BOOK REVIEWS

EDITED BY NICHOLAS D. KAZARINOFF

Mathematical Problems from Combustion Theory. *By Jerrold Bebernes and David Eberly.* Springer-Verlag, New York, 1989. x + 178 pp. $34.00. ISBN 0-387-97104-1. Applied Mathematical Sciences, Vol. 83.

Mathematical problems involving nonlinear forcing, or source terms, are well exemplified physically by combustion processes, which are usefully modeled as involving strongly temperature-sensitive rates of chemical reaction. Depending on the type of interaction that becomes important under appropriate prevailing conditions, a wide range of interesting problems can be extracted for detailed analysis. In this deceptively thin volume, Bebernes and Eberly start with a sketch of the Navier–Stokes equations augmented by chemical behaviour and show how two basic families of problems (which they describe as *solid fuel models* and *gaseous fuel models*) can be extracted. The behaviour of the resulting systems proves to be very rich and so offers a challenging field for mathematical analysis.

The "solid fuel" models apply in a domain $\bar{x} \in \Omega$ and satisfy the equations

$$(1) \quad \begin{aligned} T_t - \Delta T &= e\delta y^m \exp\left(\frac{T-1}{eT}\right), \\ y_t - \beta \Delta y &= -e\delta \Gamma y^m \exp\left(\frac{T-1}{eT}\right) \end{aligned}$$

along with suitable boundary and initial conditions. In the limit as $e \to 0$, the reduced model

$$(2) \quad \theta_t - \Delta \theta = \delta f(\bar{x}, \theta)$$

is identified and is examined in some depth. The combustion model (1) leads to the form $f(\bar{x}, \theta) = \exp(\theta)$ for the forcing function f

but generalisations such as $f(\bar{x}, \theta) = \theta^p$, for $p > 1$, are also considered. These models are characterised by the absence of any convective or compressible effects, leading the authors to describe them as "solid," even though solids would also normally be associated with the limit $\beta \to 0$.

In posing their "gaseous fuel" models, compressibility effects are specifically taken into consideration, leading to different models that may be appropriate under different circumstances. The first model arises for relatively weak effects of compressibility and reduces to the equation

$$(3) \quad \begin{aligned} \theta_t - a\Delta\theta &= \delta e^\theta \\ &+ \frac{\gamma-1}{\gamma} \frac{1}{\text{vol}(\Omega)} \int_\Omega \theta_t(\bar{x}, t)\, d\bar{x}, \end{aligned}$$

in which the constant a may be positive or zero. With stronger effects of compressibility, a reduced Euler model becomes

$$(4) \quad \begin{aligned} \gamma\theta_t - (\gamma-1)P_t &= he^\theta, \\ \gamma\bar{\nabla}\cdot\bar{v} + P_t &= he^\theta, \\ \gamma\bar{v}_t + b\bar{\nabla}P &= 0 \end{aligned}$$

for $b > 0$. Finally, a full system is considered, involving conduction, diffusion, convection, viscosity, and reaction.

The common thread that links all of these problems is the phenomenon of *self-ignition* or "*blowup*," the analysis of which in recent years has been due, in no small part, to the authors themselves. Indeed, the title of this book would have described its contents more precisely had the words "blowup" or "ignition" been inserted. The existence, location, and nature of any blowup (as well as the associated existence of any possible steady-state solutions) are rigorously and inexorably examined.

Steady-state solutions of the "solid fuel" model (2) (and, equivalently, the steady version of the "gaseous" model (3) for $a > 0$), with the boundary condition $\theta = 0$ on $\bar{x} \in \partial\Omega$, are the first to come under scrutiny in a variety of geometries and number of dimensions n.

Mathematical Problems From Combustion Theory

Lu Ting,Rupert Klein,Omar M Knio

Mathematical Problems From Combustion Theory:

    Mathematical Problems from Combustion Theory Jerrold Bebernes,David Eberly,2013-12-01 This monograph evolved over the past five years It had its origin as a set of lecture notes prepared for the Ninth Summer School of Mathematical Physics held at Ravello Italy in 1984 and was further refined in seminars and lectures given primarily at the University of Colorado The material presented is the product of a single mathematical question raised by Dave Kassoy over ten years ago This question and its partial resolution led to a successful exciting almost unique interdisciplinary col laborative scientific effort The mathematical models described are often times deceptively simple in appearance But they exhibit a mathematical richness and beauty that belies that simplicity and affirms their physical significance The mathe matical tools required to resolve the various problems raised are diverse and no systematic attempt is made to give the necessary mathematical background The unifying theme of the monograph is the set of models themselves This monograph would never have come to fruition without the enthu siasm and drive of Dave Eberly a former student now collaborator and coauthor and without several significant breakthroughs in our understand ing of the phenomena of blowup or thermal runaway which certain models discussed possess A collaborator and former student who has made significant contribu tions throughout is Alberto Bressan There are many other collaborators William Troy Watson Fulks Andrew Lacey Klaus Schmitt and former students Paul Talaga and Richard Ely who must be acknowledged and thanked   **A mathematical analysis of some problems from combustion theory** J.W. Bebernes,1976   *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   *Differential Equations with Applications to Mathematical Physics* W. F. Ames,1993-03-05 Differential Equations with Applications to Mathematical Physics   *Vortex Dominated Flows* Lu Ting,Rupert Klein,Omar M Knio,2007-07-05 This monograph provides in depth analyses of vortex dominated flows via matched and multiscale asymptotics and demonstrates how insight gained through these analyses can be exploited in the construction of robust efficient and accurate numerical techniques The book explores the dynamics of slender vortex filaments in detail including fundamental derivations compressible core structure weakly non linear limit regimes and associated numerical methods Similarly the volume covers asymptotic analysis and computational

techniques for weakly compressible flows involving vortex generated sound and thermoacoustics The book is addressed to both graduate students and researchers   Mathematics Applied to Engineering, Modelling, and Social Issues Frank T. Smith,Hemen Dutta,John N. Mordeson,2019-03-14 This book presents several aspects of research on mathematics that have significant applications in engineering modelling and social matters discussing a number of current and future social issues and problems in which mathematical tools can be beneficial Each chapter enhances our understanding of the research problems in a particular an area of study and highlights the latest advances made in that area The self contained contributions make the results and problems discussed accessible to readers and provides references to enable those interested to follow subsequent studies in still developing fields Presenting real world applications the book is a valuable resource for graduate students researchers and educators It appeals to general readers curious about the practical applications of mathematics in diverse scientific areas and social problems   **Functional Analytic Methods for Evolution Equations** Giuseppe Da Prato,Peer Christian Kunstmann,Irena Lasiecka,Alessandra Lunardi,Roland Schnaubelt,Lutz Weis,2004-08-30 This book consists of five introductory contributions by leading mathematicians on the functional analytic treatment of evolutions equations In particular the contributions deal with Markov semigroups maximal L p regularity optimal control problems for boundary and point control systems parabolic moving boundary problems and parabolic nonautonomous evolution equations The book is addressed to PhD students young researchers and mathematicians doing research in one of the above topics   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   **Optimization** Elijah Polak,2012-12-06 This book deals with optimality conditions algorithms and discretization tech niques for nonlinear

programming semi infinite optimization and optimal con trol problems The unifying thread in the presentation consists of an abstract theory within which optimality conditions are expressed in the form of zeros of optimality junctions algorithms are characterized by point to set iteration maps and all the numerical approximations required in the solution of semi infinite optimization and optimal control problems are treated within the context of con sistent approximations and algorithm implementation techniques Traditionally necessary optimality conditions for optimization problems are presented in Lagrange F John or Karush Kuhn Tucker multiplier forms with gradients used for smooth problems and subgradients for nonsmooth prob lems We present these classical optimality conditions and show that they are satisfied at a point if and only if this point is a zero of an upper semicontinuous optimality junction The use of optimality functions has several advantages First optimality functions can be used in an abstract study of optimization algo rithms Second many optimization algorithms can be shown to use search directions that are obtained in evaluating optimality functions thus establishing a clear relationship between optimality conditions and algorithms Third estab lishing optimality conditions for highly complex problems such as optimal con trol problems with control and trajectory constraints is much easier in terms of optimality functions than in the classical manner In addition the relationship between optimality conditions for finite dimensional problems and semi infinite optimization and optimal control problems becomestransparent   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   **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   *Analysis of Spherical Symmetries in Euclidean Spaces* Claus Müller,2012-12-06 This book gives a new and direct approach into the theories of special functions with emphasis on spherical symmetry in Euclidean spaces of ar bitrary dimensions Essential parts may even be called elementary because of the chosen techniques The central topic is the presentation of spherical harmonics in a theory of invariants of the orthogonal group H Weyl was one of the first to point out that spherical harmonics must be more than a fortunate guess to simplify numerical computations in mathematical physics His opinion arose from his occupation with quan tum mechanics and was supported by many physicists These ideas are the leading theme throughout this treatise When R Richberg and I started this project we were surprised how easy and elegant the general theory could be One of the highlights of this book is the extension of the classical results of spherical harmonics into the complex This is particularly important for the complexification of the Funk Hecke formula which is successfully used to introduce orthogonally invariant solutions of the reduced wave equation The radial parts of these solutions are either Bessel or Hankel functions which play an important role in the mathematical theory of acoustical and optical waves These theories often require a detailed analysis of the asymptotic behavior of the solutions The presented introduction of Bessel and Hankel functions yields directly the leading terms of the asymptotics Approximations of higher order can be deduced   Delay Equations Odo Diekmann,Stephan A.van Gils,Sjoerd M.V. Lunel,Hans-Otto Walther,2012-12-06 The aim of this book is to provide an introduction to the mathematical theory of infinite dimensional dynamical systems by focusing on a relatively simple yet rich class of examples that is those described by delay differential equations It is a textbook giving detailed proofs and providing many exercises which is intended both for self study and for courses at a graduate level The book would also be suitable as a reference for basic results As the subtitle indicates the book is about concepts ideas results and methods from linear functional analysis complex function theory the qualitative theory of dynamical systems and nonlinear analysis After studying this book the reader should have a working knowledge of applied functional analysis and dynamical systems   *Chaos, Fractals, and Noise* Andrzej Lasota,Michael C. Mackey,2013-11-27 The first edition of this book was originally published in 1985 under the ti tle Probabilistic Properties of Deterministic Systems In the intervening years interest in so called chaotic systems has continued unabated but with a more thoughtful and sober eye toward applications as befits a ma turing field This interest in the serious usage of the concepts and techniques of nonlinear dynamics by applied scientists has probably been spurred more by the availability of inexpensive computers than by any other factor Thus computer experiments have been prominent suggesting the wealth of phe nomena that may be resident in nonlinear systems In particular they allow one to observe the interdependence between the deterministic and probabilistic properties of these systems such as the existence of invariant measures and densities statistical stability and periodicity the influence of stochastic perturbations the formation of attractors and many others The

aim of the book and especially of this second edition is to present recent theoretical methods which allow one to study these effects We have taken the opportunity in this second edition to not only correct the errors of the first edition but also to add substantially new material in five sections and a new chapter **Integral Manifolds and Inertial Manifolds for Dissipative Partial Differential Equations** P. Constantin,C. Foias,B. Nicolaenko,R. Temam,2012-12-06 This work was initiated in the summer of 1985 while all of the authors were at the Center of Nonlinear Studies of the Los Alamos National Laboratory it was then continued and polished while the authors were at Indiana Univer sity at the University of Paris Sud Orsay and again at Los Alamos in 1986 and 1987 Our aim was to present a direct geometric approach in the theory of inertial manifolds global analogs of the unstable center manifolds for dissipative partial differential equations This approach based on Cauchy integral mani folds for which the solutions of the partial differential equations are the generating characteristic curves has the advantage that it provides a sound basis for numerical Galerkin schemes obtained by approximating the inertial manifold The work is self contained and the prerequisites are at the level of a graduate student The theoretical part of the work is developed in Chapters 2 14 while in Chapters 15 19 we apply the theory to several remarkable partial differ ential equations **Nonlinear Evolutionary Partial Differential Equations** Xiaxi Ding,Tai-Ping Liu,1997 This volume contains the proceedings from the International Conference on Nonlinear Evolutionary Partial Differential Equations held in Beijing in June 1993 The topic for the conference was selected because of its importance in the natural sciences and for its mathematical significance Discussion topics include conservation laws dispersion waves Einstein s theory of gravitation reaction diffusion equations the Navier Stokes equations and more New results were presented and are featured in this volume Titles in this series are co published with International Press Cambridge MA Averaging Methods in Nonlinear Dynamical Systems Jan A. Sanders,Ferdinand Verhulst,James Murdock,2007-08-18 Perturbation theory and in particular normal form theory has shown strong growth during the last decades So it is not surprising that the authors have presented an extensive revision of the first edition of the Averaging Methods in Nonlinear Dynamical Systems book There are many changes corrections and updates in chapters on Basic Material and Asymptotics Averaging and Attraction Chapters on Periodic Averaging and Hyperbolicity Classical first level Normal Form Theory Nilpotent classical Normal Form and Higher Level Normal Form Theory are entirely new and represent new insights in averaging in particular its relation with dynamical systems and the theory of normal forms Also new are surveys on invariant manifolds in Appendix C and averaging for PDEs in Appendix E Since the first edition the book has expanded in length and the third author James Murdock has been added Review of First Edition One of the most striking features of the book is the nice collection of examples which range from the very simple to some that are elaborate realistic and of considerable practical importance Most of them are presented in careful detail and are illustrated with profuse illuminating diagrams Mathematical Reviews **Partial Differential Equations III** 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   **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   *Analysis and Simulation of Chaotic Systems* Frank C. Hoppensteadt,2008-01-27 Beginning with realistic mathematical or verbal models of physical or biological phenomena the author derives tractable models for further mathematical analysis or computer simulations For the most part derivations are based on perturbation methods and the majority of the text is devoted to careful derivations of implicit function theorems the method of averaging and quasi static state approximation methods The duality between stability and perturbation is developed and used relying heavily on the concept of stability under persistent disturbances Relevant topics

about linear systems nonlinear oscillations and stability methods for difference differential delay integro differential and ordinary and partial differential equations are developed throughout the book For the second edition the author has restructured the chapters placing special emphasis on introductory materials in Chapters 1 and 2 as distinct from presentation materials in Chapters 3 through 8 In addition more material on bifurcations from the point of view of canonical models sections on randomly perturbed systems and several new computer simulations have been added

Whispering the Strategies of Language: An Mental Journey through **Mathematical Problems From Combustion Theory**

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Table of Contents Mathematical Problems From Combustion Theory

- Fact-Checking eBook Content of Mathematical Problems From Combustion Theory
- Distinguishing Credible Sources
13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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