oriented Models** Vishwesh Vyawahare,Paluri S. V. Nataraj,2018-02-03 This book addresses the topic of fractional order modeling of nuclear reactors Approaching neutron transport in the reactor core as anomalous diffusion specifically subdiffusion it starts with the development of fractional order neutron telegraph equations Using a systematic approach the book then examines the development and analysis of various fractional order models representing nuclear reactor dynamics ultimately leading to the fractional order linear and nonlinear control oriented models The book utilizes the mathematical tool of fractional calculus the calculus of derivatives and integrals with arbitrary non integer orders real or complex which has recently been found to provide a more compact and realistic representation to the dynamics of diverse physical systems Including extensive simulation results and discussing important issues related to the fractional order modeling of nuclear reactors the book offers a valuable resource for students and researchers working in the areas of fractional order modeling and control and nuclear reactor modeling      **Simulation and Modeling Methodologies, Technologies and Applications** Mohammad S. Obaidat,Tuncer Ören,Janusz Kacprzyk,Joaquim Filipe,2016-01-14 The present book includes a set of selected extended papers from the 4th International Conference on Simulation and Modeling Methodologies Technologies and Applications SIMULTECH 2014 held in Vienna Austria from 28 to 30 August 2014 The conference brought

together researchers engineers and practitioners interested in methodologies and applications of modeling and simulation New and innovative solutions are reported in this book SIMULTECH 2014 received 167 submissions from 45 countries in all continents After a double blind paper review performed by the Program Committee 23% were accepted as full papers and thus selected for oral presentation Additional papers were accepted as short papers and posters A further selection was made after the Conference based also on the assessment of presentation quality and audience interest so that this book includes the extended and revised versions of the very best papers of SIMULTECH 2014 Commitment to high quality standards is a major concern of SIMULTECH that will be maintained in the next editions considering not only the stringent paper acceptance ratios but also the quality of the program committee keynote lectures participation level and logistics

**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

**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 indispensable 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      **Fractional Calculus** Varsha Daftardar-Gejji, 2013-07-26 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      **Applications of Chaos and Nonlinear Dynamics in Science and Engineering - Vol. 3** Santo Banerjee, Lamberto Rondoni, 2013-06-12 Chaos and nonlinear dynamics initially developed as a new emergent field with its foundation in physics and applied mathematics The highly generic interdisciplinary quality of the insights gained in the last few decades has spawned myriad applications in almost all branches of science and technology and even well beyond Wherever quantitative modeling and analysis of complex nonlinear phenomena is required chaos theory and its methods can play a key role This third volume concentrates on reviewing further relevant contemporary applications of chaotic nonlinear systems as they apply to the various cutting edge branches of engineering This encompasses but is not limited to topics such fluctuation relations and chaotic dynamics in physics fractals and their applications in epileptic seizures as well as chaos synchronization Featuring contributions from active and leading research groups this collection is ideal both as a reference and as a recipe book full of tried and tested successful engineering applications      **Differential Equations on Measures and Functional Spaces** Vassili Kolokoltsov, 2019-06-20 This advanced book focuses on ordinary differential equations ODEs in Banach and more general locally convex spaces most notably the ODEs on measures and various function spaces It briefly discusses the fundamentals before moving on to the cutting edge research in linear and nonlinear partial and pseudo differential equations general kinetic equations and fractional evolutions The level of generality chosen is suitable for the study of the most important nonlinear equations of mathematical physics such as Boltzmann Smoluchovskii Vlasov Landau Fokker Planck Cahn Hilliard Hamilton Jacobi Bellman nonlinear Schroedinger McKean Vlasov diffusions and their nonlocal extensions mass action law kinetics from chemistry It also covers nonlinear evolutions arising in evolutionary biology and mean field games optimization theory epidemics and system biology in general models of interacting particles or agents describing splitting and merging collisions and breakage mutations and the preferential attachment growth on networks The book is intended mainly for upper undergraduate and



graduate students but is also of use to researchers in differential equations and their applications It particularly highlights the interconnections between various topics revealing where and how a particular result is used in other chapters or may be used in other contexts and also clarifies the links between the languages of pseudo differential operators generalized functions operator theory abstract linear spaces fractional calculus and path integrals

**Novel Antibacterial Biomaterials for Medical Applications and Modeling of Drug Release Process** Vesna Mišković-Stanković, Teodor Atanackovic, 2024-06-12 This book provides a comprehensive review of synthesis and physicochemical and biological characterization of novel antibacterial biomaterials produced according to original procedures and aimed at medical applications such as wound dressing soft and hard tissue implants drug delivery devices and carriers for cell cultivation It is intended for all researchers working in the fields of biomaterials and biomedical engineering as well as medical professionals science and engineering graduate students academics and industrial researchers Includes in depth discussions on synthesis and physicochemical characterization of novel poly vinyl alcohol based hydrogels aimed at wound dressings and soft tissue implants Explores synthesis and physicochemical characterization of novel bioceramic hydroxyapatite based coatings on metal surface aimed for hard tissue implants Reviews cytotoxicity and antibacterial activity of novel poly vinyl alcohol based hydrogels aimed for wound dressing and soft tissue implants Discusses cytotoxicity and antibacterial activity of bioceramic hydroxyapatite based coatings on metal surface aimed for hard tissue implants Provides original fractional derivative models of drug release process from hydrogels and bioceramic coatings on metal surface and explores diffusion mechanism

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