

International Series of Numerical Mathematics
Internationale Schriftenreihe zur Numerischen Mathematik
Série Internationale d'Analyse Numérique
Vol. 99

ISNM 99

Numerical Methods for Free Boundary Problems

Edited by

P. Neittaanmäki

Springer Basel AG

Numerical Methods For Free Boundary Problems
International Series Of Numerical Mathematics Volume
99

**Tomáš Bodnár, Giovanni P. Galdi, Šárka
Nečasová**



Numerical Methods For Free Boundary Problems International Series Of Numerical Mathematics Volume 99:

Numerical Methods for Free Boundary Problems VEITTAANMÄKI, 2013-11-22 About 80 participants from 16 countries attended the Conference on Numerical Methods for Free Boundary Problems held at the University of Jyväskylä Finland July 23-27 1990 The main purpose of this conference was to provide up to date information on important directions of research in the field of free boundary problems and their numerical solutions The contributions contained in this volume cover the lectures given in the conference The invited lectures were given by H W Alt V Barbu K H Hoffmann H Mittelmann and V Rivkind In his lecture H W Alt considered a mathematical model and existence theory for non isothermal phase separations in binary systems The lecture of V Barbu was on the approximate solvability of the inverse one phase Stefan problem K H Hoffmann gave an up to date survey of several directions in free boundary problems and listed several applications but the material of his lecture is not included in this proceedings H D Mittelmann handled the stability of thermo capillary convection in float zone crystal growth V Rivkind considered numerical methods for solving coupled Navier Stokes and Stefan equations Besides of those invited lectures mentioned above there were 37 contributed papers presented We shall briefly outline the topics of the contributed papers Stefan like problems Modelling existence and uniqueness *Software Systems for Structural Optimization* H.R. Hörnlein, K. Schnittkowski, 2013-03-07 Herbert Hornlein Klaus Schittkowski The finite element method FEM has been used successfully for many years to simulate and analyse mechanical structural problems The results are accepted or rejected by means of comparison of state variables stresses displacements natural frequencies etc and user requirements In further analyses the design variables will be updated until the user specifications are met and the design is feasible This is the primary aim of the design process On this set of feasible designs the additional requirement given by an objective function e.g. weight stiffness efficiency etc defines the structural optimization problem In recent years more and more finite element based analysis systems were extended and offer now optimization modules They proceed from the design model as defined for structural analysis to perform an internal adaption of design parameters based on formal mathematical methods Despite of many common features there are significant differences in the selected optimization strategy the current implementation and the numerical results *Mathematical Modelling and Simulation of Electrical Circuits and Semiconductor Devices* Randolph Bank, R. Bulirsch, H. Gajewski, K. Merten, 2012-12-06 Progress in today's high technology industries is strongly associated with the development of new mathematical tools A typical illustration of this partnership is the mathematical modelling and numerical simulation of electric circuits and semiconductor devices At the second Oberwolfach conference devoted to this important and timely field scientists from around the world mainly applied mathematicians and electrical engineers from industry and universities presented their new results Their contributions forming the body of this work cover electric circuit simulation device simulation and process simulation Discussions on experiences with standard software packages and improvements of such packages are included In the semiconductor area

special lectures were given on new modelling approaches numerical techniques and existence and uniqueness results In this connection mention is made for example of mixed finite element methods an extension of the Baliga Patankar technique for a three dimensional simulation and the connection between semiconductor equations and the Boltzmann equations

The Classical Stefan Problem S.C. Gupta, 2017-10-13 The Classical Stefan Problem Basic Concepts Modelling and Analysis with Quasi Analytical Solutions and Methods New Edition provides fundamental theory concepts modelling and analysis of the physical mathematical thermodynamical and metallurgical properties of classical Stefan and Stefan like problems as applied to heat transfer problems involving phase changes such as from liquid to solid This self contained work reports and derives the results from tensor analysis differential geometry non equilibrium thermodynamics physics and functional analysis and is thoroughly enriched with many appropriate references for an in depth background reading on theorems This new edition includes more than 400 pages of new material on quasi analytical solutions and methods of classical Stefan and Stefan like problems The book aims to bridge the gap between the theoretical and solution aspects of the afore mentioned problems Provides both the phenomenology and mathematics of Stefan problems Bridges physics and mathematics in a concrete and readable manner Presents well organized chapters that start with proper definitions followed by explanations and references for further reading Includes both numerical and quasi analytical solutions and methods of classical Stefan and Stefan like problems

Transport Simulation in Microelectronics Alfred Kersch, William J. Morokoff, 2012-12-06 Computer simulation of semiconductor processing equipment and devices requires the use of a wide variety of numerical methods Of these methods the Monte Carlo approach is perhaps most fundamentally suited to modeling physical events occurring on microscopic scales which are intricately connected to the particle structure of nature Here physical phenomena can be simulated by following simulation particles such as electrons molecules photons etc through a statistical sampling of scattering events Monte Carlo is however generally looked on as a last resort due to the extremely slow convergence of these methods It is of interest then to examine when in microelectronics it is necessary to use Monte Carlo methods how such methods may be improved and what are the alternatives This book addresses three general areas of simulation which frequently arise in semiconductor modeling where Monte Carlo methods play a significant role In the first chapter the basic mathematical theory of the Boltzmann equation for particle transport is presented The following chapters are devoted to the modeling of the transport processes and the associated Monte Carlo methods Specific examples of industrial applications illustrate the effectiveness and importance of these methods Two of these areas concern simulation of physical particles which may be assigned a time dependent position and velocity This includes the molecules of a dilute gas used in such processing equipment as chemical vapor decomposition reactors and sputtering reactors We also consider charged particles moving within a semiconductor lattice

Flow in Porous Media J. Douglas, U. Hornung, 2012-12-06 Jim Douglas Jr These proceedings reflect some of the thoughts expressed at the Oberwolfach Conference on Porous Media held June 21-27 1992

organized by Jim Douglas Jr Ulrich Hornung and Cornelius J van Duijn Forty five scientists attended the conference and about thirty papers were presented Fourteen manuscripts were submitted for the proceedings and are incorporated in this volume they cover a number of aspects of flow and transport in porous media Indeed there are 223 individual references in the fourteen papers but fewer than fifteen are cited in more than one paper The papers appear in alphabetical order on the basis of the first author A brief introduction to each paper is given below Allen and Curran consider a variety of questions related to the simulation of ground water contamination Accurate water velocities are essential for acceptable results and the authors apply mixed finite elements to the pressure equation to obtain these velocities Since fine grids are required to resolve heterogeneities standard iterative procedures are too slow for practical simulation the authors introduce a parallelizable multigrid based iterative scheme for the lowest order Raviart Thomas mixed method Contaminant transport is approximated through a finite element collocation procedure and an alternating direction modified method of characteristics technique is employed to time step the simulation Computational experiments carried out on an nCube 2 computer

Numerical Simulations of Incompressible Flows M. M. Hafez, Dochan Kwak, 2003 This book consists of 37 articles dealing with simulation of incompressible flows and applications in many areas It covers numerical methods and algorithm developments as well as applications in aeronautics and other areas It represents the state of the art in the field Contents Navier-Stokes Solvers Projection Methods Finite Element Methods Higher Order Methods Innovative Methods Applications in Aeronautics Applications Beyond Aeronautics Multiphase and Cavitating Flows Special Topics Readership Researchers and graduate students in computational science and engineering **Archives of Control Sciences**, 1992

Numerical Methods in Approximation Theory, Vol. 9 D. Braess, L.L. Schumaker, 2013-03-11 This book is the official proceedings of a conference on Numerical Methods in Approximation Theory which was held at the Mathematisches Forschungsinstitut in Oberwolfach during the week of November 24-30 1991 It contains refereed and edited papers by 20 of the 49 participants The book is dedicated to the memory of Prof Lothar Collatz who maintained a long and active interest in numerical approximation It is the ninth in a series of volumes published by Birkhäuser resulting from conferences on the subject held at Oberwolfach and co organized by Prof Collatz We now briefly describe the contents of the book The paper of BASZENSKI, DELVOS and JESTER deals with blending using sine double series expansions of functions defined on the unit square In addition to giving explicit error estimates for partial sums and for interpolating sine polynomials they also show that Boolean sums yield almost the same asymptotic error estimates as the conventional tensor product approach but with a reduced number of terms The paper of BEATSON and LIGHT discusses approximation by quasi-interpolants which are sums of scaled translates of a one parameter family of functions They do not require reproduction of low degree polynomials but nevertheless are able to give error bounds and analyze quasi-interpolation based on Gaussians and exponentials BINEV and JETTER deal with multivariate interpolation using shifts of a single basis function They treat both gridded data and scattered

data As examples they consider box splines and certain radial basis functions

Fluid-Structure Interaction and

Biomedical Applications Tomáš Bodnár, Giovanni P. Galdi, Šárka Nečasová, 2014-10-13 This book presents in a methodical way updated and comprehensive descriptions and analyses of some of the most relevant problems in the context of fluid structure interaction FSI Generally speaking FSI is among the most popular and intriguing problems in applied sciences and includes industrial as well as biological applications Various fundamental aspects of FSI are addressed from different perspectives with a focus on biomedical applications More specifically the book presents a mathematical analysis of basic questions like the well posedness of the relevant initial and boundary value problems as well as the modeling and the numerical simulation of a number of fundamental phenomena related to human biology These latter research topics include blood flow in arteries and veins blood coagulation and speech modeling We believe that the variety of the topics discussed along with the different approaches used to address and solve the corresponding problems will help readers to develop a more holistic view of the latest findings on the subject and of the relevant open questions For the same reason we expect the book to become a trusted companion for researchers from diverse disciplines such as mathematics physics mathematical biology bioengineering and medicine

Free Boundary Problems in Continuum Mechanics S.N. Antontsev, K.H. Hoffmann, A.M. Khludnev, 2013-03-07 Progress in different fields of mechanics such as filtration theory elastic plastic problems crystallization processes internal and surface waves etc is governed to a great extent by the advances in the study of free boundary problems for nonlinear partial differential equations Free boundary problems form a scientific area which attracts attention of many specialists in mathematics and mechanics Increasing interest in the field has given rise to the International Conferences on Free Boundary Problems and Their Applications which have convened since the 1980s in such countries as England the United states Italy France and Germany This book comprises the papers presented at the International Conference Free Boundary Problems in Continuum Mechanics organized by the Lavrentyev Institute of Hydrodynamics Russian Academy of Sciences July 15 19 1991 Novosibirsk Russia The scientific committee consisted of Co chairmen K H Hoffmann L V Ovsianikov S Antontsev Russia J Ockendon UK M Fremont France L Ovsianikov Russia A Friedman USA S Pokhozhaev Russia K H Hoffmann Germany M Primicerio Italy A Khludnev Russia V Pukhnachov Russia V Monakhov Russia Yu Shokin Russia V Teshukov Russia Our thanks are due to the members of the Scientific Committee all authors and participants for contributing to the success of the Conference We would like to express special appreciation to N Makarenko J Mal'tseva and T Savelieva Lavrentyev Institute of Hydrodynamics for their help in preparing this book for publication

Free Boundary Value Problems HOFFMANN, SPREKELS, 2013-03-08 This monograph contains a collection of 16 papers that were presented at the conference Free Boundary Problems Numerical Treatment and Optimal Control held at the Mathematisches Forschungsinstitut Oberwolfach West Germany July 9 15 1989 It was the aim of the organizers of the meeting to bring together experts from different areas in the broad field of free boundary problems where a certain emphasis

was given to the numerical treatment and optimal control of free boundary problems. However, during the conference, also a number of papers leading to important new theoretical insights were presented. The strong connection between theory and applications finds its reflection in this monograph, which contains papers of high theoretical and numerical interest as well as applications to important practical problems. Many of the contributions are concerned with phase transition phenomena, a field which was of particular importance during the meeting. Topics like spinodal decomposition, shape memory alloys, crystal growth, and flow through porous media are addressed. Another field of major interest during the conference was fluid flow; also this field is addressed in this volume. The volume opens with a contribution by H. W. Alt and I. Pawlow. In their paper, the problem of spinodal decomposition is treated in the non-isothermal situation. For the first time, the existence of a weak solution to the corresponding system of evolution equations could be proved. The results of some numerical experiments are also reported. In the following paper, M. Bornert and I. *Free Boundary Problems*, Isabel Narra Figueiredo, Lisa Santos, 2007-01-11. This book collects refereed lectures and communications presented at the Free Boundary Problems Conference FBP2005. These discuss the mathematics of a broad class of models and problems involving nonlinear partial differential equations arising in physics, engineering, biology, and finance. Among other topics, the talks considered free boundary problems in biomedicine, in porous media, in thermodynamic modeling, in fluid mechanics, in image processing, in financial mathematics, or in computations for inter-scale problems. *Advances in Mathematical Sciences and Applications*, 1996. *Nonlinear Inclusions and Hemivariational Inequalities*, Stanisław Migórski, Anna Ochal, Mircea Sofonea, 2012-09-18. This book introduces the reader to the theory of nonlinear inclusions and hemivariational inequalities, with emphasis on the study of contact mechanics. The work covers both abstract results in the area of nonlinear inclusions, hemivariational inequalities, as well as the study of specific contact problems, including their modelling and their variational analysis. Provided results are based on original research on the existence, uniqueness, regularity, and behavior of the solution for various classes of nonlinear stationary and evolutionary inclusions. In carrying out the variational analysis of various contact models, one systematically uses results of hemivariational inequalities and in this way illustrates the applications of nonlinear analysis in contact mechanics. New mathematical methods are introduced and applied in the study of nonlinear problems which describe the contact between a deformable body and a foundation. Contact problems arise in industry, engineering, and geophysics. Their variational analysis, presented in this book, lies in the background for their numerical analysis. This volume will interest mathematicians, applied mathematicians, engineers, and scientists, as well as advanced graduate students. **A Variational Inequality Approach to free Boundary Problems with Applications in Mould Filling**, Jörg Steinbach, 2012-12-06. Since the early 1960s, the mathematical theory of variational inequalities has been under rapid development, based on complex analysis and strongly influenced by real-life applications. Many, but of course not all, moving free Lebesgue a priori unknown boundary problems originating from engineering and economic applications can directly or after a transformation be

formulated as variational inequalities In this work we investigate an evolutionary variational inequality with a memory term which is as a fixed domain formulation the result of the application of such a transformation to a degenerate moving free boundary problem This study includes mathematical modelling existence uniqueness and regularity results numerical analysis of finite element and finite volume approximations as well as numerical simulation results for applications in polymer processing Essential parts of these research notes were developed during my work at the Chair of Applied Mathematics LAM of the Technical University Munich I would like to express my sincerest gratitude to K H Hoffmann the head of this chair and the present scientific director of the Center of Advanced European Studies and Research caesar for his encouragement and support With this work I am following a general concept of Applied Mathematics to which he directed my interest and which based on application problems comprises mathematical modelling mathematical and numerical analysis computational aspects and visualization of simulation results

Subject Guide to Books in Print, 2001 *Computational Optimization of Systems Governed by Partial Differential Equations* Alfio Borzi, Volker Schulz, 2012-01-26 This book provides a bridge between continuous optimization and PDE modelling and focuses on the numerical solution of the corresponding problems Intended for graduate students in PDE constrained optimization it is also suitable as an introduction for researchers in scientific computing or optimization

Modelling and Control in Solid Mechanics A. M. Khludnev, Jan Sokołowski, 1997 This book covers the boundary value problems for a wide range of mathematical models of the mechanics of deformable bodies in particular the boundary value problems concerning plates and shells crack theory and elastoplastic bodies An essential feature of the discussed boundary value problems is the availability of the inequality type constraints imposed on solutions such as the impenetration condition for contact problems the yield plasticity condition etc As a consequence the presence of free boundaries is typical of the boundary value problems concerned The objective of the book is to display some new methods of analyzing such problems as well as to perform research on new models evolved from engineering practice Readers will find a variety of new mathematical models describing some contact problems for plates and shells an equilibrium of plates involving cracks etc Furthermore some new mathematical methods are presented which were specially developed by the authors to study the problems concerned These help to convey a comprehensive picture of the present state of mathematical problems on the free boundary elasticity and plasticity theory The book is intended for postgraduates scientists and engineers and for Students interested in problems of modelling and optimal control in the mechanics of deformable bodies

Numerical Solution of the Incompressible Navier-Stokes Equations L. Quartapelle, 2013-03-07 This book presents different formulations of the equations governing incompressible viscous flows in the form needed for developing numerical solution procedures The conditions required to satisfy the no slip boundary conditions in the various formulations are discussed in detail Rather than focussing on a particular spatial discretization method the text provides a unitary view of several methods currently in use for the numerical solution of incompressible Navier Stokes equations using

either finite differences finite elements or spectral approximations For each formulation a complete statement of the mathematical problem is provided comprising the various boundary possibly integral and initial conditions suitable for any theoretical and or computational development of the governing equations The text is suitable for courses in fluid mechanics and computational fluid dynamics It covers that part of the subject matter dealing with the equations for incompressible viscous flows and their determination by means of numerical methods A substantial portion of the book contains new results and unpublished material

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Introduction

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