of a two-volume presentation on current research problems in quantum optics, and will serve as a standard reference in the field for many years to come. The book provides an introduction to the methods of quantum statistical mechanics used in quantum optics and their application to the quantum theories of the single-mode laser and optical bistability. The generalized representations of Drummond and Gardiner are discussed together with the more standard methods for deriving Fokker-Planck equations.

Molecular motors convert chemical energy (typically from ATP hydrolysis) to directed motion and mechanical work. Biomolecular motors are proteins able of converting chemical energy into mechanical motion and force. Because of their dimension, the many small parts that make up molecular motors must operate at energies only a few times greater than those of the thermal baths. The description of molecular motors must be stochastic in nature. Their actions are often described in terms of Brownian Ratchets mechanisms. In order to describe the principles used in their movement, we need to use the tools that theoretical physics give us. In this book we centralize on the some physical mechanisms of molecular motors. The Fokker-Planck equation is reduced to a form that is useful from the viewpoint of doing practical calculations of problems involving configuration space as well as velocity space. The basic technique is a spherical harmonic decomposition in velocity space that reduces the number of independent variables by two. As an example, we show how to apply this method to a problem with theta-pinch geometry. The book is devoted to the fundamental relationship between three objects: a stochastic process, stochastic differential equations driven by that process and their associated Fokker-Planck-Kolmogorov equations. This book discusses wide fractional generalizations of this fundamental triple relationship, where the driving process represents a time-changed stochastic process; the Fokker-Planck-Kolmogorov equation involves time-fractional order derivatives and spatial pseudo-differential operators; and the associated stochastic differential equation describes the stochastic behavior of the solution process. It contains recent results obtained in this direction. This book is important since the latest developments in the field, including the role of driving processes and their scaling limits, the forms of corresponding stochastic differential equations, and associated FPK equations, are systematically presented. Examples and important applications to various scientific, engineering, and economics problems make the book attractive for all interested researchers, educators, and graduate students. In 438 alphabetically-arranged essays, this work provides a useful overview of the core mathematical background for nonlinear science, as well as its applications to key problems in ecology and biological systems, chemical reaction-diffusion problems, geophysics, economics, electrical and mechanical oscillations in engineering systems, lasers and nonlinear optics, fluid mechanics and turbulence, and condensed matter physics, among others. Stochastic Methods & their Applications to Communications presents a valuable approach to the modelling, synthesis and numerical simulation of random processes with applications in communications and related fields. The authors provide a detailed account of random processes from an engineering point of view and illustrate the concepts with examples taken from the communications area.
The discussions mainly focus on the analysis and synthesis of Markov models of random processes as applied to modelling such phenomena as interference and fading in communications. Encompassing both theory and practice, this original text provides a unified approach to the analysis and generation of continuous, impulsive and mixed random processes based on the Fokker-Planck equation for Markov processes. Presents the cumulated analysis of Markov processes Offers a SDE (Stochastic Differential Equations) approach to the generation of random processes with specified characteristics Includes the modelling of communication channels and interfer ences using SDE Features new results and techniques for the of solution of the generalized Fokker-Planck equation Essential reading for researchers, engineers, and graduate and upper year undergraduate students in the field of communications, signal processing, control, physics and other areas of science, this reference will have wide ranging appeal. This is an analysis of multidimensional nonlinear dissipative Hamiltonian dynamical systems subjected to parametric and external stochastic excitations by the Fokker-Planck equation method. The author answers three types of questions concerning this area. First, what probabilistic tools are necessary for constructing a stochastic model and deriving the FKP equation for nonlinear stochastic dynamical systems? Secondly, what are the main results concerning the existence and uniqueness of an invariant measure and its associated stationary response? Finally, what is the class of multidimensional dynamical systems that have an explicit invariant measure and what are the fundamental examples for applications? This Festschrift is dedicated to Professor Dr.-Ing. habil. Peter Wriggers on the occasion of his 60th birthday. It contains contributions from friends and collaborators as well as current and former PhD students from almost all continents. A s a very diverse group of people, the authors cover a wide range of topics from fundamental research to industrial applications: contact mechanics, finite element technology, micromechanics, multiscale approaches, particle methods, isogeometric analysis, stochastic methods and further research interests. In summary, the volume presents an overview of the international state of the art in computational mechanics, both in academia and industry. This thesis deals with the numerical solution of the Fokker-Planck equation in n-dimensional space using the method of finite element with n-simplex elements. The numerical code is validated through numerous examples. Finally the method is used in investigating the problem of cooling atoms and ions using laser light. Die mathematische Theorie der optimalen Steuerung hat sich im Zusammenhang mit Berechnungen für die Luft- und Raumfahrt schnell zu einem wichtigen und eigenständigen Gebiet der angewandten Mathematik entwickelt. Die optimale Steuerung durch partielle Differentialgleichungen modellierter Prozesse wird eine numerische Herausforderung der Zukunft sein. Im Buch werden entsprechende Grundlagen mit langsam steigendem Schwierigkeitsgrad entwickelt. Es enthält viele Beispiele und eignet sich als Grundlage für Vorlesungen und Seminare. Der Text wurde für die 2. Auflage grundlegend überarbeitet. Die Darstellung der numerischen Methoden orientiert sich stärker an den konkret zu rechnenden Systemen. Neueste Ergebnisse zur maximalen Regularität parabolischer Differentialgleichungen sind eingearbeitet.
Lösungshinweise zu den Übungsaufgaben findet der Studierende nun im OnlinePLUS-Service des Verlages. This is the first textbook to include the matrix continued-fraction method, which is very effective in dealing with simple Fokker-Planck equations having two variables. Other methods covered are the simulation method, the eigen-function expansion, numerical integration, and the variational method. Each solution is applied to the statistics of a simple laser model and to Brownian motion in potentials. The whole is rounded off with a supplement containing a short review of new material together with some recent references. This new study edition will prove to be very useful for graduate students in physics, chemical physics, and electrical engineering, as well as for research workers in these fields. Our original objective in writing this book was to demonstrate how the concept of the equation of motion of a Brownian particle — the Langevin equation or Newtonian-like evolution equation of the random phase space variables describing the motion — first formulated by Langevin in 1908 — so making him inter alia the founder of the subject of stochastic differential equations, may be extended to solve the nonlinear problems arising from the Brownian motion in a potential. Such problems appear under various guises in many diverse applications in physics, chemistry, biology, electrical engineering, etc. However, they have been invariably treated (following the original approach of Einstein and Smoluchowski) via the Fokker–Planck equation for the evolution of the probability density function in phase space. Thus the more simple direct dynamical approach of Langevin which we use and extend here, has been virtually ignored as far as the Brownian motion in a potential is concerned. In addition two other considerations have driven us to write this new edition of The Langevin Equation. First, more than five years have elapsed since the publication of the third edition and following many suggestions and comments of our colleagues and other interested readers, it became increasingly evident to us that the book should be revised in order to give a better presentation of the contents. In particular, several chapters appearing in the third edition have been rewritten so as to provide a more direct appeal to the particular community involved and at the same time to emphasize via a synergetic approach how seemingly unrelated physical problems all involving random noise may be described using virtually identical mathematical methods. Secondly, in that period many new and exciting developments have occurred in the application of the Langevin equation to Brownian motion. Consequently, in order to accommodate all these, a very large amount of new material has been added so as to present a comprehensive overview of the subject. There has recently been a renewal of interest in Fokker-Planck operators, motivated by problems in statistical physics, in kinetic equations, and differential geometry. Compared to more standard problems in the spectral theory of partial differential operators, those operators are not self-adjoint and only hypoelliptic. The aim of the analysis is to give, as generally as possible, an accurate qualitative and quantitative description of the exponential return to the thermodynamical equilibrium. While exploring and improving recent results in this direction, this volume proposes a review of known techniques on: the hypoellipticity of polynomial of vector fields and its global counterpart, the global Weyl-Hörmander
pseudo-differential calculus, the spectral theory of non-self-adjoint operators, the semi-classical analysis of Schrödinger-type operators, the Witten complexes, and the Morse inequalities. 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 (3+1)-dimensional time-fractional Khokhlov–Zabolotskaya–Kuznetsov equation, (3+1)-dimensional time-fractional KdV–Khokhlov–Zabolotskaya–Kuznetsov equation, fractional (2+1)-dimensional Davey–Stewartson equation, and 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, 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. Safety, Reliability, Risk and Life-Cycle Performance of Structures and Infrastructures contains the plenary lectures and papers presented at the 11th International Conference on STRUCTURAL SAFETY AND RELIABILITY (ICOSSAR2013, New York, NY, USA, 16-20 June 2013), and covers major aspects of safety, reliability, risk and life-cycle performance of structures. The central problem of synergetics is concerned with the study of macroscopic qualitative changes of systems belonging to various disciplines such as physics, chemistry, or electrical engineering. When such transitions from one state to another take place, fluctuations, i.e., random processes, may play an important role. Over the past decades it has turned out that the Fokker-Planck equation provides a powerful tool with which the effects of fluctuations close to transition points can be adequately treated and that the approaches based on the Fokker Planck equation are superior to other approaches, e.g., based on Langevin equations. Quite generally, the Fokker-Planck equation plays an important role in problems which involve noise, e.g., in electrical circuits. For these reasons I am sure that this book will find a broad audience. It provides the reader with a sound basis for the study of the Fokker-Planck equation and gives an excellent survey of the methods of its solution. The author of this book, Hannes Risken, has made substantial contributions to the development and application of such methods, e.g., to laser physics, diffusion in periodic potentials, and other problems. Therefore this book is written by an experienced practitioner, who has had in mind explicit applications to
important problems in the natural sciences and electrical engineering. This book gives an exposition of the principal concepts and results related to second order elliptic and parabolic equations for measures, the main examples of which are Fokker-Planck-Kolmogorov equations for stationary and transition probabilities of diffusion processes. Existence and uniqueness of solutions are studied along with existence and Sobolev regularity of their densities and upper and lower bounds for the latter. The target readership includes mathematicians and physicists whose research is related to diffusion processes as well as elliptic and parabolic equations. The book is suitable for a lecture course on the theory of Brownian motion, being based on final year undergraduate lectures given at Trinity College, Dublin. Topics that are discussed include: white noise; the Chapman-Kolmogorov equation; Kramers-Moyal expansion; the Langevin equation; the Fokker-Planck equation; Brownian motion of a free particle; spectral density and the Wiener-Khintchin theorem; Brownian motion in a potential application to the Josephson effect, ring laser gyro; Brownian motion in two dimensions; harmonic oscillators; itinerant oscillators; linear response theory; rotational Brownian motion; application to loss processes in dielectric and ferrofluids; superparamagnetism and nonlinear relaxation processes.

As the first elementary book on the Langevin equation approach to Brownian motion, this volume attempts to fill in all the missing details which students find particularly hard to comprehend from the fundamental papers contained in the Dover reprint: Selected Papers on Noise and Stochastic Processes, ed. N. Wax (1954) together with modern applications particularly to relaxation in ferrofluids and polar dielectrics. This book presents various results and techniques from the theory of stochastic processes that are useful in the study of stochastic problems in the natural sciences. The main focus is analytical methods, although numerical methods and statistical inference methodologies for studying diffusion processes are also presented. The goal is the development of techniques that are applicable to a wide variety of stochastic models that appear in physics, chemistry and other natural sciences. Applications such as stochastic resonance, Brownian motion in periodic potentials and Brownian motors are studied and the connection between diffusion processes and time-dependent statistical mechanics is elucidated. The book contains a large number of illustrations, examples, and exercises. It will be useful for graduate-level courses on stochastic processes for students in applied mathematics, physics and engineering. Many of the topics covered in this book (reversible diffusions, convergence to equilibrium for diffusion processes, inference methods for stochastic differential equations, derivation of the generalized Langevin equation, exit time problems) cannot be easily found in textbook form and will be useful to both researchers and students interested in the applications of stochastic processes.

This book is a pedagogical presentation of the application of spectral and pseudospectral methods to kinetic theory and quantum mechanics. There are additional applications to astrophysics, engineering, biology and many other fields. The main objective of this book is to provide the basic concepts to enable the use of spectral and pseudospectral methods to solve problems in diverse fields of interest and to a wide audience. While spectral methods are generally based on
Fourier Series or Chebychev polynomials, non-classical polynomials and associated quadratures are used for many of the applications presented in the book. Fourier series methods are summarized with a discussion of the resolution of the Gibbs phenomenon. Classical and non-classical quadratures are used for the evaluation of integrals in reaction dynamics including nuclear fusion, radial integrals in density functional theory, in elastic scattering theory and other applications. The subject matter includes the calculation of transport coefficients in gases and other gas dynamical problems based on spectral and pseudospectral solutions of the Boltzmann equation. Radiative transfer in astrophysics and atmospheric science, and applications to space physics are discussed. The relaxation of initial non-equilibrium distributions to equilibrium for several different systems is studied with the Boltzmann and Fokker-Planck equations. The eigenvalue spectra of the linear operators in the Boltzmann, Fokker-Planck and Schrödinger equations are studied with spectral and pseudospectral methods based on non-classical orthogonal polynomials. The numerical methods referred to as the Discrete Ordinate Method, Differential Quadrature, the Quadrature Discretization Method, the Discrete Variable Representation, the Lagrange Mesh Method, and others are discussed and compared. MATLAB codes are provided for most of the numerical results reported in the book - see Link under 'Additional Information' on the the right-hand column.

The main focus of the book is to implement wavelet based transform methods for solving problems of fractional order partial differential equations arising in modelling real physical phenomena. It explores analytical and numerical approximate solution obtained by wavelet methods for both classical and fractional order partial differential equations. Uncertainty presents significant challenges in the reasoning about and controlling of complex dynamical systems. To address this challenge, numerous researchers are developing improved methods for stochastic analysis. This book presents a diverse collection of some of the latest research in this important area. In particular, this book gives an overview of some of the theoretical methods and tools for stochastic analysis, and it presents the applications of these methods to problems in systems theory, science, and economics.

In the study of charged particle transport in plasmas, numerical techniques for solving the Fokker-Planck equation have been developed which closely parallel those used in neutron transport. This was a natural step since the theory and methods of neutron transport have been well developed. Moreover a line of treatment has been developed tailored to the specific requirements of transport in mirror machines. This approach involves the assumption that the distribution function remain constant along a guiding center orbit. Diffusion techniques have been developed in which sequential moments of the transport equation are taken so as to generate a set of coupled equations. Here a method is developed which treats the transport operator according to the standard diamond differencing techniques of neutron transport, but treats the collision term by a method designed to take advantage of the form of the Fokker-Planck collision operator. This latter method makes use of matrix factorization techniques. In the absence of applied external fields, this method conserves particles rigorously. Deterministic methods run into difficulty in
the treatment of magnetized plasmas in cases in which the guiding-center approximation does not apply. Thus, there are some situations in which one is driven to Monte Carlo techniques which are not a subject of this paper. A symptotic methods are of great importance for practical applications, especially in dealing with boundary value problems for small stochastic perturbations. This book deals with nonlinear dynamical systems perturbed by noise. It addresses problems in which noise leads to qualitative changes, escape from the attraction domain, or extinction in population dynamics. The most likely exit point and expected escape time are determined with singular perturbation methods for the corresponding Fokker-Planck equation. The authors indicate how their techniques relate to the Itô calculus applied to the Langevin equation. The book will be useful to researchers and graduate students. Centered around the natural phenomena of relaxations and fluctuations, this monograph provides readers with a solid foundation in the linear and nonlinear Fokker-Planck equations that describe the evolution of distribution functions. It emphasizes principles and notions of the theory (e.g., self-organization, stochastic feedback, free energy, and Markov processes), while also illustrating the wide applicability (e.g., collective behavior, multistability, front dynamics, and quantum particle distribution). The focus is on relaxation processes in homogeneous many-body systems describable by nonlinear Fokker-Planck equations. Also treated are Langevin equations and correlation functions. Since these phenomena are exhibited by a diverse spectrum of systems, examples and applications span the fields of physics, biology and neurophysics, mathematics, psychology, and biomechanics. A method for solving the linear Fokker-Planck equation with anisotropic beam-beam charge exchange loss is presented. The 2-D equation is transformed to a system of coupled 1-D equations which are solved iteratively as independent equations. Although isotropic approximations to the beam-beam losses lead to inaccurate fast ion distributions, typically only a few angular harmonics are needed to include accurately the effect of the beam-beam charge exchange loss on the usual integrals of the fast ion distribution. Consequently, the algorithm converges very rapidly and is much more efficient than a 2-D finite difference method. A convenient recursion formula for the coupling coefficients is given and generalization of the method is discussed. 13 refs., 2 figs. This unique volume presents the scientific achievements, significant discoveries and pioneering contributions of various academicians, industrialist and research scholars. The book is an essential source of reference and provides a comprehensive overview of the author's work in the field of mathematics, statistics and computer science. Contents: Databased Intrinsic Weights of Indicators of Multi-Indicator Systems and Performance Measures of Multivariate Rankings of Systemic Objects (G P Patil & S W Joshi) Statistical Aspects of SuDoK u-Based Experimental Designs (Jyotirmoy Sarkar & Bikas K Sinha) Multi Criteria Decision Making Model for Optimal Selection of Recovery Facility Location and Collection Routes for a Sustainable Reverse Logistics Network under Fuzzy Environment (J D Darbari, V Agarwal & P C Jha) Optimal allocation of SKU and Safety Stock in Supply Chain System Network (K Gandhi, K Goyal, A Jha & J D Darbari) Bi-Objective Optimization Model for Fault-Tolerant Embedded Systems Under Build-
improved methods for stochastic analysis. This book presents a diverse collection of some of the latest research in this important area. In particular, this book gives an overview of some of the theoretical methods and tools for stochastic analysis, and it presents the applications of these methods to problems in systems theory, science, and economics. Centered around the natural phenomena of relaxations and fluctuations, this monograph provides readers with a solid foundation in the linear and nonlinear Fokker-Planck equations that describe the evolution of distribution functions. It emphasizes principles and notions of the theory (e.g. self-organization, stochastic feedback, free energy, and Markov processes), while also illustrating the wide applicability (e.g. collective behavior, multistability, front dynamics, and quantum particle distribution). The focus is on relaxation processes in homogeneous many-body systems describable by nonlinear Fokker-Planck equations. Also treated are Langevin equations and correlation functions. Since these phenomena are exhibited by a diverse spectrum of systems, examples and applications span the fields of physics, biology and neurophysics, mathematics, psychology, and biomechanics. This invaluable book provides a broad introduction to a rapidly growing area of nonequilibrium statistical physics. The first part of the book complements the classical book on the Langevin and Fokker-Planck equations (H. Risken, The Fokker-Planck Equation: Methods of Solution and Applications (Springer, 1996)). Some topics and methods of solutions are presented and discussed in details which are not described in Risken's book, such as the method of similarity solution, the method of characteristics, transformation of diffusion processes into the Wiener process in different prescriptions, harmonic noise and relativistic Brownian motion. Connection between the Langevin equation and Tsallis distribution is also discussed. Due to the growing interest in the research on the generalized Langevin equations, several of them are presented. They are described with some details. Recent research on the integro-differential Fokker-Planck equation derived from the continuous time random walk model shows that the topic has several aspects to be explored. This equation is worked analytically for the linear force and the generic waiting time probability distribution function. Moreover, generalized Klein-Kramers equations are also presented and discussed. They have the potential to be applied to natural systems, such as biological systems. Contents: Introduction Langevin and Fokker-Planck Equations Fokker-Planck Equation for One Variable and its Solution Fokker-Planck Equation for Several Variables Generalized Langevin Equations Continuous Time Random Walk Model Uncoupled Continuous Time Random Walk Model and its Solution Readershop: Advanced undergraduate and graduate students in mathematical physics and statistical physics; biologists and chemists who are interested in nonequilibrium statistical physics. Keywords: Langevin Equation; Fokker-Planck Equation; Klein-Kramers Equation; Continuous Time Random Walk Model; Colored Noise; Tsallis Entropy; Population Growth Models; Wright Functions; Mittag-Leffler Function; Method of Similarity Solution; First Passage Time; Relativistic Brownian Motion; Fractional Derivatives; Integro-Differential Fokker-Planck Equation Review: Key Features: This book complements Risken's book on the Langevin and Fokker-Planck equations. Some
topics and methods of solutions are presented and discussed in details which are not described in Risken's book. Several generalized Langevin equations are presented and discussed with some detail. Integro-differential Fokker–Planck equation is derived from the uncoupled continuous time random walk model for generic waiting time probability distribution function which can be used to distinguish the differences for the initial and intermediate times with the same behavior in the long-time limit. Moreover, generalized Klein–Kramers equations are also described and discussed. To our knowledge these approaches are not found in other textbooks. This is the first of a two-volume presentation on current research problems in quantum optics, and will serve as a standard reference in the field for many years to come. The book provides an introduction to the methods of quantum statistical mechanics used in quantum optics and their application to the quantum theories of the single-mode laser and optical bistability. The generalized representations of Drummond and Gardiner are discussed together with the more standard methods for deriving Fokker–Planck equations.

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