

Mathematical Models in Boundary Layer Theory

O. A. Oleinik
V. N. Samokhin

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Ian John Sobey



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Mathematical Models in Boundary Layer Theory V.N. Samokhin, 2018-05-02 Since Prandtl first suggested it in 1904 boundary layer theory has become a fundamental aspect of fluid dynamics Although a vast literature exists for theoretical and experimental aspects of the theory for the most part mathematical studies can be found only in separate scattered articles *Mathematical Models in Boundary Layer Theory* offers the first systematic exposition of the mathematical methods and main results of the theory Beginning with the basics the authors detail the techniques and results that reveal the nature of the equations that govern the flow within boundary layers and ultimately describe the laws underlying the motion of fluids with small viscosity They investigate the questions of existence and uniqueness of solutions the stability of solutions with respect to perturbations and the qualitative behavior of solutions and their asymptotics Of particular importance for applications they present methods for an approximate solution of the Prandtl system and a subsequent evaluation of the rate of convergence of the approximations to the exact solution Written by the world's foremost experts on the subject *Mathematical Models in Boundary Layer Theory* provides the opportunity to explore its mathematical studies and their importance to the nonlinear theory of viscous and electrically conducting flows the theory of heat and mass transfer and the dynamics of reactive and multiphase media With the theory's importance to a wide variety of applications applied mathematicians especially those in fluid dynamics along with engineers of aeronautical and ship design will undoubtedly welcome this authoritative state of the art treatise

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mathematicians especially those in fluid dynamics along with engineers of aeronautical and ship design will undoubtedly welcome this authoritative state of the art treatise

Introduction to Interactive Boundary Layer Theory Ian John Sobey, 2000 One of the major achievements in fluid mechanics in the last quarter of the twentieth century has been the development of an asymptotic description of perturbations to boundary layers known generally as triple deck theory These developments have had a major impact on our understanding of laminar fluid flow particularly laminar separation It is also true that the theory rests on three quarters of a century of development of boundary layer theory which involves analysis experimentation and computation All these parts go together and to understand the triple deck it is necessary to understand which problems the triple deck resolves and which computational techniques have been applied This book presents a unified account of the development of laminar boundary layer theory as a historical study together with a description of the application of the ideas of triple deck theory to flow past a plate to separation from a cylinder and to flow in channels The book is intended to provide a graduate level teaching resource as well as a mathematically oriented account for a general reader in applied mathematics engineering physics or scientific computation

Mathematical Models of Fluid Dynamics Rainer Ansorge, Thomas Sonar, 2009-07-10 Without sacrificing scientific strictness this introduction to the field guides readers through mathematical modeling the theoretical treatment of the underlying physical laws and the construction and effective use of numerical procedures to describe the behavior of the dynamics of physical flow The book is carefully divided into three main parts The design of mathematical models of physical fluid flow A theoretical treatment of the equations representing the model as Navier Stokes Euler and boundary layer equations models of turbulence in order to gain qualitative as well as quantitative insights into the processes of flow events The construction and effective use of numerical procedures in order to find quantitative descriptions of concrete physical or technical fluid flow situations Both students and experts wanting to control or predict the behavior of fluid flows by theoretical and computational fluid dynamics will benefit from this combination of all relevant aspects in one handy volume

Handbook of Differential Equations: Evolutionary Equations C.M. Dafermos, Eduard Feireisl, 2011-09-22 The material collected in this volume reflects the active present of this area of mathematics ranging from the abstract theory of gradient flows to stochastic representations of non linear parabolic PDE s Articles will highlight the present as well as expected future directions of development of the field with particular emphasis on applications The article by Ambrosio and Savar discusses the most recent development in the theory of gradient flow of probability measures After an introduction reviewing the properties of the Wasserstein space and corresponding subdifferential calculus applications are given to evolutionary partial differential equations The contribution of Herrero provides a description of some mathematical approaches developed to account for quantitative as well as qualitative aspects of chemotaxis Particular attention is paid to the limits of cell scapability to measure external cues on the one hand and to provide an overall description of aggregation models for the slim mold Dictyostelium discoideum on the other The chapter

written by Masmoudi deals with a rather different topic examples of singular limits in hydrodynamics This is nowadays a well studied issue given the amount of new results based on the development of the existence theory for rather general systems of equations in hydrodynamics The paper by DeLellis addresses the most recent results for the transport equations with regard to possible applications in the theory of hyperbolic systems of conservation laws Emphasis is put on the development of the theory in the case when the governing field is only a BV function The chapter by Rein represents a comprehensive survey of results on the Poisson Vlasov system in astrophysics The question of global stability of steady states is addressed in detail The contribution of Soner is devoted to different representations of non linear parabolic equations in terms of Markov processes After a brief introduction on the linear theory a class of non linear equations is investigated with applications to stochastic control and differential games The chapter written by Zuazua presents some of the recent progresses done on the problem of controllability of partial differential equations The applications include the linear wave and heat equations parabolic equations with coefficients of low regularity and some fluid structure interaction models Volume 1 focuses on the abstract theory of evolution Volume 2 considers more concrete problems relating to specific applications Volume 3 reflects the active present of this area of mathematics ranging from the abstract theory of gradient flows to stochastic representations of non linear PDEs Asymptotic Modelling of Fluid Flow Phenomena Radyadour Kh.

Zeytounian, 2006-04-10 for the fluctuations around the means but rather fluctuations and appearing in the following incompressible system of equations on any wall at initial time and are assumed known This contribution arose from discussion with J P Guiraud on attempts to push forward our last co signed paper 1986 and the main idea is to put a stochastic structure on fluctuations and to identify the large eddies with a part of the probability space The Reynolds stresses are derived from a kind of Monte Carlo process on equations for fluctuations Those are themselves modelled against a technique using the Guiraud and Zeytounian 1986 The scheme consists in a set of like equations considered as random because they mimic the large eddy fluctuations The Reynolds stresses are got from stochastic averaging over a family of their solutions Asymptotics underlies the scheme but in a rather loose hidden way We explain this in relation with homogenization localization processes described within the 3.4 of Chapter 3 Of course the mathematical well posedness of the scheme is not known and the numerics would be formidable Whether this attempt will inspire researchers in the field of highly complex turbulent flows is not foreseeable and we have hope that the idea will prove useful Mathematical Models in the Applied Sciences A. C. Fowler, 1997-11-28 Presents a thorough grounding in the techniques of mathematical modelling and proceeds to explore a range of classical and continuum models from an array of disciplines **Mathematical Models and Methods of Localized Interaction Theory** Abram I. Bunimovich, Anatolii V. Dubinskii, 1995 The interaction of the environment with a moving body is called localized if it has been found or assumed that the force or and thermal influence of the environment on each body surface point is independent and can be determined by the local geometrical and kinematical characteristics of

this point as well as by the parameters of the environment and body environment interactions which are the same for the whole surface of contact. Such models are widespread in aerodynamics and gas dynamics covering supersonic and hypersonic flows and rarefied gas flows. They describe the influence of light on a body and are used for modelling penetration of solids into metals and soils etc. Localized Interaction Theory (LIT) studies various theoretical and applied problems using the most general description of the influence of the environment on the body. This makes it possible to integrate results obtained from different models and to create new universal methods that can be used for various conditions even if the description of the real interaction model is unknown. Such a unified approach to the problems of analysis, calculation and optimization of the integral characteristics of bodies moving in different media is the main content of this book which is the first monograph on this subject. Many applications, chiefly in aerodynamics and space engineering, are presented.

Geometric Theory of Incompressible Flows with Applications to Fluid Dynamics Tian Ma, Shouhong Wang, 2005. This monograph presents a geometric theory for incompressible flow and its applications to fluid dynamics. The main objective is to study the stability and transitions of the structure of incompressible flows and its applications to fluid dynamics and geophysical fluid dynamics. The development of the theory and its applications goes well beyond its original motivation of the study of oceanic dynamics. The authors present a substantial advance in the use of geometric and topological methods to analyze and classify incompressible fluid flows. The approach introduces genuinely innovative ideas to the study of the partial differential equations of fluid dynamics. One particularly useful development is a rigorous theory for boundary layer separation of incompressible fluids. The study of incompressible flows has two major interconnected parts. The first is the development of a global geometric theory of divergence free fields on general two dimensional compact manifolds. The second is the study of the structure of velocity fields for two dimensional incompressible fluid flows governed by the Navier Stokes equations or the Euler equations. Motivated by the study of problems in geophysical fluid dynamics, the program of research in this book seeks to develop a new mathematical theory maintaining close links to physics along the way. In return, the theory is applied to physical problems with more problems yet to be explored. The material is suitable for researchers and advanced graduate students interested in nonlinear PDEs and fluid dynamics.

Partial Differential Equations: Waves, Nonlinearities and Nonlocalities Mats Ehrnström, Helge Holden, Espen R. Jakobsen, 2025-08-22. This volume in the renowned Abel Symposia series contains the peer reviewed proceedings of the Abel Symposium 2023 on Partial Differential Equations: Waves, Nonlinearities and Nonlocalities held at Brdshaug Mansion in Orkanger outside Trondheim, Norway, June 13-16, 2023. Research in nonlinear partial differential equations has been undergoing an intense development with new phenomena modelled by increasingly complicated systems integrating nonlocal effects and with the solution of previously unsolved problems such as the Onsager conjecture. Comprising fifteen articles written by leading researchers covering a wide range of topics, this book takes readers to the forefront of a highly active subject.

Mathematical Modelling of Heat and Mass

Transfer Processes V.G. Danilov, Victor P. Maslov, K.A. Volosov, 2012-12-06 In the present book the reader will find a review of methods for constructing a certain class of asymptotic solutions which we call self stabilizing solutions This class includes solitons kinks traveling waves etc It can be said that either the solutions from this class or their derivatives are localized in the neighborhood of a certain curve or surface For the present edition the book published in Moscow by the Nauka publishing house in 1987 was almost completely revised essentially up dated and shows our present understanding of the problems considered The new results obtained by the authors after the Russian edition was published are referred to in footnotes As before the book can be divided into two parts the methods for constructing asymptotic solutions Chapters I V and the application of these methods to some concrete problems Chapters VI VII In Appendix a method for justification some asymptotic solutions is discussed briefly The final formulas for the asymptotic solutions are given in the form of theorems These theorems are unusual in form since they present the results of calculations The authors hope that the book will be useful to specialists both in differential equations and in the mathematical modeling of physical and chemical processes The authors express their gratitude to Professor M Hazewinkel for his attention to this work and his support Small Viscosity and Boundary Layer Methods Guy Métivier, 2004 Metivier is an expert in the field of pdes math physics with a particular emphasis on shock waves New monograph focuses on mathematical methods models and applications of boundary layers present in many problems of physics engineering fluid mechanics Metivier has good Birkhauser track record one of the main authors of *Advances in the Theory of Shock Waves* Freistuehler Szepessy eds 4187 4 Manuscript endorsed by N Bellomo MSSET series editor should be a good sell to members of MSSET community who by in large are based in Europe Included are self contained introductions to different topics such as hyperbolic boundary value problems parabolic systems WKB methods construction of profiles introduction to the theory of Evans functions and energy methods with Kreiss symmetrizers

Partial Differential Equations and Fluid Mechanics James C. Robinson, 2009-07-16 Reviews and research articles summarizing a wide range of active research topics in fluid mechanics **Scientific and Technical Aerospace Reports**, 1973 Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database Applied Mechanics Reviews, 1968 *Computational Techniques for Modeling Atmospheric Processes* Prusov, Vitaliy, Doroshenko, Anatoliy, 2017-06-16 Meteorology has made significant strides in recent years due to the development of new technologies With the aid of the latest instruments the analysis of atmospheric data can be optimized *Computational Techniques for Modeling Atmospheric Processes* is an academic reference source that encompasses novel methods for the collection and study of meteorological data Including a range of perspectives on pertinent topics such as air pollution parameterization and thermodynamics this book is an ideal publication for researchers academics practitioners and students interested in instrumental methods in the study of atmospheric processes *Computational Fluid Flow and Heat Transfer* Mukesh Kumar

Awasthi,Ashwani Kumar,Nitesh Dutt,Satyvir Singh,2024-04-25 The text provides insight into the different mathematical tools and techniques that can be applied to the analysis and numerical computations of flow models It further discusses important topics such as the heat transfer effect on boundary layer flow modeling of flows through porous media anisotropic polytropic gas model and thermal instability in viscoelastic fluids This book Discusses modeling of Rayleigh Taylor instability in nanofluid layer and thermal instability in viscoelastic fluids Covers open FOAM simulation of free surface problems and anisotropic polytropic gas model Highlights the Sensitivity Analysis in Aerospace Engineering MHD Flow of a Micropolar Hybrid Nanofluid and IoT Enabled Monitoring for Natural Convection Presents thermal behavior of nanofluid in complex geometries and heat transfer effect on Boundary layer flow Explains natural convection heat transfer in non Newtonian fluids and homotopy series solution of the boundary layer flow Illustrates modeling of flows through porous media and investigates Shock driven Richtmyer Meshkov instability It is primarily written for senior undergraduate graduate students and academic researchers in the fields of Applied Sciences Mechanical Engineering Manufacturing Engineering Production Engineering Industrial engineering Automotive engineering and Aerospace engineering **Simultaneous Mass Transfer and Chemical Reactions in Engineering Science** Bertram K. C. Chan,2023-02-01 Simultaneous Mass Transfer and Chemical Reactions in Engineering Science A comprehensive look at the basic science of diffusional process and mass transfer Mass transfer as a principle is an essential part of numerous unit operations in biomolecular chemical and process engineering crystallization distillation and membrane separation processes for example use this important method Given this significance particularly in engineering design where these processes occur understanding the design and analysis of such unit operations must begin with a basic understanding of how simultaneous mass transfer and the chemical reactions that influence these occurrences It is also vital to be aware of the most up to date technologies for analyzing and predicting the phenomena Given the significance of this process Simultaneous Mass Transfer and Chemical Reactions in Engineering Science is an important resource as it introduces the reader to the complex subject of simultaneous mass transfer with biochemical and chemical reactions and gives them the tools to develop an applicable design Analyzing the systems of simultaneous mass transfer and reactions is at the core of this book as all known design approaches are carefully examined and compared The volume also provides the reader with a working knowledge of the latest technologies with a special focus on the open sourced computer programming language R and how these tools are an essential resource in quantitative assessment in analysis models Simultaneous Mass Transfer and Chemical Reactions in Engineering Science provides a working knowledge of the latest information on simultaneous mass transfer and reactions by focusing on the analysis of this process as well as discussing the existence and distinctive quality of the solutions to the Simultaneous Mass Transfer and Chemical Reactions in Engineering Science readers will also find A theoretical basis of each design model that is carefully stated compared and assessed Carefully developed and established Existence and Uniqueness Theorems for a general design

model Comprehensive coverage of how the programming language R may be used to analyze models Numerous examples and case studies that provide a working knowledge of simultaneous mass transfer and reactions Simultaneous Mass Transfer and Chemical Reactions in Engineering Science is a useful reference for students in chemical engineering biotechnology or chemistry as well as professional process and chemical engineers

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