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The numerical analysis shows that the fractionally damped energy harvesting system exhibits chaos, periodic motion, chaos and periodic motion in turn when the fractional order changes from 0.2 to 1.5. The period doubling route to chaos and the inverse period doubling route from chaos to periodic motion can be clearly observed.

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Abstract Vibration phenomena of the fractionally damped systems have attracted increasing attentions in recent years. In this paper, dynamics of the fractionally damped Duffing equation is examined. The fractionally damped Duffing equation is transformed into a set of fractional integral equations solved by a predictor–corrector method. The effect of fractional order of damping on the ...

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Vibration phenomena of the fractionally damped systems have attracted increasing attentions in recent years. In this paper, dynamics of the fractionally damped Duffing equation is examined. The fractionally damped Duffing equation is transformed into a set of fractional integral equations solved by a predictor-corrector method. The effect of fractional order of damping on the dynamic behaviors ...

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Abstract: The effect of nonsinusoidal forces on the onset of horseshoe chaos is studied both

analytically and numerically in the fractionally damped Duf?ng-vander Pol (DVP) oscillator. The nonsinusoidal peri-odic forces considered are square-wave, symmetric saw-tooth wave, and asymmetric saw-tooth wave. An

Horseshoe Dynamics in Fractionally Damped Duf?ng-Vander ...

Before a solution to the linear fractionally damped oscillator equation is constructed it will be useful to review the Laplace transform method of solution for the linearly damped oscillator equation The ... “Chaotic and pseudochaotic attractors of perturbed fractional oscillator,” Chaos, vol. 16, no. 1, Article ID 013102.

Linear Fractionally Damped Oscillator

the fractionally damped energy harvesting system exhibits chaos, and periodic motion, as the fractional order changes. The observed bifurcations strongly in?uence the power output. 1 Introduction A recent concept of frequency broadband energy harvesting systems consists of using nonlinear phenomena (such as

Discontinuity in Nonlinear Physical Systems explores recent developments in experimental research in this broad field, organized in four distinct sections. Part I introduces the reader to the fractional dynamics and Lie group analysis for nonlinear partial differential equations. Part II covers chaos and complexity in nonlinear Hamiltonian systems, important to understand the resonance interactions in nonlinear dynamical systems, such as Tsunami waves and wildfire propagations; as well as Lev flights in chaotic trajectories, dynamical system synchronization and DNA information complexity analysis. Part III examines chaos and periodic motions in discontinuous dynamical systems, extensively present in a range of systems, including piecewise linear systems, vibro-impact systems and drilling systems in engineering. And in Part IV, engineering and financial nonlinearity are discussed. The mechanism of shock wave with saddle-node bifurcation and rotating disk stability will be presented, and the financial nonlinear models will be discussed.

"Fractional-Order Nonlinear Systems: Modeling, Analysis and Simulation" presents a study of fractional-order chaotic systems accompanied by Matlab programs for simulating their state space trajectories, which are shown in the illustrations in the book. Description of the chaotic systems is clearly presented and their analysis and numerical solution are done in an easy-to-follow manner. Simulink models for the selected fractional-order systems are also presented. The readers will understand the fundamentals of the fractional calculus, how real dynamical systems can be described using fractional derivatives and fractional differential equations, how such equations can be solved, and how to simulate and explore chaotic systems of fractional order. The book addresses to mathematicians, physicists, engineers, and other scientists interested in chaos phenomena or in fractional-order systems. It can be used in courses on dynamical systems, control theory, and applied mathematics at graduate or postgraduate level. Ivo Petráš is an Associate Professor of automatic control and the Director of the Institute of Control and Informatization of Production Processes, Faculty of BERG, Technical University of Košice, Slovak Republic. His main research interests include control systems, industrial automation, and applied mathematics.

This multi-volume handbook is the most up-to-date and comprehensive reference work in the field of fractional calculus and its numerous applications. This fourth volume collects authoritative chapters covering several applications of fractional calculus in physics, including

classical and continuum mechanics.

It is very well known that differential equations are related with the rise of physical science in the last several decades and they are used successfully for models of real-world problems in a variety of fields from several disciplines. Additionally, difference equations represent the discrete analogues of differential equations. These types of equations started to be used intensively during the last several years for their multiple applications, particularly in complex chaotic behavior. A certain class of differential and related difference equations is represented by their respective fractional forms, which have been utilized to better describe non-local phenomena appearing in all branches of science and engineering. The purpose of this book is to present some common results given by mathematicians together with physicists, engineers, as well as other scientists, for whom differential and difference equations are valuable research tools. The reported results can be used by researchers and academics working in both pure and applied differential equations.

This book is devoted to the application of fractional calculus in economics to describe processes with memory and non-locality. Fractional calculus is a branch of mathematics that studies the properties of differential and integral operators that are characterized by real or complex orders. Fractional calculus methods are powerful tools for describing the processes and systems with memory and nonlocality. Recently, fractional integro-differential equations have been used to describe a wide class of economical processes with power law memory and spatial nonlocality. Generalizations of basic economic concepts and notions the economic processes with memory were proposed. New mathematical models with continuous time are proposed to describe economic dynamics with long memory. This book is a collection of articles reflecting the latest mathematical and conceptual developments in mathematical economics with memory and non-locality based on applications of fractional calculus.

The book is a collection of contributions devoted to analytical, numerical and experimental techniques of dynamical systems, presented at the International Conference on Dynamical Systems: Theory and Applications, held in ?ód?, Poland on December 2-5, 2013. The studies give deep insight into both the theory and applications of non-linear dynamical systems, emphasizing directions for future research. Topics covered include: constrained motion of mechanical systems and tracking control; diversities in the inverse dynamics; singularly perturbed ODEs with periodic coefficients; asymptotic solutions to the problem of vortex structure around a cylinder; investigation of the regular and chaotic dynamics; rare phenomena and chaos in power converters; non-holonomic constraints in wheeled robots; exotic bifurcations in non-smooth systems; micro-chaos; energy exchange of coupled oscillators; HIV dynamics; homogenous transformations with applications to off-shore slender structures; novel approaches to a qualitative study of a dissipative system; chaos of postural sway in humans; oscillators with fractional derivatives; controlling chaos via bifurcation diagrams; theories relating to optical choppers with rotating wheels; dynamics in expert systems; shooting methods for non-standard boundary value problems; automatic sleep scoring governed by delay differential equations; isochronous oscillations; the aerodynamics pendulum and its limit cycles; constrained N-body problems; nano-fractal oscillators and dynamically-coupled dry friction.

Vibration is important subject in many fields, ranging from mechanical engineering to electronic one. This book aims at giving a combination of conventional linear vibrations with recent fractional ones from a view of engineering. It consists of two parts. One is for conventional linear vibrations in Chapters 1 - 6 based on the authors lectures on the course of ship hull

vibrations for undergraduates and postgraduates in Ocean College, Zhejiang University, China. The other, Chapters 7 - 15, contains his research in fractional vibrations. the book is suitable for researchers and graduate students in science and engieering. Preferred preliminaries are calculus, university physics, theoretic mechanics, and material mechanics for readers.

This book constitutes the refereed proceedings of the 4th Computational Methods in Systems and Software 2020 (CoMeSySo 2020) proceedings. Software engineering, computer science and artificial intelligence are crucial topics for the research within an intelligent systems problem domain. The CoMeSySo 2020 conference is breaking the barriers, being held online. CoMeSySo 2020 intends to provide an international forum for the discussion of the latest high-quality research results.

This volume covers a diverse collection of topics dealing with some of the fundamental concepts and applications embodied in the study of nonlinear dynamics. Each of the 15 chapters contained in this compendium generally fit into one of five topical areas: physics applications, nonlinear oscillators, electrical and mechanical systems, biological and behavioral applications or random processes. The authors of these chapters have contributed a stimulating cross section of new results, which provide a fertile spectrum of ideas that will inspire both seasoned researches and students.

Presents a systematic treatment of fuzzy fractional differential equations as well as newly developed computational methods to model uncertain physical problems Complete with comprehensive results and solutions, Fuzzy Arbitrary Order System: Fuzzy Fractional Differential Equations and Applications details newly developed methods of fuzzy computational techniquesneeded to model solve uncertainty. Fuzzy differential equations are solved via various analytical andnumerical methodologies, and this book presents their importance for problem solving, prototypeengineering design, and systems testing in uncertain environments. In recent years, modeling of differential equations for arbitrary and fractional order systems has been increasing in its applicability, and as such, the authors feature examples from a variety of disciplines to illustrate the practicality and importance of the methods within physics, applied mathematics, engineering, and chemistry, to name a few. The fundamentals of fractional differential equations and the basic preliminaries of fuzzy fractional differential equations are first introduced, followed by numerical solutions, comparisons of various methods, and simulated results. In addition, fuzzy ordinary, partial, linear, and nonlinear fractional differential equations are addressed to solve uncertainty in physical systems. In addition, this book features: Basic preliminaries of fuzzy set theory, an introduction of fuzzy arbitrary order differential equations, and various analytical and numerical procedures for solving associated problems Coverage on a variety of fuzzy fractional differential equations including structural, diffusion, and chemical problems as well as heat equations and biomathematical applications Discussions on how to model physical problems in terms of nonprobabilistic methods and provides systematic coverage of fuzzy fractional differential equations and its applications Uncertainties in systems and processes with a fuzzy concept Fuzzy Arbitrary Order System: Fuzzy Fractional Differential Equations and Applications is an ideal resource for practitioners, researchers, and academicians in applied mathematics, physics, biology, engineering, computer science, and chemistry who need to model uncertain physical phenomena and problems. The book is appropriate for graduate-level courses on fractional differential equations for students majoring in applied mathematics, engineering, physics, and computer science.