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# Journal Of Fractional Calculus And Applications

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Fractional Calculus with Applications in Mechanics Springer  
General Fractional Derivatives: Theory, Methods and Applications provides knowledge of the special functions with respect to another function, and the integro-differential operators where the integrals are of the convolution type and exist the singular, weakly singular and nonsingular kernels, which exhibit the fractional derivatives, fractional integrals, general fractional derivatives, and general fractional integrals of the constant and variable order without and with respect to another function due to the appearance of the power-law and complex herbivores to

figure out the modern developments in theoretical and applied science. Features: Give some new results for fractional calculus of constant and variable orders. Discuss some new definitions for fractional calculus with respect to another function. Provide definitions for general fractional calculus of constant and variable orders. Report new results of general fractional calculus with respect to another function. Propose news special functions with respect to another function and their applications. Present new models for the anomalous relaxation and rheological behaviors. This book serves as a reference book and textbook for scientists and engineers in the fields of mathematics, physics, chemistry and engineering, senior undergraduate and graduate students. Dr. Xiao-Jun Yang is a full professor of Applied Mathematics and

Mechanics, at China University of Mining and Technology, China. He is currently an editor of several scientific journals, such as Fractals, Applied Numerical Mathematics, Mathematical Modelling and Analysis, International Journal of Numerical Methods for Heat & Fluid Flow, and Thermal Science.

**An Introduction to Fractional Derivatives, Fractional Differential Equations, to Methods of Their Solution and Some of Their Applications** CRC Press  
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*

**Wave Propagation, Impact and Variational Principles**  
Springer

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.

**Theory and Applications**  
MDPI

The fractional Laplacian, also called the Riesz fractional derivative, describes an unusual diffusion process associated with random

excursions. The Fractional Laplacian explores applications of the fractional Laplacian in science, engineering, and other areas where long-range interactions and conceptual or physical particle jumps resulting in an irregular diffusive or conductive flux are encountered. Presents the material at a level suitable for a broad audience of scientists and engineers with rudimentary background in ordinary differential equations and integral calculus Clarifies the concept of the fractional Laplacian for functions in one, two, three, or an arbitrary number of dimensions defined over the entire space, satisfying periodicity conditions, or restricted to a finite domain Covers physical and mathematical concepts as well as detailed mathematical derivations Develops a numerical framework for solving differential equations involving the fractional Laplacian and presents specific algorithms accompanied by numerical results in one, two, and three dimensions Discusses viscous flow and physical examples from scientific and engineering disciplines Written by a prolific author well known for his contributions in fluid mechanics, biomechanics,

applied mathematics, scientific computing, and computer science, the book emphasizes fundamental ideas and practical numerical computation. It includes original material and novel numerical methods.

The Fractional Laplacian  
World Scientific

This monograph provides a comprehensive overview of the author's work on the fields of fractional calculus and waves in linear viscoelastic media, which includes his pioneering contributions on the applications of special functions of the Mittag-Leffler and Wright types. It is intended to serve as a general introduction to the above-mentioned areas of mathematical modeling. The explanations in the book are detailed enough to capture the interest of the curious reader, and complete enough to provide the necessary background material needed to delve further into the subject and explore the research literature given in the huge general bibliography. This book is likely to be of interest to applied scientists and engineers.

Contents:Essentials of Fractional CalculusEssentials of Linear ViscoelasticityFractional Viscoelastic ModelsWaves in Linear Viscoelastic Media: Dispersion and DissipationWaves in Linear Viscoelastic Media: Asymptotic RepresentationsDiffusion and Wave–Propagation via Fractional CalculusAppendices:The Eulerian FunctionsThe Bessel FunctionsThe Error FunctionsThe Exponential Integral FunctionsThe Mittag-Leffler FunctionsThe Wright Functions Readership: Graduate and PhD students in applied mathematics, classical physics, mechanical engineering and chemical physics; academic institutions; research centers.  
Keywords:Fractional Calculus;Fractional Derivatives;Fractional Integrals;Linear Viscoelasticity;Rheological Models;Special Functions;Mittag-Leffler Functions;Wright Functions;Integral Transforms;Laplace Transforms;Fourier Transforms;Waves;Dispersion;Di

ssipation; Diffusion; Anomalous Diffusion  
**Key Features:** Contains accessible mathematical language for easy understanding  
**Features:** ample examples to reiterate concepts in the book  
 Makes extensive use of graphical images  
 Includes a large and informative general bibliography for further research

*Matrix Methods And Fractional Calculus* Springer

Fractional calculus in terms of mathematics and statistics and its applications to problems in natural sciences is NOT yet part of university teaching curricula. This book is one attempt to provide an approach to include topics of fractional calculus into university curricula.

Additionally the material is useful for people who do research work in the areas of special functions, fractional calculus, applications of fractional calculus, and mathematical statistics.

**Contents:** Preface  
 List of Symbols  
 Vector/Matrix Derivatives and Optimization  
 Jacobians of Matrix Transformations and Functions of Matrix Argument  
 Fractional Calculus and Special Functions  
 Fractional Calculus and Fractional Differential Equations  
 Kober Fractional Calculus and Matrix-Variate Functions  
 Lie Theory and Special Functions  
 Selected

Topics in Multivariate Analysis  
**Readership:** Graduate students and researchers in all aspects of fractional calculus and its applications.  
**Keywords:** Vector/Matrix Derivatives; Optimization; Jacobians of Matrix Transformations; Multivariate Analysis; Functions of Matrix Argument; Fractional Calculus; Special Functions; Lie Theory; Fractional Differential Equations; Kober Fractional Calculus; Matrix-Variate Functions  
**Review:** 0  
[Generalized Fractional Calculus and Applications](#)  
 Springer

Due to its ubiquity across a variety of fields in science and engineering, fractional calculus has gained momentum in industry and academia. While a number of books and papers introduce either fractional calculus or numerical approximations, no current literature provides a comprehensive collection of both topics. This monograph introduces fundamental information on fractional calculus, provides a detailed treatment of existing numerical approximations, and presents an inclusive review of fractional calculus in terms of theory and numerical methods and systematically examines almost all existing numerical approximations for fractional integrals and derivatives. The authors consider the relationship between the

fractional Laplacian and the Riesz derivative, a key component absent from other related texts, and highlight recent developments, including their own research and results. The core audience spans several fractional communities, including those interested in fractional partial differential equations, the fractional Laplacian, and applied and computational mathematics. Advanced undergraduate and graduate students will find the material suitable as a primary or supplementary resource for their studies.

### **Journal of Fractional Calculus** SIAM

This book is likely to be of interest to applied scientists and engineers.  
 --Book Jacket.

### **Multiple Solutions Of Boundary Value Problems: A Variational Approach** Bentham Science Publishers

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. Contents: Introduction Functions The Fractional Derivative Friction Forces Fractional Calculus The Fractional Harmonic Oscillator Wave Equations and Parity Nonlocality and Memory Effects Fractional Calculus in

Multidimensional Space — 2D-Image Processing Fractional Calculus in Multidimensional Space — 3D-Folded Potentials in Cluster Physics Quantum Mechanics The Fractional Schrödinger Equation with the Infinite Well Potential — Numerical Results using the Riesz Derivative Uniqueness of a Fractional Derivative — Riesz and Regularized Liouville Derivative as Examples Fractional Spin — A Property of Particles Described with the Fractional Schrödinger Equation Factorization Symmetries The Fractional Symmetric Rigid Rotor  $q$ -Deformed Lie Algebras and Fractional Calculus Infrared Spectroscopy of Diatomic Molecules Fractional Spectroscopy of Hadrons Magic Numbers in Atomic Nuclei Magic Numbers in Metal Clusters Fractors — Fractional Tensor Calculus Fractional Fields Gauge Invariance in Fractional Field Theories On the Origin of Space Outlook Readership: Students and researchers in physics. Keywords: Mathematical

Physics; Fractional Calculus; Long-Memory Kernels; Non-Local Field Theories; Fractional Quantum Mechanics Key Features: This was the first book on the market covering the full area of a physical application of fractional calculus. The book provides a skillful insight into a vividly growing research area and guides the reader from his first steps on an introductory level up to the current state of the art of a physical interpretation and application in different fields. This book enables the reader to participate and contribute to the development of this exciting research area by applying these methods in his own research area too. Reviews: Reviews of the First Edition: "Fractional Calculus is an affordable and valuable introduction to the field that will appeal to physicists interested in scientific what-ifs." Physics Today "... the first three chapters actually appear very helpful at the graduate level. Each chapter has a careful precis at the start. There are many analyses illustrating outcomes of fractional

analyses... If this [fractional calculus] is the field of your research then this book is essential with numerous references... ” Contemporary Physics “The book has the property that derived results are directly compared with experimental findings. As a consequence, the reader is guided and encouraged to apply the fractional calculus approach in her/his research area. The reviewer strongly recommends this book for beginners as well as specialists in the fields of physics, mathematics and complex adaptive systems.” Zentralblatt MATH “A very welcome new feature in the second edition is the inclusion of exercises at the end of every chapter, with detailed solutions in the back of the book. This book is specifically aimed at physicists, although many of my colleagues outside physics have also found it useful. This is particularly true of graduate students and beginning researchers, or those new to the subject of fractional calculus.” Mark Meerschaert Dept of Statistics and Probability,

Michigan State University  
New Trends in Fractional Differential Equations with Real-World Applications in Physics Elsevier

Variational methods and their generalizations have been verified to be useful tools in proving the existence of solutions to a variety of boundary value problems for ordinary, impulsive, and partial differential equations as well as for difference equations. In this monograph, we look at how variational methods can be used in all these settings. In our first chapter, we gather the basic notions and fundamental theorems that will be applied in the remainder of this monograph. While many of these items are easily available in the literature, we gather them here both for the convenience of the reader and for the purpose of making this volume somewhat self-contained. Subsequent chapters deal with the Sturm-Liouville problems, multi-point boundary value problems, problems with impulses, partial differential equations, and difference equations. An extensive bibliography is also included.

Nonlocal and Fractional Operators World Scientific

This book contains mathematical preliminaries in which basic definitions of fractional derivatives and spaces are presented. The central part of the book contains various

applications in classical mechanics including fields such as: viscoelasticity, heat conduction, wave propagation and variational Hamilton-type principles. Mathematical rigor will be observed in the applications. The authors provide some problems formulated in the classical setting and some in the distributional setting. The solutions to these problems are presented in analytical form and these solutions are then analyzed numerically. Theorems on the existence of solutions will be presented for all examples discussed. In using various constitutive equations the restrictions following from the second law of thermodynamics will be implemented. Finally, the physical implications of obtained solutions will be discussed in detail.

**Solved Exercises in Fractional Calculus**

Academic Press

The purpose of this volume is to explore new bridges between different research areas involved in the theory and applications of the fractional calculus. In particular, it collects scientific and original contributions to the development of the theory of nonlocal and fractional operators. Special attention is

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given to the applications in mathematical physics, as well as in probability. Numerical methods aimed to the solution of problems with fractional differential equations are also treated in the book. The contributions have been presented during the international workshop "Nonlocal and Fractional Operators", held in Sapienza University of Rome, in April 2019, and dedicated to the retirement of Prof. Renato Spigler (University Roma Tre). Therefore we also wish to dedicate this volume to this occasion, in order to celebrate his scientific contributions in the field of numerical analysis and fractional calculus. The book is suitable for mathematicians, physicists and applied scientists interested in the various aspects of fractional calculus.

*General Fractional Derivatives* CRC Press

The book is devoted to recent developments in the theory of fractional calculus and its applications. Particular attention is paid to the applicability of this currently popular research field in various branches of pure and applied mathematics. In particular, the book focuses on the more recent results in mathematical physics, engineering applications, theoretical and applied physics as quantum mechanics, signal analysis, and in those relevant

research fields where nonlinear dynamics occurs and several tools of nonlinear analysis are required. Dynamical processes and dynamical systems of fractional order attract researchers from many areas of sciences and technologies, ranging from mathematics and physics to computer science.

**Fractional Calculus with Applications in Mechanics** Cambridge Scholars Publishing

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

Advanced Mathematical Methods CRC Press

This book brings together eleven topics on different aspects of fractional calculus in a single volume.

It provides readers the basic knowledge of fractional calculus and introduces advanced topics and applications. The information in the book is presented in four parts: Fractional Diffusion Equations: (i) solutions of fractional diffusion equations using wavelet methods, (ii) the maximum principle for time fractional diffusion equations, (iii) nonlinear sub-diffusion equations. Mathematical Analysis: (i) shifted Jacobi polynomials for solving and identifying coupled fractional delay differential equations, (ii) the monotone iteration principle in the theory of Hadamard fractional delay differential equations, (iii) dynamics of fractional order modified Bhalekar-Gejji System, (iv) Grunwald-Letnikov derivatives. Computational Techniques: GPU computing of special mathematical functions used in fractional calculus. Reviews: (i) the popular iterative method NIM, (ii) fractional derivative with non-singular kernels, (iii) some open problems in fractional order nonlinear system This is a useful reference for researchers and graduate level mathematics students seeking knowledge about of fractional calculus and applied mathematics. **Fractional Calculus and its**

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## Applications in Physics

Springer Nature

Fractional calculus was first developed by pure mathematicians in the middle of the 19th century. Some 100 years later, engineers and physicists have found applications for these concepts in their areas. However there has traditionally been little interaction between these two communities. In particular, typical mathematical works provide extensive findings on aspects with comparatively little significance in applications, and the engineering literature often lacks mathematical detail and precision. This book bridges the gap between the two communities. It concentrates on the class of fractional derivatives most important in applications, the Caputo operators, and provides a self-contained, thorough and mathematically rigorous study of their properties and of the corresponding differential equations. The text is a useful tool for mathematicians and researchers from the applied sciences alike. It can also be used as a basis for teaching graduate courses on fractional differential equations.

*Fractional Differential*

*Equations* Springer Science & Business Media

In many fields of application of mathematics, progress is crucially dependent on the good flow of information between (i) theoretical mathematicians looking for applications, (ii)

mathematicians working in applications in need of theory, and (iii) scientists and engineers applying mathematical models and methods. The intention of this book is to stimulate this flow of information. In the first three chapters (accessible to third year students of mathematics and physics and to mathematically interested engineers) applications of Abel integral equations are surveyed broadly including determination of potentials, stereology, seismic travel times, spectroscopy, optical fibres. In subsequent chapters (requiring some background in functional analysis) mapping properties of Abel integral operators and their relation to other integral transforms in various function spaces are investigated, questions of existence and uniqueness of solutions of linear and nonlinear Abel integral equations are treated, and for equations of the first kind problems of ill-posedness are discussed. Finally, some numerical methods are described. In the theoretical parts, emphasis is put on the aspects relevant to applications.

## Special Functions: Fractional Calculus and the Pathway for Entropy

Springer

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.



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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.

**Theory, Methods and Applications** CRC Press

This book presents a simplified deliberation of fractional calculus, which will appeal not only to beginners, but also to various applied science mathematicians and engineering researchers. The text develops the ideas behind this new field of mathematics, beginning at the most elementary level, before discussing its actual applications in different areas of science and engineering. This book shows that the

simple, classical laws based on Newtonian calculus, which work quite well under limiting and idealized conditions, are not of much use in describing the dynamics of actual systems. As such, the application of non-Newtonian, or generalized, calculus in the governing equations, allows the order of differentiation and integration to take on non-integer values.

Fractional Calculus: Theory and Applications Walter de Gruyter GmbH & Co KG

This book is a printed edition of the Special Issue "Special Functions: Fractional Calculus and the Pathway for Entropy Dedicated to Professor Dr. A.M. Mathai on the occasion of his 80th Birthday" that was published in Axioms