K.W. Chang
F.A. Howes

Nonlinear Singular Perturbation Phenomena: Theory and Application
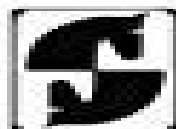
Nonlinear Singular Perturbation Phenomena Theory And Applications Applied Mathematical Sciences

Peter J. Schmid,Dan S. Henningson

Nonlinear Singular Perturbation Phenomena Theory And Applications Applied Mathematical Sciences:

Nonlinear Singular Perturbation Phenomena K. W. Chang,F. A. Howes,1984-10-08 Our purpose in writing this monograph is twofold On the one hand we want to collect in one place many of the recent results on the exist ence and asymptotic behavior of solutions of certain classes of singularly perturbed nonlinear boundary value problems On the other we hope to raise along the way a number of questions for further study mostly ques tions we ourselves are unable to answer The presentation involves a study of both scalar and vector boundary value problems for ordinary dif ferential equations by means of the consistent use of differential in equality techniques Our results for scalar boundary value problems obeying some type of maximum principle are fairly complete however we have been unable to treat under any circumstances problems involving resonant behavior The linear theory for such problems is incredibly complicated already and at the present time there appears to be little hope for any kind of general nonlinear theory Our results for vector boundary value problems even those admitting higher dimensional maximum principles in the form of invariant regions are also far from complete We offer them with some trepidation in the hope that they may stimulate further work in this challenging and important area of differential equa tions The research summarized here has been made possible by the support over the years of the National Science Foundation and the National Science and Engineering Research Council   Multiple Scale and Singular Perturbation Methods J.K. Kevorkian,J.D. Cole,2012-12-06 This book is a revised and updated version including a substantial portion of new material of our text Perturbation Methods in Applied Mathematics Springer Verlag 1981 We present the material at a level that assumes some familiarity with the basics of ordinary and partial differential equations Some of the more advanced ideas are reviewed as needed therefore this book can serve as a text in either an advanced undergraduate course or a graduate level course on the subject Perturbation methods first used by astronomers to predict the effects of small disturbances on the nominal motions of celestial bodies have now become widely used analytical tools in virtually all branches of science A problem lends itself to perturbation analysis if it is close to a simpler problem that can be solved exactly Typically this closeness is measured by the occurrence of a small dimensionless parameter E in the governing system consisting of differential equations and boundary conditions so that for E 0 the resulting system is exactly solvable The main mathematical tool used is asymptotic expansion with respect to a suitable asymptotic sequence of functions of E In a regular perturbation problem a straightforward procedure leads to a system of differential equations and boundary conditions for each term in the asymptotic expansion This system can be solved recursively and the accuracy of the result improves as E gets smaller for all values of the independent variables throughout the domain of interest We discuss regular perturbation problems in the first chapter   *Lie Groups and Algebras with Applications to Physics, Geometry, and Mechanics* D.H. Sattinger,O.L. Weaver,2013-11-11 This book is intended as an introductory text on the subject of Lie groups and algebras and their role in various fields of mathematics and physics It is written by and for researchers who are primarily

analysts or physicists not algebraists or geometers Not that we have eschewed the algebraic and geo metric developments But we wanted to present them in a concrete way and to show how the subject interacted with physics geometry and mechanics These interactions are of course manifold we have discussed many of them here in particular Riemannian geometry elementary particle physics sym metries of differential equations completely integrable Hamiltonian systems and spontaneous symmetry breaking Much ofthe material we have treated is standard and widely available but we have tried to steer a course between the descriptive approach such as found in Gilmore and Wybourne and the abstract mathematical approach of Helgason or Jacobson Gilmore and Wybourne address themselvesto the physics community whereas Helgason and Jacobson address themselves to the mathematical community This book is an attempt to synthesize the two points of view and address both audiences simultaneously We wanted to present the subject in a way which is at once intuitive geometric applications oriented mathematically rigorous and accessible to students and researchers without an extensive background in physics algebra or geometry   <u>Elements of Applied Bifurcation Theory</u> Yuri Kuznetsov,2008-01-10 Providing readers with a solid basis in dynamical systems theory as well as explicit procedures for application of general mathematical results to particular problems the focus here is on efficient numerical implementations of the developed techniques The book is designed for advanced undergraduates or graduates in applied mathematics as well as for Ph D students and researchers in physics biology engineering and economics who use dynamical systems as model tools in their studies A moderate mathematical background is assumed and whenever possible only elementary mathematical tools are used This new edition preserves the structure of the first while updating the context to incorporate recent theoretical developments in particular new and improved numerical methods for bifurcation analysis   *The Nonlinear Schrödinger Equation* Catherine Sulem,Pierre-Louis Sulem,2007-06-30 Filling the gap between the mathematical literature and applications to domains the authors have chosen to address the problem of wave collapse by several methods ranging from rigorous mathematical analysis to formal aymptotic expansions and numerical simulations   **Manifolds, Tensor Analysis, and Applications** Ralph Abraham,Jerrold E. Marsden,Tudor Ratiu,2012-12-06 The purpose of this book is to provide core material in nonlinear analysis for mathematicians physicists engineers and mathematical biologists The main goal is to provide a working knowledge of manifolds dynamical systems tensors and differential forms Some applications to Hamiltonian mechanics fluid me chanics electromagnetism plasma dynamics and control thcory arc given in Chapter 8 using both invariant and index notation The current edition of the book does not deal with Riemannian geometry in much detail and it does not treat Lie groups principal bundles or Morse theory Some of this is planned for a subsequent edition Meanwhile the authors will make available to interested readers supplementary chapters on Lie Groups and Differential Topology and invite comments on the book s contents and development Throughout the text supplementary topics are given marked with the symbols and l J This device enables the reader to skip various topics without disturbing the main flow of the text Some of these provide additional

background material intended for completeness to minimize the necessity of consulting too many outside references We treat finite and infinite dimensional manifolds simultaneously This is partly for efficiency of exposition Without advanced applications using manifolds of mappings the study of infinite dimensional manifolds can be hard to motivate **Averaging Methods in Nonlinear Dynamical Systems** Jan A. Sanders,Ferdinand Verhulst,2013-04-17 In this book we have developed the asymptotic analysis of nonlinear dynamical systems We have collected a large number of results scattered throughout the literature and presented them in a way to illustrate both the underlying common theme as well as the diversity of problems and solutions While most of the results are known in the literature we added new material which we hope will also be of interest to the specialists in this field The basic theory is discussed in chapters two and three Improved results are obtained in chapter four in the case of stable limit sets In chapter five we treat averaging over several angles here the theory is less standardized and even in our simplified approach we encounter many open problems Chapter six deals with the definition of normal form After making the somewhat philosophical point as to what the right definition should look like we derive the second order normal form in the Hamiltonian case using the classical method of generating functions In chapter seven we treat Hamiltonian systems The resonances in two degrees of freedom are almost completely analyzed while we give a survey of results obtained for three degrees of freedom systems The appendices contain a mix of elementary results expansions on the theory and research problems **Shape Optimization by the Homogenization Method** Gregoire Allaire,2012-12-06 The topic of this book is homogenization theory and its applications to optimal design in the conductivity and elasticity settings Its purpose is to give a self contained account of homogenization theory and explain how it applies to solving optimal design problems from both a theoretical and a numerical point of view The application of greatest practical interest tar geted by this book is shape and topology optimization in structural design where this approach is known as the homogenization method Shape optimization amounts to finding the optimal shape of a domain that for example would be of maximal conductivity or rigidity under some specified loading conditions possibly with a volume or weight constraint Such a criterion is embodied by an objective function and is computed through the solution of astate equation that is a partial differential equa tion modeling the conductivity or the elasticity of the structure Apart from those areas where the loads are applied the shape boundary is al ways assumed to support Neumann boundary conditions i e isolating or traction free conditions In such a setting shape optimization has a long history and has been studied by many different methods There is therefore a vast literat ure in this field and we refer the reader to the following short list of books and references therein 39 42 130 135 149 203 220 225 237 245 258 Determinants and Their Applications in Mathematical Physics Robert Vein,Paul Dale,2006-05-07 The last treatise on the theory of determinants by T Muir revised and enlarged by W H Metzler was published by Dover Publications Inc in 1960 It is an unabridged and corrected republication of the edition ori nally published by Longman Green and Co in 1933 and contains a preface by Metzler dated 1928 The Table of Contents of this treatise is

given in Appendix 13 A small number of other books devoted entirely to determinants have been published in English but they contain little if anything of importance that was not known to Muir and Metzler A few have appeared in German and Japanese In contrast the shelves of every mathematics library groan under the weight of books on linear algebra some of which contain short chapters on determinants but usually only on those aspects of the subject which are applicable to the chapters on matrices There appears to be tacit agreement among authorities on linear algebra that determinant theory is important only as a branch of matrix theory In sections devoted entirely to the establishment of a determinantal relation many authors de ne a determinant by rst de ning a matrixM and then adding the words Let detM be the determinant of the matrix M as though determinants have no separate existence This belief has no basis in history *Dynamics: Numerical Explorations* Helena E. Nusse,James A. Yorke,2012-12-06 Plotting trajectories is a useful capability in exploring a dynamical system but it is just the beginning The Maryland Chaos Group developed an array of tools to help visualize the properties of dynamical systems induding automatic method for plotting all basins and attractors and for automatically searching for all computing straddle trajectories periodic orbits of a specified period In the investigations of the Maryland Chaos Group I A Yorke found it useful to be able to combine these various basic tools with each other into so that each new study could benefit a single package that grew with time from the previous programming efforts He has been writing this software and distributing versions for the last nine years The resulting program Dynamics requires either a Unix workstation running XII graphics or an IBM PC compatible computer Eric I Kostelich has put in a great deal of effort to port the program to Unix workstations Some basic tools in Dynamics such as the computation of Lyapunov exponents and the use of Newton s method are standard The method of computation of stable and unstable manifolds is superior to standard procedures Dynamics is currently being used extensively in our research and it is being used in undergraduate courses Dynamics Numerical Explora ons provides an introduction to and overview of fundamental tools and numerical methods together with many simple examples All the numerical methods described in this book are implemented in Dynamics **Partial Differential Equations II** Michael Taylor,2013-04-17 Partial differential equations is a many faceted subject Created to describe the mechanical behavior of objects such as vibrating strings and blowing winds it has developed into a body of material that interacts with many branches of math ematics such as differential geometry complex analysis and harmonic analysis as weil as a ubiquitous factor in the description and elucidation of problems in mathematical physics This work is intended to provide a course of study of some of the major aspects of PDE It is addressed to readers with a background in the basic introductory grad uate mathematics courses in American universities elementary real and complex analysis differential geometry and measure theory Chapter 1 provides background material on the theory of ordinary differential equations ODE This includes both very basic material on topics such as the existence and uniqueness of solutions to ODE and explicit solutions to equations with constant coefficients and relations to linear algebra and more sophisticated results on flows generated by

vector fields connections with differential geom etry the calculus of differential forms stationary action principles in mechanics and their relation to Hamiltonian systems We discuss equations of relativistic motion as weIl as equations of c1assical Newtonian mechanics There are also applications to topological results such as degree theory the Brouwer fixed point theorem and the Jordan Brouwer separation theorem In this chapter we also treat scalar first order PDE via Hamilton Jacobi theory **Stability and Transition in Shear Flows** Peter J. Schmid,Dan S. Henningson,2012-12-06 The field of hydrodynamic stability has a long history going back to Rey nolds and Lord Rayleigh in the late 19th century Because of its central role in many research efforts involving fluid flow stability theory has grown into a mature discipline firmly based on a large body of knowledge and a vast body of literature The sheer size of this field has made it difficult for young researchers to access this exciting area of fluid dynamics For this reason writing a book on the subject of hydrodynamic stability theory and transition is a daunting endeavor especially as any book on stability theory will have to follow into the footsteps of the classical treatises by Lin 1955 Betchov Criminale 1967 Joseph 1971 and Drazin Reid 1981 Each of these books has marked an important development in stability theory and has laid the foundation for many researchers to advance our understanding of stability and transition in shear flows Inverse Problems for Partial Differential Equations Victor Isakov,2013-06-29 This book describes the contemporary state of the theory and some numerical aspects of inverse problems in partial differential equations The topic is of sub stantial and growing interest for many scientists and engineers and accordingly to graduate students in these areas Mathematically these problems are relatively new and quite challenging due to the lack of conventional stability and to nonlinearity and nonconvexity Applications include recovery of inclusions from anomalies of their gravitational fields reconstruction of the interior of the human body from exterior electrical ultrasonic and magnetic measurements recovery of interior structural parameters of detail of machines and of the underground from similar data non destructive evaluation and locating flying or navigated objects from their acoustic or electromagnetic fields Currently there are hundreds of publica tions containing new and interesting results A purpose of the book is to collect and present many of them in a readable and informative form Rigorous proofs are presented whenever they are relatively short and can be demonstrated by quite general mathematical techniques Also we prefer to present results that from our point of view contain fresh and promising ideas In some cases there is no com plete mathematical theory so we give only available results We do not assume that a reader possesses an enormous mathematical technique In fact a moderate knowledge of partial differential equations of the Fourier transform and of basic functional analysis will suffice **Nonlinear Theory of Shallow Shells** Iosif I. Vorovich,2008-01-08 This book presents rigorous treatment of boundary value problems in nonlinear theory of shallow shells The consideration of the problems is carried out using methods of nonlinear functional analysis **Imperfect Bifurcation in Structures and Materials** Kiyohiro Ikeda,Kazuo Murota,2013-03-09 Many physical systems lose or gain stability and pattern through bifurca tion behavior Extensive research of this behavior is carried out in many fields of science

and engineering The study of dynamic bifurcation be havior for example has made clear the mechanism of dynamic instability and chaos The group theoretic bifurcation theory is an established means to deal with the formation and selection of patterns in association with symmetry breaking bifurcation Since all physical systems are imperfect in that they inevitably involve some initial imperfections the study of im perfect bifurcation bifurcation of imperfect systems has drawn a keen mathematical interest to yield a series of important results such as the universal unfolding In structural mechanics bifurcation behavior has been studied to model the buckling and failure of structural systems The sharp reduction of the strength of structural systems by initial imperfections is formulated as im perfection sensitivity laws A series of statistical studies has been conducted to make clear the dependence of the strength of structures on the statis tical variation of initial imperfections A difficulty in these studies arises from the presence of a large number of initial imperfections At this state most of these studies are carried out based on the Monte Carlo simulation for a number of initial imperfections or on an imperfection sensitivity law against a single initial imperfection   <u>Partial Differential Equations III</u> Michael Taylor,2013-11-11 Partial differential equations is a many faceted subject Created to describe the mechanical behavior of objects such as vibrating strings and blowing winds it has developed into a body of material that interacts with many branches of math ematics such as differential geometry complex analysis and harmonic analysis as weIl as a ubiquitous factor in the description and elucidati n of problems in mathematical physics This work is intended to provide a course of study of some of the major aspects ofPDE 1t is addressed to readers with a background in the basic introductory grad uate mathematics courses in American universities elementary real and complex analysis differential geometry and measure theory Chapter 1 provides background material on the theory of ordinary differential equations ODE This includes both very basic material on topics such as the existence and uniqueness of solutions to ODE and explicit solutions to equations with constant coefficients and relations to linear algebra and more sophisticated resuIts on ftows generated by vector fields connections with differential geom etry the calculus of differential forms stationary action principles in mechanics and their relation to Hamiltonian systems We discuss equations of relativistic motion as weIl as equations of classical Newtonian mechanics There are also applications to topological resuIts such as degree theory the Brouwer fixed point theorem and the Jordan Brouwer separation theorem In this chapter we also treat scalar first order PDE via Hamilton Jacobi theory

Adaptive Markov Control Processes Onesimo Hernandez-Lerma,2012-12-06 This book is concerned with a class of discrete time stochastic control processes known as controlled Markov processes CMP s also known as Markov decision processes or Markov dynamic programs Starting in the mid 1950swith Richard Bellman many contributions to CMP s have been made and applications to engineering statistics and operations research among other areas have also been developed The purpose of this book is to present some recent developments on the theory of adaptive CMP s i e CMP s that depend on unknown parameters Thus at each decision time the controller or decision maker must estimate the true parameter values

and then adapt the control actions to the estimated values We do not intend to describe all aspects of stochastic adaptive control rather the selection of material reflects our own research interests The prerequisite for this book is a knowledgeof real analysis and prob ability theory at the level of say Ash 1972 or Royden 1968 but no previous knowledge of control or decision processes is required The pre sentation on the other hand is meant to beself contained in the sensethat whenever a result from analysisor probability is used it is usually stated in full and references are supplied for further discussion if necessary Several appendices are provided for this purpose The material is divided into six chapters Chapter 1 contains the basic definitions about the stochastic control problems we are interested in a brief description of some applications is also provided   **Nonlinear Problems of Elasticity** Stuart Antman,2013-03-14 The scientists of the seventeenth and eighteenth centuries led by Jas Bernoulli and Euler created a coherent theory of the mechanics of strings and rods undergoing planar deformations They introduced the basic con cepts of strain both extensional and flexural of contact force with its com ponents of tension and shear force and of contact couple They extended Newton s Law of Motion for a mass point to a law valid for any deformable body Euler formulated its independent and much subtler complement the Angular Momentum Principle Euler also gave effective variational characterizations of the governing equations These scientists breathed life into the theory by proposing formulating and solving the problems of the suspension bridge the catenary the velaria the elastica and the small transverse vibrations of an elastic string The level of difficulty of some of these problems is such that even today their descriptions are sel dom vouchsafed to undergraduates The realization that such profound and beautiful results could be deduced by mathematical reasoning from fundamental physical principles furnished a significant contribution to the intellectual climate of the Age of Reason At first those who solved these problems did not distinguish between linear and nonlinear equations and so were not intimidated by the latter By the middle of the nineteenth century Cauchy had constructed the basic framework of three dimensional continuum mechanics on the founda tions built by his eighteenth century predecessors   Infinite-Dimensional Dynamical Systems in Mechanics and Physics Roger Temam,2013-12-11 In this book the author presents the dynamical systems in infinite dimension especially those generated by dissipative partial differential equations This book attempts a systematic study of infinite dimensional dynamical systems generated by dissipative evolution partial differential equations arising in mechanics and physics and in other areas of sciences and technology This second edition has been updated and extended   **Applied Functional Analysis** Eberhard Zeidler,2012-12-06 A theory is the more impressive the simpler are its premises the more distinct are the things it connects and the broader is its range of applicability Albert Einstein There are two different ways of teaching mathematics namely i the systematic way and ii the application oriented way More precisely by i I mean a systematic presentation of the material governed by the desire for mathematical perfection and completeness of the results In contrast to i approach ii starts out from the question What are the most important applications and then tries to answer this question as quickly as possible

Here one walks directly on the main road and does not wander into all the nice and interesting side roads The present book is based on the second approach It is addressed to undergraduate and beginning graduate students of mathematics physics and engineering who want to learn how functional analysis elegantly solves mathematical problems that are related to our real world and that have played an important role in the history of mathematics The reader should sense that the theory is being developed not simply for its own sake but for the effective solution of concrete problems viii Preface Our introduction to applied functional analysis is divided into two parts Part I Applications to Mathematical Physics AMS Vol 108 Part II Main Principles and Their Applications AMS Vol 109 A detailed discussion of the contents can be found in the preface to AMS Vol 108

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