Multiple Scale And Singular Perturbation Methods

Singular Perturbations and HysteresisSingular-Perturbation TheoryAlgebraic Analysis of Singular Perturbation TheorySingular Perturbation TheorySingular Perturbations ISingular Perturbation Methods in ControlThe Theory of Singular PerturbationsIntroduction to Singular PerturbationsSingular Perturbation Methods for Ordinary Differential EquationsGeometric Singular Perturbation Theory Beyond the Standard FormMultiple Scale and Singular Perturbation MethodsFluid Mechanics and Singular PerturbationsSingular Perturbations in Systems and ControlSingular Perturbations and Boundary LayersPerturbationsSingular Perturbations and AsymptoticsProblems in Singular Perturbation TheorySingular Perturbation in the Physical SciencesSingular Perturbation Methods in ControlMultiple Scale and Singular Perturbation Methods Michael P. Mortell Donald R. Smith Takahiro Kawai R.S. Johnson L.S. Frank Petar Kokotovic E.M. de Jager Robert E. Jr. O'Malley Robert E., Jr. O'Malley Martin Wechselberger J.K. Kevorkian Paco Lagerstrom M.D. Ardema Gung-Min Gie James A. Murdock Richard E. Meyer James Alan Cochran John C. Neu Petar V. Kokotovic J K Kevorkian

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this book brings together many important recent developments in the analysis of singular perturbation and hysteresis phenomena in an accessible and reasonably comprehensive fashion to bridge a gap between practitioners of these phenomena the editors conducted a workshop in april 2002 at university college cork to provide a forum for experts in both fields to share their interests and knowledge for this book the editors have compiled research from those practitioners in areas such as reacting systems semiconductor lasers shock phenomena in economic modeling and fluid mechanics all with an emphasis on hysteresis and singular perturbations

introduction to singular perturbation problems since the nature of the nonuniformity can vary from case to case the author considers and solves a variety of problems mostly for ordinary differential equations

the topic of this book is the study of singular perturbations of ordinary differential equations i e perturbations that represent solutions as asymptotic series rather than as analytic functions in a perturbation parameter the main method used is the so called wkb wentzel kramers brillouin method originally invented for the study of quantum mechanical systems the authors describe in detail the wkb method and its applications to the study of monodromy problems for fuchsian differential equations and to the analysis of painleve functions this volume is suitable for graduate students and researchers interested in differential equations and special functions

the importance of mathematics in the study of problems arising from the real world and the increasing success with which it has been used to model situations ranging from the purely deterministic to the stochastic is well established the purpose of the set of volumes to which the present one belongs is to make available authoritative up to date and self contained accounts of some of the most important and useful of these analytical approaches and techniques each volume provides a detailed introduction to a specific subject area of current importance that is summarized below and then goes beyond this by reviewing recent contributions and so serving as a valuable reference source the progress in applicable mathematics has been brought about by the extension and development of many important analytical approaches and techniques in areas both old and new frequently aided by the use of computers without which the solution of realistic problems would otherwise have been impossible

singular perturbations one of the central topics in asymptotic analysis also play a special role in describing physical phenomena such as the propagation of waves in media in the presence of small energy dissipations or dispersions the appearance of boundary or interior layers in fluid and gas dynamics as well as in elasticity theory semi classical asymptotic approximations in quantum mechanics etc elliptic and coercive singular perturbations are of special interest for the asymptotic solution of problems which are characterized by boundary layer phenomena e g the theory of thin buckling plates elastic rods and beams this first volume deals with linear singular perturbations on smooth manifolds without boundary considered as equicontinuous linear mappings between corresponding families of sobolev slobodetski s type spaces of vectorial order

this siam classics edition of the 1986 book provides the theoretical foundation for representative control applications

the subject of this textbook is the mathematical theory of singular perturbations which despite its respectable history is still in a state of vigorous development singular perturbations of cumulative and of boundary layer type are presented attention has been given to composite expansions of solutions of initial and

boundary value problems for ordinary and partial differential equations linear as well as quasilinear also turning points are discussed the main emphasis lies on several methods of approximation for solutions of singularly perturbed differential equations and on the mathematical justification of these methods the latter implies a priori estimates of solutions of differential equations this involves the application of gronwall s lemma maximum principles energy integrals fixed point theorems and gåding s theorem for general elliptic equations these features make the book of value to mathematicians and researchers in the engineering sciences interested in the mathematical justification of formal approximations of solutions of practical perturbation problems the text is selfcontained and each chapter is concluded with some exercises

introduction to singular perturbations provides an overview of the fundamental techniques for obtaining asymptomatic solutions to boundary value problems this text explores singular perturbation techniques which are among the basic tools of several applied scientists this book is organized into eight chapters wherein chapter 1 discusses the method of matched asymptomatic expansions which has been frequently applied to several physical problems involving singular perturbations chapter 2 considers the nonlinear initial value problem to illustrate the regular perturbation method and chapter 3 explains how to construct asymptotic solutions for general linear equations chapter 4 discusses scalar equations and nonlinear system whereas chapters 5 and 6 explain the contrasts for initial value problems where the outer expansion cannot be determined without obtaining the initial values of the boundary layer correction chapters 7 and 8 deal with boundary value problem that arises in the study of adiabatic tubular chemical flow reactors with axial diffusion this monograph is a valuable resource for applied mathematicians engineers researchers students and readers whose interests span a variety of fields

this book results from various lectures given in recent years early drafts were used for several single semester courses on singular perturbation meth ods given at rensselaer and a more complete version was used for a one year course at the technische universitat wien some portions have been used for short lecture series at universidad central de venezuela west vir ginia university the university of southern california the university of california at davis east china normal university the university of texas at arlington universita di padova and the university of new hampshire among other places as a result i ve obtained lots of valuable feedback from students and listeners for which i am grateful this writing continues a pattern earlier lectures at bell laboratories at the university of edin burgh and new york university and at the australian national university led to my earlier works 1968 1974 and 1978 all seem to have been useful for the study of singular perturbations and i hope the same will be true of this monograph i ve personally learned much from reading and analyzing the works of others so i would especially encourage readers to treat this book as an introduction to a diverse and exciting literature the topic coverage selected is personal and reflects my current opin ions an attempt has been made to encourage a consistent method of ap proaching problems largely through correcting outer limits in regions of rapid change formal proofs of correctness are not emphasized

this volume provides a comprehensive review of multiple scale dynamical systems mathematical models of such multiple scale systems are considered singular

perturbation problems and this volume focuses on the geometric approach known as geometric singular perturbation theory gspt it is the first of its kind that introduces the gspt in a coordinate independent manner this is motivated by specific examples of biochemical reaction networks electronic circuit and mechanic oscillator models and advection reaction diffusion models all with an inherent non uniform scale splitting which identifies these examples as singular perturbation problems beyond the standard form the contents cover a general framework for this gspt beyond the standard form including canard theory concrete applications and instructive qualitative models it contains many illustrations and key pointers to the existing literature the target audience are senior undergraduates graduate students and researchers interested in using the gspt toolbox in nonlinear science either from a theoretical or an application point of view martin wechselberger is professor at the school of mathematics statistics university of sydney australia he received the j d crawford prize in 2017 by the society for industrial and applied mathematics siam for achievements in the field of dynamical systems with multiple time scales

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

fluid mechanics and singular perturbations a collection of papers by saul kaplun focuses on the works and contributions of saul kaplun to the studies of fluid mechanics and singular perturbations the book first discusses the role of coordinate system in boundary layer theory boundary layer approximations as limits of exact solutions comparison of different boundary layer solutions and comparison with exact solution and choice of optimal are discussed the text also looks at asymptotic experiment of navier stokes solution for small reynolds numbers basic concepts in the theory of singular perturbations and their applications to flow at small reynolds numbers and low reynolds number flow the book discusses as well a generalization of poiseuille and couette flows and nature of solutions of the boundary layer equations numerical solutions and analyses are presented the text also looks at compatibility condition for boundary layer equation at a point of zero skin friction intuitive background the past like solution and its principal asymptotic expansions and class of compatible profiles are discussed the book is a valuable source of information for readers who want to study fluid mechanics

singular perturbations occur when a small coefficient affects the highest order derivatives in a system of partial differential equations from the physical point of view singular perturbations generate in the system under consideration thin layers located often but not always at the boundary of the domains that are called boundary layers or internal layers if the layer is located inside the domain important physical phenomena occur in boundary layers the most common boundary layers appear in fluid mechanics e g the flow of air around an airfoil or a whole airplane or the flow of air around a car also in many instances in geophysical fluid mechanics like the interface of air and earth or air and ocean this self contained monograph is devoted to the study of certain classes of singular perturbation problems mostly related to thermic fluid mechanics and optics and where mostly elliptic or parabolic equations in a bounded domain are considered this book is a fairly unique resource regarding the rigorous mathematical treatment of boundary layer problems the explicit methodology developed in this book extends in many different directions the concept of correctors initially introduced by j l lions and in particular the lower and higher order error estimates of asymptotic expansions are obtained in the setting of functional analysis the review of differential geometry and treatment of boundary layers in a curved domain is an additional strength of this book in the context of fluid mechanics the outstanding open problem of the vanishing viscosity limit of the navier stokes equations is investigated in this book and solved for a number of particular but physically relevant cases this book will serve as a unique resource for those studying singular perturbations and boundary layer problems at the advanced graduate level in mathematics or applied mathematics and may be useful for practitioners in other related fields in science and engineering such as aerodynamics fluid mechanics geophysical fluid mechanics acoustics and optics

perturbations theory and methods gives a thorough introduction to both regular and singular perturbation methods for algebraic and differential equations unlike most introductory books on the subject this one distinguishes between formal and rigorous asymptotic validity which are commonly confused in books that treat perturbation theory as a bag of heuristic tricks with no foundation the meaning of uniformity is carefully explained in a variety of contexts all standard methods such as rescaling multiple scales averaging matching and the wkb method are covered and the asymptotic validity in the rigorous sense of each method is carefully proved first published in 1991 this book is still useful today because it is an introduction it combines perturbation results with those known through other methods sometimes a geometrical result such as the existence of a periodic solution is rigorously deduced from a perturbation result and at other times a knowledge of the geometry of the solutions is used to aid in the selection of an effective perturbation method dr murdock s approach differs from other introductory texts because he attempts to present perturbation theory as a natural part of a larger whole the mathematical theory of differential equations he explores the meaning of the results and their connections to other ways of studying the same problems

mathematics research center symposia and advanced seminar series singular perturbations and asymptotics covers the lectures presented at an advanced seminar on singular perturbation and asymptotics held in madison wisconsin on may 28 30 1980 under the auspices of the mathematics research center of the university of wisconsin madison the book focuses on the processes methodologies reactions and principles involved in singular perturbations and asymptotics including boundary value problems equations perturbations water waves and gas dynamics the selection first elaborates on basic concepts in the analysis of

singular perturbations limit process expansions and approximate equations and results on singularly perturbed boundary value problems discussions focus on quasi linear and nonlinear problems semilinear systems water waves expansion in gas dynamics asymptotic matching principles and classical perturbation analysis the text then takes a look at multiple solutions of singularly perturbed systems in the conditionally stable case and singular perturbations stochastic differential equations and applications the book ponders on connection problems in the parameterless case general connection formula problem for linear differential equations of the second order and turning point problems for ordinary differential equations of hydrodynamic type topics include the comparison equation method boundary layer flows compound matrix method asymptotic solution of the connection formula problem and higher order equations the selection is a valuable source of information for researchers interested in singular perturbations and asymptotics

this book is the testimony of a physical scientist whose language is singular perturbation analysis classical mathematical notions such as matched asymptotic expansions projections of large dynamical systems onto small center manifolds and modulation theory of oscillations based either on multiple scales or on averaging transformation theory are included the narratives of these topics are carried by physical examples let s say that the moment when we see how a mathematical pattern fits a physical problem is like hitting the ball yes we want to hit the ball but a powerful stroke includes the follow through one intention of this book is to discern in the structure and or solutions of the equations their geometric and physical content through analysis we come to sense directly the shape and feel of phenomena the book is structured into a main text of fundamental ideas and a subtext of problems with detailed solutions roughly speaking the former is the initial contact between mathematics and phenomena and the latter emphasizes geometric and physical insight it will be useful for mathematicians and physicists learning singular perturbation analysis of ode and pde boundary value problems as well as the full range of related examples and problems prerequisites are basic skills in analysis and a good junior senior level undergraduate course of mathematical physics

this book is a revised and updated version including a substantial portion of new material of the authors widely acclaimed earlier text perturbation methods in applied mathematics a new chapter dealing with regular expansions has been added the discussion of layer type singular perturbations has been revised and the coverage of multiple scale and averaging methods has been significantly expanded to reflect recent advances and viewpoints the result is a comprehensive account of the various perturbation techniques currently used in the sciences and engineering and is suitable for a graduate text as well as a reference work on the subject

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Introduction

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