

APPLICATION OF NONLINEAR STOCHASTIC MECHANICS IN OFFSHORE ENGINEERING

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ABSTRACT

Nonlinear stochastic mechanics are widely used in the field of offshore engineering. In this paper we survey four applications: nonlinear collapse and fatigue analysis of jacket structures, dynamic analysis of jack-up structures, springing and slow-drift response of a tension leg platform, and hysteretic foundation behavior of a concrete gravity platform.

1. INTRODUCTION

Offshore engineering poses many challenges for structural and soil engineers, oceanographers, and hydrodynamicists. In particular, as current offshore oil reserves become depleted, oil exploration and production is moving into increasing water depths and offshore platforms are installed at water depths of several hundred meters. For example, fixed offshore structures exist at water depth exceeding 300 meters.

Nonlinear phenomena are present in both the loading process, the structural behavior and, for fixed platforms, in the soil mechanics. Nonlinearities in the loading arise from nonlinear waves (non-Gaussian sea surface elevation) and nonlinearities in force mechanisms, as given for example by the Morison equation or second-order diffraction theory. The structure itself may exhibit various nonlinearities. This is the case for example for fixed, dynamically sensitive jack-up and deep-water jacket structures, tethered tension leg platforms, and moored semi-submersible platforms. Depending on soil conditions, nonlinear soil effects may influence both fixed structures—either gravity-based or on piles—and temporarily installed jack-up structures with footings at the sea bed.

Extensive analysis of the behavior and strength of offshore structures takes place throughout the life cycle of the structure, i.e. in concept evaluation, design, construction and operation. In operation, analyses are performed because of damage caused by dropped objects, platform/ship collisions, and explosion damages. Furthermore, a need for substantial re-design of the (deck) structure often arises.

Nonlinear Dynamic And Stochastic Mechanics

Wolfgang Kliemann



Nonlinear Dynamic And Stochastic Mechanics:

Nonlinear Dynamics and Stochastic Mechanics Wolfgang Kliemann, 2018-05-04 Engineering systems have played a crucial role in stimulating many of the modern developments in nonlinear and stochastic dynamics After 20 years of rapid progress in these areas this book provides an overview of the current state of nonlinear modeling and analysis for mechanical and structural systems This volume is a coherent compendium written by leading experts from the United States Canada Western and Eastern Europe and Australia The 22 articles describe the background recent developments applications and future directions in bifurcation theory chaos perturbation methods stochastic stability stochastic flows random vibrations reliability disordered systems earthquake engineering and numerics The book gives readers a sophisticated toolbox that will allow them to tackle modeling problems in mechanical systems that use stochastic and nonlinear dynamics ideas An extensive bibliography and index ensure this volume will remain a reference standard for years to come Nonlinear Dynamics and Stochastic Mechanics Navaratnam Sri Namachchivaya, 1996 This volume contains the proceedings of the International Symposium on Nonlinear Dynamics and Stochastic Mechanics held at the Fields Institute for Research in Mathematical Sciences from August September 1993 as part of the 1992 93 Program Year on Dynamical Systems and Bifurcation Theory In recent years mathematicians and applied scientists have made significant progress in understanding and have developed powerful tools for the analysis of the complex behaviour of deterministic and stochastic dynamical systems By moving beyond classical perturbation methods to more general geometrical computational and analytical methods this book is at the forefront in transferring these new mathematical ideas into engineering practice This work presents the solutions of some specific problems in engineering structures and mechanics and demonstrates by explicit example these new methods of solution Nonlinear Dynamics and Stochastic Mechanics Wei-Chau Xie, Navaratnam Sri Namachchivaya, Balakumar Balachandran, 2000 Thirteen papers from a November 2000 meeting examine central topics in theory and applications of nonlinear dynamics stochastic mechanics and dynamics and control of nonlinear mechanical and structural systems Papers address topics related to fundamental applied analytical computational and e Nonlinear Stochastic Mechanics Nicola Bellomo, Fabio Casciati, 2012-12-06 The Symposium held in Torino ISI Villa Gualino July 1 5 1991 is the sixth of a series of IUTAM Symposia on the application of stochastic analysis to continuum and discrete mechanics The previous one held in Innsbruck 1987 was mainly concentrated on qualitative and quantitative analysis of stochastic dynamical systems as well as on bifurcation and transition to chaos of deterministic systems This Symposium concentrated on fundamental aspects stochastic analysis and mathematical methods on specific applications in various branches of mechanics engineering and applied sciences as well as on related fields as analysis of large systems system identification earthquake prediction Numerical methods suitable to provide quantitative results say stochastic finite elements approximation of probability distribution and direct integration of differential equations have also been the object of

interesting presentations Specific topics of the sessions have been Engineering Applications Equivalent Linearization of Discrete Stochastic Systems Fatigue and Life Estimation Fluid Dynamics Numerical Methods Random Vibration Reliability Analysis Stochastic Differential Equations System Identification Stochastic Control We are indebted to the IUTAM Bureau for having promoted and sponsored this Symposium and the Scientific Committee for having collaborated to the selection of participants and lecturers as well as to a prompt reviewing of the papers submitted for publication into these proceedings A special thank is due to Frank Kozin the organization of this meeting was for him very important he missed the meeting but his organizer ability was present

IUTAM Symposium on Advances in Nonlinear Stochastic Mechanics A. Naess, S. Krenk, 2012-12-06 The IUTAM Symposium on Advances in Nonlinear Stochastic Mechanics held in Trondheim July 3-7 1995 was the eighth of a series of IUTAM sponsored symposia which focus on the application of stochastic methods in mechanics The previous meetings took place in Coventry UK 1972 Southampton UK 1976 FrankfurtjOder Germany 1982 Stockholm Sweden 1984 Innsbruckjlgls Austria 1987 Turin Italy 1991 and San Antonio Texas 1993 The symposium provided an extraordinary opportunity for scholars to meet and discuss recent advances in stochastic mechanics The participants represented a wide range of expertise from pure theoreticians to people primarily oriented toward applications A significant achievement of the symposium was the very extensive discussions taking place over the whole range from highly theoretical questions to practical engineering applications Several presentations also clearly demonstrated the substantial progress that has been achieved in recent years in terms of developing and implementing stochastic analysis techniques for mechanical engineering systems This aspect was further underpinned by specially invited extended lectures on computational stochastic mechanics engineering applications of stochastic mechanics and nonlinear active control The symposium also reflected the very active and high quality research taking place in the field of stochastic stability Ten presentations were given on this topic of a total of 47 papers A main conclusion that can be drawn from the proceedings of this symposium is that stochastic mechanics as a subject has reached great depth and width in both methodology and applicability

Nonlinear Dynamics Stochastic Mechanics W.-C. Xie, N. Sri Namachchivaya, 2002 **Differential Equations and Dynamical Systems** Antonio Galves, 2002 This volume contains contributed papers authored by participants of a Conference on Differential Equations and Dynamical Systems which was held at the Instituto Superior Tecnico Lisbon Portugal The conference brought together a large number of specialists in the area of differential equations and dynamical systems and provided an opportunity to celebrate Professor Waldyr Oliva's 70th birthday honoring his fundamental contributions to the field The volume constitutes an overview of the current research over a wide range of topics extending from qualitative theory for ordinary partial or functional differential equations to hyperbolic dynamics and ergodic theory

Holomorphic Dynamics and Renormalization Mikhail Lyubich, Michael Yampolsky, 2008 Collects papers that reflect some of the directions of research in two closely related fields Complex Dynamics and Renormalization in Dynamical Systems This title contains papers that

introduces the reader to this fascinating world and a related area of transcendental dynamics It also includes open problems and computer simulations Computational Stochastic Mechanics P.D. Spanos,C.A. Brebbia,2012-12-06 Over a period of several years the field of probabilistic mechanics and computational mechanics have progressed vigorously but independently With the advent of powerful computational hardware and the development of novel mechanical techniques the field of stochastic mechanics has progressed in such a manner that the inherent uncertainty of quite complicated systems can be addressed The first International Conference on Computational Stochastic Mechanics was convened in Corfu in September 1991 in an effort to provide a forum for the exchanging of ideas on the current status of computational methods as applied to stochastic mechanics and for identifying needs for further research The Conference covered both theoretical techniques and practical applications The Conference also celebrated the 60th anniversary of the birthday of Dr Masanobu Shinozuka the Sollenberger Professor of Civil Engineering at Princeton University whose work has contributed in such a great measure to the development of Computational Stochastic Mechanics A brief summary of his career and achievements are given in the Dedication This book comprises some of the papers presented at the meeting and covers sections on Theoretical Reliability Analysis Damage Analysis Applied Reliability Analysis Theoretical Random Vibrations Stochastic Finite Element Concept Fatigue and Fracture Monte Carlo Simulations Earthquake Engineering Applications Materials Applied Random Vibrations Applied Stochastic Finite Element Analysis and Flow Related Applications and Chaotic Dynamics The Editors hope that the book will be a valuable contribution to the growing literature covering the field of Computational Stochastic Mechanics *Partially Hyperbolic Dynamics, Laminations, and Teichmüller Flow* Giovanni Forni, This volume collects a set of contributions by participants of the Workshop Partially hyperbolic dynamics laminations and Teichmüller flow held at the Fields Institute in Toronto in January 2006 The Workshop brought together several leading experts in two very active fields of contemporary dynamical systems theory partially hyperbolic dynamics and Teichmüller dynamics They are unified by ideas coming from the theory of laminations and foliations dynamical hyperbolicity and ergodic theory These are the main themes of the current volume The volume contains both surveys and research papers on non uniform and partial hyperbolicity on dominated splitting and beyond in Part I Teichmüller dynamics with applications to interval exchange transformations and on the topology of moduli spaces of quadratic differentials in Part II foliations and laminations and other miscellaneous papers in Part III Taken together these papers provide a snapshot of the state of the art in some of the most active topics at the crossroads between dynamical systems smooth ergodic theory geometry and topology suitable for advanced graduate students and researchers Non specialists will find the extensive in depth surveys especially useful

Nonlinear Dynamics and Renormalization Group Israel Michael Sigal,Catherine Sulem, **Nonlinear Problems In Engineering - Proceedings Of The Enea Workshops On Nonlinear Dynamics - Vol 4** Costantino Carmignani,Giuseppe Maino,1991-10-31 The papers collected in this volume presented at the workshop on Nonlinear Problems in Engineering held

in ENEA Rome Italy from 6 7 May 1991 and sponsored by ENEA report nonlinear problems of prevailing engineering interest Both nonlinear static and dynamic topics are dealt with in particular plastic behavior of materials elastic plastic models fracture mechanics geophysical prospecting theory of nonlinear control mixing models for chemical reactors nonlinear responses of structures rotor dynamics and impact loads on structures Dynamical Mechanical Systems Under Random Impulses Radoslaw Iwankiewicz,1995-11-07 The book presents the methods of analysis of dynamical mechanical systems subjected to stochastic excitations in form of random trains of impulses This particular class of excitations is adequately characterized by stochastic point processes and behaviour of dynamical systems is governed by stochastic differential equations driven by point processes Based on the methods of point processes the analytical techniques are devised to characterize the response of linear and nonlinear mechanical systems as the solutions of underlying stochastic differential equations A number of example problems of engineering importance are also solved such as the vibration of plates and shells and of nonlinear oscillators under random impulses The Control Handbook (three volume set) William S. Levine,2018-10-08 At publication The Control Handbook immediately became the definitive resource that engineers working with modern control systems required Among its many accolades that first edition was cited by the AAP as the Best Engineering Handbook of 1996 Now 15 years later William Levine has once again compiled the most comprehensive and authoritative resource on control engineering He has fully reorganized the text to reflect the technical advances achieved since the last edition and has expanded its contents to include the multidisciplinary perspective that is making control engineering a critical component in so many fields Now expanded from one to three volumes The Control Handbook Second Edition brilliantly organizes cutting edge contributions from more than 200 leading experts representing every corner of the globe They cover everything from basic closed loop systems to multi agent adaptive systems and from the control of electric motors to the control of complex networks Progressively organized the three volume set includes Control System Fundamentals Control System Applications Control System Advanced Methods Any practicing engineer student or researcher working in fields as diverse as electronics aeronautics or biomedicine will find this handbook to be a time saving resource filled with invaluable formulas models methods and innovative thinking In fact any physicist biologist mathematician or researcher in any number of fields developing or improving products and systems will find the answers and ideas they need As with the first edition the new edition not only stands as a record of accomplishment in control engineering but provides researchers with the means to make further advances **Probabilistic Structural Mechanics: Advances in Structural Reliability Methods** Pol D. Spanos,Y.-T. Wu,2013-03-13 This symposium is the seventh of a series of IUTAM sponsored symposia which focus on probabilistic methods in mechanics It is the sequel to the series of meetings in Coventry UK 1972 Southhampton UK 1976 Frankfurt Oder Germany 1982 Stockholm Sweden 1984 Innsbruck Igls Austria 1987 and Turin Italy 1991 The symposium focused on advances in the area of probabilistic mechanics with direct application to structural

reliability issues The contributed papers address collectively the four components of a structural reliability problem They are characterization of stochastic loads description of material properties in terms of fatigue and fracture response determination and quantitative assessment of the reliability of the structural system Four Keynote Lectures by V Bolotin Russia o Ditlevsen Denmark R Heller USA and F Ziegler Austria were delivered the remaining contributed papers were organized in ten technical sessions A reception was hosted by Dr Y Wu the first day of the symposium the second day of the symposium a banquet was hosted by Dr P Spanos with Dr N Abramson serving as the banquet speaker Closing remarks were provided by the IUTAM Secretary General Dr F Ziegler

Applied Nonlinear Dynamics And Chaos Of Mechanical Systems With Discontinuities Bram De Kraker, Marian Wiercigroch, 2000-04-28 Rapid developments in nonlinear dynamics and chaos theory have led to publication of many valuable monographs and books However most of these texts are devoted to the classical nonlinear dynamics systems for example the Duffing or van der Pol oscillators and either neglect or refer only briefly to systems with motion dependent discontinuities In engineering practice a good part of problems is discontinuous in nature due to either deliberate reasons such as the introduction of working clearance and or the finite accuracy of the manufacturing processes The main objective of this volume is to provide a general methodology for describing solving and analysing discontinuous systems It is compiled from the dedicated contributions written by experts in the field of applied nonlinear dynamics and chaos The main focus is on mechanical engineering problems where clearances piecewise stiffness intermittent contact variable friction or other forms of discontinuity occur Practical applications include vibration absorbers percussive drilling of hard materials and dynamics of metal cutting

A Course in Mathematical and Statistical Ecology Anil Gore, S.A. Paranjpe, 2000-12-31 A Course in Mathematical and Statistical Ecology Probability Towards 2000 L. Accardi, C.C. Heyde, 2012-12-06 Senior probabilists from around the world with widely differing specialities gave their visions of the state of their specialty why they think it is important and how they think it will develop in the new millenium The volume includes papers given at a symposium at Columbia University in 1995 but papers from others not at the meeting were added to broaden the coverage of areas All papers were refereed *Applied mechanics reviews*, 1948 *Operator Theory and Its Applications* Alexander G. Ramm, P. N. Shivakumar, Abraham Vilgelmovich Strauss, This volume contains a selection of papers presented at an international conference on operator theory and its applications held in Winnipeg The papers chosen for this volume are intended to illustrate that operator theory is the language of modern analysis and its applications Together with the papers on the abstract operator theory are many papers on the theory of differential operators boundary value problems inverse scattering and other inverse problems and on applications to biology chemistry wave propagation and many other areas The volume is dedicated to the late A V Strauss whose principal areas of research were spectral theory of linear operators in Hilbert spaces extension theory for symmetric linear operators theory of the characteristic functions and functional models of linear operators and boundary value problems with boundary conditions

depending on spectral parameter The bibliography of publications by A V Strauss combined with the papers from the conference provide both historical perspective and contemporary research on the field of operator theory and its applications

The book delves into Nonlinear Dynamic And Stochastic Mechanics. Nonlinear Dynamic And Stochastic Mechanics is an essential topic that needs to be grasped by everyone, ranging from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Nonlinear Dynamic And Stochastic Mechanics, encompassing both the fundamentals and more intricate discussions.

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 6. In chapter 5, this book will draw a conclusion about Nonlinear Dynamic And Stochastic Mechanics. The final chapter will summarize the key points that have been discussed throughout the book.
- The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Nonlinear Dynamic And Stochastic Mechanics.

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