

3.The nonlinear Boussinesq equation

The idealized cross section of the model under consideration is depicted in figure1 below.



Figure1. Idealized cross section of the model of transient stream-aquifer interaction.

The governing equation for one-dimensional, lateral, unconfined groundwater flow with Dupuit assumptions is the Boussinesq equation (Bear, 1972) [2]:

$$\frac{\partial h}{\partial t} = \frac{K}{S_y} \frac{\partial}{\partial x} \left(h \frac{\partial h}{\partial x} \right) \quad (12)$$

where $h(x,t)$ is the water table elevation at a distance x from the origin and time t , K , S_y are the saturated hydraulic conductivity and specific yield respectively which are considered to be constant.

In order to solve Boussinesq equation (12) completely, the specific initial condition and boundary conditions are as considered in [8] are given by:

$$h(0,t) = H(t), \quad t \geq 0, \quad (13)$$

$$\frac{\partial h(l_x,t)}{\partial x} = 0, \quad t \geq 0, \quad (14)$$

The exact solution of equation(12) – (14) is as given in [7]

$$h(x,t) = \frac{x}{t+1} - \frac{x^2}{6(t+1)} + \frac{3}{2(t+1)} \left[(t+1)^{2/3} - 1 \right] \quad (15)$$

we have considered the case where $H(t)$ increases from zero to a maximum and then decreases back to zero, thus providing a realistic behaviour for all times.

We take $H(t) = \frac{3}{2(t+1)} \left[(t+1)^{2/3} - 1 \right]$ shown in figure 2 below.

Approximate Analytical Solution Of The Boussinesq Equation

**Manoj Sahni, José M. Merigó, Walayat
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Approximate Analytical Solution Of The Boussinesq Equation:

Simulation of Water Waves by Boussinesq Models Ge Wei, 1997 A new set of time dependent Boussinesq equations is derived to simulate nonlinear long wave propagation in coastal regions Following the approaches by Nwogu and later by Chen and Liu the velocity or velocity potential at a certain water depth corresponding to the optimum linear dispersion property is used as a dependent variable Therefore the resulting equations are valid in intermediate water depth as well as for highly nonlinear waves Coefficients for second order bound waves and the third order Schrodinger equation are derived and compared with exact solutions A numerical model using a combination of second and fourth order schemes to discretize equation terms is developed for obtaining solutions to the equations A fourth order predictor corrector scheme is employed for time stepping and the first order derivative terms are finite differenced to fourth order accuracy making the truncation errors smaller than the dispersive terms in the equations Linear stability analysis is performed to determine the corresponding numerical stability range for the model To avoid the problem of wave reflection from the conventional incident boundary condition internal wave generation by source function is employed for the present model Numerical filtering is applied at specified time steps in the model to eliminate short waves about 2 to 5 times of the grid size which are generated by the nonlinear interaction of long waves To simulate the wave breaking process additional terms for artificial eddy viscosity are included in the model equations to dissipate wave energy The dissipation terms are activated when the horizontal gradient of the horizontal velocity exceeds the specified breaking criteria Some of the existing models for simulating the process of wave runup are reviewed and we attempt to incorporate the present model to simulate the process by maintaining a thin layer of water over the physically dry grids

Approximation Methods and Analytical Modeling Using Partial Differential Equations Tamara Fastovska, Yurii Kolomoitsev, Kateryna Buryachenko, Marina Chugunova, 2025-03-28

Adequate mathematical modeling is the key to success for many real world projects in engineering medicine and other applied areas As soon as an appropriate mathematical model is developed it can be comprehensively analyzed by a broad spectrum of available mathematical methods For example compartmental models are widely used in mathematical epidemiology to describe the dynamics of infectious diseases and in mathematical models of population genetics While the existence of an optimal solution under certain condition can be often proved rigorously this does not always mean that such a solution is easy to implement in practice Finding a reasonable approximation can in itself be a challenging research problem This Research Topic is devoted to modeling analysis and approximation problems whose solutions exploit and explore the theory of partial differential equations It aims to highlight new analytical tools for use in the modeling of problems arising in applied sciences and practical areas Researchers are invited to submit articles that investigate the qualitative behavior of weak solutions removability conditions for singularities the dependence of the local asymptotic property of these solutions on initial and boundary data and also the existence of solutions Contributors are particularly encouraged to focus on anisotropic

models analyzing the preconditions on the strength of the anisotropy and comparing the analytical estimates for the growth behavior of the solutions near the singularities with the observed growth in numerical simulations The qualitative analysis and analytical results should be confirmed by the numerically observed solution behavior *Numerical Modeling of Water Waves* Pengzhi Lin, 2008-04-30 Modelling large scale wave fields and their interaction with coastal and offshore structures has become much more feasible over the last two decades with increases in computer speeds Wave modelling can be viewed as an extension of wave theory a mature and widely published field applied to practical engineering through the use of computer tools Information about the various wave models which have been developed is often widely scattered in the literature and consequently this is one of the first books devoted to wave models and their applications At the core of the book is an introduction to various types of wave models For each model the theoretical assumptions the application range and the advantages and limitations are elaborated The combined use of different wave models from large scale to local scale is highlighted with a detailed discussion of the application and matching of boundary conditions At the same time the book provides a grounding in hydrodynamics wave theory and numerical methods which underlie wave modelling It presents the theoretical background and also shows how to use these models for achieving different engineering tasks illustrated and reinforced with case study examples **Analytical Methods in Nonlinear Oscillations** Ebrahim Esmailzadeh, Davood Younesian, Hassan Askari, 2018-06-29 This book covers both classical and modern analytical methods in nonlinear systems A wide range of applications from fundamental research to engineering problems are addressed The book contains seven chapters each with miscellaneous problems and their detailed solutions More than 100 practice problems are illustrated which might be useful for students and researchers in the areas of nonlinear oscillations and applied mathematics With providing real world examples this book shows the multidisciplinary emergence of nonlinear dynamical systems in a wide range of applications including mechanical and electrical oscillators micro nano resonators and sensors and also modelling of global warming epidemic diseases sociology chemical reactions biology and ecology *Selected Water Resources Abstracts*, 1991 *Modelling and Simulation of Diffusive Processes* S.K. Basu, Naveen Kumar, 2014-04-15 This book addresses the key issues in the modeling and simulation of diffusive processes from a wide spectrum of different applications across a broad range of disciplines Features discusses diffusion and molecular transport in living cells and suspended sediment in open channels examines the modeling of peristaltic transport of nanofluids and isotachophoretic separation of ionic samples in microfluidics reviews thermal characterization of non homogeneous media and scale dependent porous dispersion resulting from velocity fluctuations describes the modeling of nitrogen fate and transport at the sediment water interface and groundwater flow in unconfined aquifers investigates two dimensional solute transport from a varying pulse type point source and futile cycles in metabolic flux modeling studies contaminant concentration prediction along unsteady groundwater flow and modeling synovial fluid flow in human joints explores the modeling of soil organic carbon and crop

growth simulation **Approximate Analytical Methods for Solving Ordinary Differential Equations** T.S.L Radhika,T. K.V. Iyengar,T. Raja Rani,2014-10-31 Approximate Analytical Methods for Solving Ordinary Differential Equations ODEs is the first book to present all of the available approximate methods for solving ODEs eliminating the need to wade through multiple books and articles It covers both well established techniques and recently developed procedures including the classical series solution method diverse perturbation methods pioneering asymptotic methods and the latest homotopy methods The book is suitable not only for mathematicians and engineers but also for biologists physicists and economists It gives a complete description of the methods without going deep into rigorous mathematical aspects Detailed examples illustrate the application of the methods to solve real world problems The authors introduce the classical power series method for solving differential equations before moving on to asymptotic methods They next show how perturbation methods are used to understand physical phenomena whose mathematical formulation involves a perturbation parameter and explain how the multiple scale technique solves problems whose solution cannot be completely described on a single timescale They then describe the Wentzel Kramers and Brillouin WKB method that helps solve both problems that oscillate rapidly and problems that have a sudden change in the behavior of the solution function at a point in the interval The book concludes with recent nonperturbation methods that provide solutions to a much wider class of problems and recent analytical methods based on the concept of homotopy of topology *Selected Water Resources Abstracts* ,1991 **A Time-dependent Numerical Code for Extended Boussinesq Equations** Ge Wei,1994 **Mathematical Modeling, Computational Intelligence Techniques and Renewable Energy** Manoj Sahni,José M. Merigó,Walayat Hussain,Ernesto León-Castro,Raj Kumar Verma,Ritu Sahni,2023-05-08 The book is a collection of best selected research papers presented at the Third International Conference on Mathematical Modeling Computational Intelligence Techniques and Renewable Energy MMCITRE 2022 organized by the University of Technology Sydney Australia in association with the Department of Mathematics Pandit Deendayal Energy University India and Forum for Interdisciplinary Mathematics This book presents new knowledge and recent developments in all aspects of computational techniques mathematical modeling energy systems applications of fuzzy sets and intelligent computing The book provides innovative works of researchers academicians and students in the area of interdisciplinary mathematics statistics computational intelligence and renewable energy **Karst Hydrogeology and Geomorphology** Derek Ford,Paul D. Williams,2013-05-03 Originally published in 1989 Karst Geomorphology and Hydrology became the leading textbook on karst studies This new textbook has been substantially revised and updated The first half of the book is a systematic presentation of the dissolution kinetics chemical equilibria and physical flow laws relating to karst environments It includes details of the many environmental factors that complicate their chemical evolution with a critique of measurement of karst erosion rates The second half of the book looks at the classification system for cave systems and the influence of climate and climatic change on karst development The book ends

with chapters on karst water resource management and a look at the important issues of environmental management including environmental impact assessment environmental rehabilitation tourism impacts and conservation values Practical application of karst studies are explained throughout the text This new edition strengthens the book's position as the essential reference in the field Karst geoscientists will not dare to stray beyond arm's reach of this volume It is certain to remain the professional standard for many decades Journal of Cave and Karst Studies August 2007 Handbook of Engineering Hydrology (Three-Volume Set) Saeid Eslamian, 2018-10-03 While most books examine only the classical aspects of hydrology this three volume set covers multiple aspects of hydrology and includes contributions from experts from more than 30 countries It examines new approaches addresses growing concerns about hydrological and ecological connectivity and considers the worldwide impact of climate change *Scientific and Technical Aerospace Reports*, 1993 **Estimating Groundwater Recharge** Richard W. Healy, 2010-09-30 Understanding groundwater recharge is essential for successful management of water resources and modeling fluid and contaminant transport within the subsurface This book provides a critical evaluation of the theory and assumptions that underlie methods for estimating rates of groundwater recharge Detailed explanations of the methods are provided allowing readers to apply many of the techniques themselves without needing to consult additional references Numerous practical examples highlight benefits and limitations of each method Approximately 900 references allow advanced practitioners to pursue additional information on any method For the first time theoretical and practical considerations for selecting and applying methods for estimating groundwater recharge are covered in a single volume with uniform presentation Hydrogeologists water resource specialists civil and agricultural engineers Earth and environmental scientists and agronomists will benefit from this informative and practical book It can serve as the primary text for a graduate level course on groundwater recharge or as an adjunct text for courses on groundwater hydrology or hydrogeology For the benefit of students and instructors problem sets of varying difficulty are available at http://www.brr.cr.usgs.gov/projects/GW_Unsat/Recharge_Book Partial Differential Equations and Their Applications Peter Charles Greiner, Canadian Mathematical Society. Seminar, 1997-01-01 Just list for purposes of NBB **Applied Mechanics Reviews**, 1972 Wavelet Methods for Solving Partial Differential Equations and Fractional Differential Equations Santanu Saha Ray, Arun Kumar Gupta, 2018-01-12 The main focus of the book is to implement wavelet based transform methods for solving problems of fractional order partial differential equations arising in modelling real physical phenomena It explores analytical and numerical approximate solution obtained by wavelet methods for both classical and fractional order partial differential equations *Generalized Fractional Order Differential Equations Arising in Physical Models* Santanu Saha Ray, Subhadarshan Sahoo, 2018-11-13 This book analyzes the various semi analytical and analytical methods for finding approximate and exact solutions of fractional order partial differential equations It explores approximate and exact solutions obtained by various analytical methods for fractional order partial differential equations arising in physical models

Modeling and Analysis of Modern Fluid Problems Liancun Zheng, Xinxin Zhang, 2017-04-26 Modeling and Analysis of Modern Fluids helps researchers solve physical problems observed in fluid dynamics and related fields such as heat and mass transfer boundary layer phenomena and numerical heat transfer These problems are characterized by nonlinearity and large system dimensionality and exact solutions are impossible to provide using the conventional mixture of theoretical and analytical analysis with purely numerical methods To solve these complex problems this work provides a toolkit of established and novel methods drawn from the literature across nonlinear approximation theory It covers Pad approximation theory embedded parameters perturbation Adomian decomposition homotopy analysis modified differential transformation fractal theory fractional calculus fractional differential equations as well as classical numerical techniques for solving nonlinear partial differential equations In addition 3D modeling and analysis are also covered in depth Systematically describes powerful approximation methods to solve nonlinear equations in fluid problems Includes novel developments in fractional order differential equations with fractal theory applied to fluids Features new methods including Homotopy Approximation embedded parameter perturbation and 3D models and analysis **Annual Report** National Geophysical Research Institute (India), 1982

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