

Christopher Goodrich · Allan C. Peterson

Discrete Fractional Calculus

 Springer

Nice Discrete Fractional Calculus Christopher Goodrich

RJ Shavelson



Nice Discrete Fractional Calculus Christopher Goodrich:

Discrete Fractional Calculus Christopher Goodrich, Allan C. Peterson, 2016-02-09 This text provides the first comprehensive treatment of the discrete fractional calculus Experienced researchers will find the text useful as a reference for discrete fractional calculus and topics of current interest Students who are interested in learning about discrete fractional calculus will find this text to provide a useful starting point Several exercises are offered at the end of each chapter and select answers have been provided at the end of the book The presentation of the content is designed to give ample flexibility for potential use in a myriad of courses and for independent study The novel approach taken by the authors includes a simultaneous treatment of the fractional and integer order difference calculus on a variety of time scales including both the usual forward and backwards difference operators The reader will acquire a solid foundation in the classical topics of the discrete calculus while being introduced to exciting recent developments bringing them to the frontiers of the subject Most chapters may be covered or omitted depending upon the background of the student For example the text may be used as a primary reference in an introductory course for difference equations which also includes discrete fractional calculus Chapters 1 2 provide a basic introduction to the delta calculus including fractional calculus on the set of integers For courses where students already have background in elementary real analysis Chapters 1 2 may be covered quickly and readers may then skip to Chapters 6 7 which present some basic results in fractional boundary value problems FBVPs Chapters 6 7 in conjunction with some of the current literature listed in the Bibliography can provide a basis for a seminar in the current theory of FBVPs For a two semester course Chapters 1 5 may be covered in depth providing a very thorough introduction to both the discrete fractional calculus as well as the integer order calculus

Chaotic Dynamics of Fractional Discrete Time Systems Vignesh Dhakshinamoorthy, Guo-Cheng Wu, Santo Banerjee, 2024-09-06 The book reviews the application of discrete fractional operators in diverse fields such as biological and chemical reactions as well as chaotic systems demonstrating their applications in physics The dynamical analysis is carried out using equilibrium points of the system for studying their stability properties and the chaotic behaviors are illustrated with the help of bifurcation diagrams and Lyapunov exponents The book is divided into three parts Part I deals with the application of discrete fractional operators in chemical reaction based systems with biological significance Two different chemical reaction models are analysed one being disproportionation of glucose which plays an important role in human physiology and the other is the Lengyel Epstein chemical model Chaotic behavior of the systems is studied and the synchronization of the system is performed Part II covers the analysis of biological systems like tumor immune system and neuronal models by introducing memristor based flux control The memductance functions are considered as quadratic periodic and exponential functions The final part of the book reviews the complex form of the Rabinovich Fabrikant system which describes physical systems with strong nonlinearity exhibiting unusual behavior

Mathematical Reviews, 2005

The Theory of Discrete Fractional Calculus Michael T. Holm, 2011

Discrete

Fractional Calculus Piotr Ostalczyk, 2015-11-26 The main subject of the monograph is the fractional calculus in the discrete version The volume is divided into three main parts Part one contains a theoretical introduction to the classical and fractional order discrete calculus where the fundamental role is played by the backward difference and sum In the second part selected applications of the discrete fractional calculus in the discrete system control theory are presented In the discrete system identification analysis and synthesis one can consider integer or fractional models based on the fractional order difference equations The third part of the book is devoted to digital image processing *Discrete Fractional Calculus and Its Applications to Tumor Growth* Sevgi Sengul, 2010 *Fractional Calculus and Scales of Spaces* Chris Waddell, University of Strathclyde, 2004 *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 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 Calculus: Models And Numerical Methods (Second Edition)* Juan J Trujillo, Enrico Scalas, Kai Diethelm, 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 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 Dumitru Baleanu, 2012 The subject of fractional calculus and its applications that is convolution type pseudo differential operators including integrals and derivatives of any arbitrary real or complex order has gained considerable popularity and importance during the past three decades or so mainly due to its applications in diverse fields of science and engineering These operators have been used to model problems with anomalous dynamics however they also are an effective tool as filters and controllers and they can be applied to write complicated functions in terms of fractional integrals or derivatives of elementary functions and so on 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 was written with a trade off in mind 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 Numerical code is also provided

Fractional Calculus and Its Applications B. Ross, 2014-09-01 The Fractional Calculus Keith B. Oldham, Jerome Spanier, 1974 **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

The fractional calculus : theory and applications of differentiation and integration to arbitrary order Keith B. Oldham, Jerome Spanier, 1974 **Handbook of Fractional Calculus for Engineering and Science** Harendra Singh, H. M. Srivastava, Juan J. Nieto, 2022-02-17

Fractional calculus is used to model many real life situations from science and engineering The book includes different topics associated with such equations and their relevance and significance in various scientific areas of study and research In this book readers will find several important and useful methods and techniques for solving various types of fractional order models in science and

engineering The book should be useful for graduate students PhD students researchers and educators interested in mathematical modelling physical sciences engineering sciences applied mathematical sciences applied sciences and so on This Handbook Provides reliable methods for solving fractional order models in science and engineering Contains efficient numerical methods and algorithms for engineering related equations Contains comparison of various methods for accuracy and validity Demonstrates the applicability of fractional calculus in science and engineering Examines qualitative as well as quantitative properties of solutions of various types of science and engineering related equations Readers will find this book to be useful and valuable in increasing and updating their knowledge in this field and will be it will be helpful for engineers mathematicians scientist and researchers working on various real life problems

Fractional Calculus: An Introduction For Physicists (2nd Edition) Richard Herrmann, 2014-01-03 The book presents a concise introduction to the basic methods and strategies in fractional calculus and enables the reader to catch up with the state of the art in this field as well as to participate and contribute in the development of this exciting research area The contents are devoted to the application of fractional calculus to physical problems The fractional concept is applied to subjects in classical mechanics group theory quantum mechanics nuclear physics hadron spectroscopy and quantum field theory and it will surprise the reader with new intriguing insights This new extended edition now also covers additional chapters about image processing folded potentials in cluster physics infrared spectroscopy and local aspects of fractional calculus A new feature is exercises with elaborated solutions which significantly supports a deeper understanding of general aspects of the theory As a result this book should also be useful as a supporting medium for teachers and courses devoted to this subject

Introduction To The Fractional Calculus Of Variations Delfim F M Torres, Agnieszka Barbara Malinowska, 2012-09-14 This invaluable book provides a broad introduction to the fascinating and beautiful subject of Fractional Calculus of Variations FCV In 1996 FVC evolved in order to better describe non conservative systems in mechanics The inclusion of non conservatism is extremely important from the point of view of applications Forces that do not store energy are always present in real systems They remove energy from the systems and as a consequence Noether's conservation laws cease to be valid However it is still possible to obtain the validity of Noether's principle using FCV The new theory provides a more realistic approach to physics allowing us to consider non conservative systems in a natural way The authors prove the necessary Euler Lagrange conditions and corresponding Noether theorems for several types of fractional variational problems with and without constraints using Lagrangian and Hamiltonian formalisms Sufficient optimality conditions are also obtained under convexity and Leitmann's direct method is discussed within the framework of FCV The book is self contained and unified in presentation It may be used as an advanced textbook by graduate students and ambitious undergraduates in mathematics and mechanics It provides an opportunity for an introduction to FCV for experienced researchers The explanations in the book are detailed in order to capture the interest of the curious reader and the book provides the necessary background material required to go further

into the subject and explore the rich research literature a

Fractional Calculus: An Introduction For Physicists

(Third Edition) Richard Herrmann, 2018-07-09 The third edition of this book is designed to carefully and coherently introduce fractional calculus to physicists by applying the ideas to two distinct applications classical problems and multi particle quantum problems There remain many open questions and the field remains an active area of research Dr Herrmann's book is an excellent introduction to this field of study Contemporary Physics The book presents a concise introduction to the basic methods and strategies in fractional calculus which enables the reader to catch up with the state of the art in this field and to participate and contribute in the development of this exciting research area This book is devoted to the application of fractional calculus on physical problems The fractional concept is applied to subjects in classical mechanics image processing folded potentials in cluster physics infrared spectroscopy group theory quantum mechanics nuclear physics hadron spectroscopy up to quantum field theory and will surprise the reader with new intriguing insights This new extended edition includes additional chapters about numerical solution of the fractional Schrödinger equation self similarity and the geometric interpretation of non isotropic fractional differential operators Motivated by the positive response new exercises with elaborated solutions are added which significantly support a deeper understanding of the general aspects of the theory Besides students as well as researchers in this field this book will also be useful as a supporting medium for teachers teaching courses devoted to this subject

Development and Application of Difference and Fractional Calculus on Discrete Time Scales Tanner J. Auch, 2013 The purpose of this dissertation is to develop and apply results of both discrete calculus and discrete fractional calculus to further develop results on various discrete time scales Two main goals of discrete and fractional discrete calculus are to extend results from traditional calculus and to unify results on the real line with those on a variety of subsets of the real line Of particular interest is introducing and analyzing results related to a generalized fractional boundary value problem with Lidstone boundary conditions on a standard discrete domain \mathbb{N}_a We also introduce new results regarding exponential order for functions on quantum time scales along with extending previously discovered results Finally we conclude by introducing and analyzing a boundary value problem again with Lidstone boundary conditions on a mixed time scale which may be thought of as a generalization of the other time scales in this work

Reviewing **Nice Discrete Fractional Calculus Christopher Goodrich**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is really astonishing. Within the pages of "**Nice Discrete Fractional Calculus Christopher Goodrich**," an enthralling opus penned by a very acclaimed wordsmith, readers embark on an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve in to the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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Table of Contents Nice Discrete Fractional Calculus Christopher Goodrich

1. Understanding the eBook Nice Discrete Fractional Calculus Christopher Goodrich
 - The Rise of Digital Reading Nice Discrete Fractional Calculus Christopher Goodrich
 - Advantages of eBooks Over Traditional Books
2. Identifying Nice Discrete Fractional Calculus Christopher Goodrich
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in a Nice Discrete Fractional Calculus Christopher Goodrich
 - User-Friendly Interface
4. Exploring eBook Recommendations from Nice Discrete Fractional Calculus Christopher Goodrich
 - Personalized Recommendations
 - Nice Discrete Fractional Calculus Christopher Goodrich User Reviews and Ratings

- Nice Discrete Fractional Calculus Christopher Goodrich and Bestseller Lists
- 5. Accessing Nice Discrete Fractional Calculus Christopher Goodrich Free and Paid eBooks
 - Nice Discrete Fractional Calculus Christopher Goodrich Public Domain eBooks
 - Nice Discrete Fractional Calculus Christopher Goodrich eBook Subscription Services
 - Nice Discrete Fractional Calculus Christopher Goodrich Budget-Friendly Options
- 6. Navigating Nice Discrete Fractional Calculus Christopher Goodrich eBook Formats
 - ePub, PDF, MOBI, and More
 - Nice Discrete Fractional Calculus Christopher Goodrich Compatibility with Devices
 - Nice Discrete Fractional Calculus Christopher Goodrich Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Nice Discrete Fractional Calculus Christopher Goodrich
 - Highlighting and Note-Taking Nice Discrete Fractional Calculus Christopher Goodrich
 - Interactive Elements Nice Discrete Fractional Calculus Christopher Goodrich
- 8. Staying Engaged with Nice Discrete Fractional Calculus Christopher Goodrich
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Nice Discrete Fractional Calculus Christopher Goodrich
- 9. Balancing eBooks and Physical Books Nice Discrete Fractional Calculus Christopher Goodrich
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Nice Discrete Fractional Calculus Christopher Goodrich
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Nice Discrete Fractional Calculus Christopher Goodrich
 - Setting Reading Goals Nice Discrete Fractional Calculus Christopher Goodrich
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Nice Discrete Fractional Calculus Christopher Goodrich
 - Fact-Checking eBook Content of Nice Discrete Fractional Calculus Christopher Goodrich
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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introduction 3 1 2 the role of diamond impurities in quantum information processing qip 3 1 3 types of diamond color center 4 1 4 key properties of nitrogen vacancy nv centers 6 1 5 techniques for creating nv centers 8

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