

# NONSTANDARD FINITE DIFFERENCE MODELS OF DIFFERENTIAL EQUATIONS

Ronald E. Mickens



World Scientific

# Nonstandard Finite Difference Models Of Differential Equations

**Ronald E. Mickens**

## **Nonstandard Finite Difference Models Of Differential Equations:**

*Nonstandard Finite Difference Models of Differential Equations* Ronald E. Mickens, 1994 This book provides a clear summary of the work of the author on the construction of nonstandard finite difference schemes for the numerical integration of differential equations. The major thrust of the book is to show that discrete models of differential equations exist such that the elementary types of numerical instabilities do not occur. A consequence of this result is that in general bigger step sizes can often be used in actual calculations and or finite difference schemes can be constructed that are conditionally stable in many instances whereas in using standard techniques no such schemes exist. The theoretical basis of this work is centered on the concepts of exact and best finite difference schemes. In addition a set of rules is given for the discrete modeling of derivatives and nonlinear expressions that occur in differential equations. These rules often lead to a unique nonstandard finite difference model for a given differential equation

### **Nonstandard Finite Difference Schemes:**

**Methodology And Applications** Ronald E. Mickens, 2020-11-11 This second edition of Nonstandard Finite Difference Models of Differential Equations provides an update on the progress made in both the theory and application of the NSFD methodology during the past two and a half decades. In addition to discussing details related to the determination of the denominator functions and the nonlocal discrete representations of functions of dependent variables we include many examples illustrating just how this should be done. Of real value to the reader is the inclusion of a chapter listing many exact difference schemes and a chapter giving NSFD schemes from the research literature. The book emphasizes the critical roles played by the principle of dynamic consistency and the use of sub equations for the construction of valid NSFD discretizations of differential equations

### Applications Of Nonstandard Finite Difference Schemes

Ronald E. Mickens, 2000-03-29 The main purpose of this book is to provide a concise introduction to the methods and philosophy of constructing nonstandard finite difference schemes and illustrate how such techniques can be applied to several important problems. Chapter 1 gives an overview of the subject and summarizes previous work. Chapters 2 and 3 consider in detail the construction and numerical implementation of schemes for physical problems involving convection diffusion reaction equations that arise in groundwater pollution and scattering of electromagnetic waves using Maxwell's equations. Chapter 4 examines certain mathematical issues related to the nonstandard discretization of competitive and cooperative models for ecology. Chapter 5 discusses exactness stability properties and the symplecticity of various schemes including the conditions for which Runge Kutta methods are exact. The application chapters illustrate well the power of nonstandard methods. In particular for the same accuracy as obtained by standard techniques larger step sizes can be used. This volume will satisfy the needs of scientists engineers and mathematicians who wish to know how to construct nonstandard schemes and see how these are applied to obtain numerical solutions of the differential equations which arise in the study of nonlinear dynamical systems modeling important physical phenomena

### Advances In The Applications Of Nonstandard Finite Difference

Schemes Ronald E Mickens,2005-10-25 This volume provides a concise introduction to the methodology of nonstandard finite difference NSFD schemes construction and shows how they can be applied to the numerical integration of differential equations occurring in the natural biomedical and engineering sciences These methods had their genesis in the work of Mickens in the 1990 s and are now beginning to be widely studied and applied by other researchers The importance of the book derives from its clear and direct explanation of NSFD in the introductory chapter along with a broad discussion of the future directions needed to advance the topic Mathematical and Numerical Studies of Nonstandard Difference Equation Models of Differential Equations. Final Technical Report, September 1995--September 1997 ,1997 The major thrust of this proposal was to continue our investigations of so called non standard finite difference schemes as formulated by other authors These schemes do not follow the standard rules used to model continuous differential equations by discrete difference equations The two major aspects of this procedure consist of generalizing the definition of the discrete derivative and using a nonlocal model on the computational grid or lattice for nonlinear terms that may occur in the differential equations Our aim was to investigate the construction of nonstandard finite difference schemes for several classes of ordinary and partial differential equations These equations are simple enough to be tractable yet have enough complexity to be both mathematically and scientifically interesting It should be noted that all of these equations differential equations model some physical phenomena under an appropriate set of experimental conditions The major goal of the project was to better understand the process of constructing finite difference models for differential equations In particular it demonstrates the value of using nonstandard finite difference procedures A secondary goal was to construct and study a variety of analytical techniques that can be used to investigate the mathematical properties of the obtained difference equations These mathematical procedures are of interest in their own right and should be a valuable contribution to the mathematics research literature in difference equations All of the results obtained from the research done under this project have been published in the relevant research technical journals or submitted for publication Our expectation is that these results will lead to improved finite difference schemes for the numerical integration of both ordinary and partial differential equations Section G of the Appendix gives a concise summary of the major results obtained under funding by the grant **Advances in the Applications of Nonstandard Finite DifffERENCE Schemes** Ronald E. Mickens,2005 This volume provides a concise introduction to the methodology of nonstandard finite difference NSFD schemes construction and shows how they can be applied to the numerical integration of differential equations occurring in the natural biomedical and engineering sciences These methods had their genesis in the work of Mickens in the 1990 s and are now beginning to be widely studied and applied by other researchers The importance of the book derives from its clear and direct explanation of NSFD in the introductory chapter along with a broad discussion of the future directions needed to advance the topic **Advances in the Applications of Nonstandard Finite DifffERENCE Schemes** Ronald E. Mickens,2005 This volume provides a concise

introduction to the methodology of nonstandard finite difference NSFD schemes construction and shows how they can be applied to the numerical integration of differential equations occurring in the natural biomedical and engineering sciences These methods had their genesis in the work of Mickens in the 1990 s and are now beginning to be widely studied and applied by other researchers The importance of the book derives from its clear and direct explanation of NSFD in the introductory chapter along with a broad discussion of the future directions needed to advance the topic **Mathematics of Continuous and Discrete Dynamical Systems** Abba B. Gumel,2014-06-18 This volume contains the proceedings of the AMS Special Session on Nonstandard Finite Difference Discretizations and Nonlinear Oscillations in honor of Ronald Mickens s 70th birthday held January 9 10 2013 in San Diego CA Included are papers on design and analysis of discrete time and continuous time dynamical systems arising in the natural and engineering sciences in particular the design of robust nonstandard finite difference methods for solving continuous time ordinary and partial differential equation models the analytical and numerical study of models that undergo nonlinear oscillations as well as the design of deterministic and stochastic models for epidemiological and ecological processes Some of the specific topics covered in the book include the analysis of deterministic and stochastic SIR type models the assessment of cost effectiveness of vaccination problems finite difference methods for oscillatory dynamical systems including the Schrödinger equation and Brusselator system the design of exact and elementary stable finite difference methods the study of a two patch model with Allee effects and disease modified fitness the study of the delay differential equation model with application to circadian rhythm and the application of some special functions in the solutions of some problems arising in the natural and engineering sciences A notable feature of the book is the collection of some relevant open problems intended to help guide the direction of future research in the area

*Trends in Biomathematics: Modeling, Optimization and Computational Problems* Rubem P. Mondaini,2018-08-16 This book brings together carefully selected peer reviewed works on mathematical biology presented at the BIOMAT International Symposium on Mathematical and Computational Biology which was held at the Institute of Numerical Mathematics Russian Academy of Sciences in October 2017 in Moscow Topics covered include but are not limited to the evolution of spatial patterns on metapopulations problems related to cardiovascular diseases and modeled by boundary control techniques in hemodynamics algebraic modeling of the genetic code and multi step biochemical pathways Also new results are presented on topics like pattern recognition of probability distribution of amino acids somitogenesis through reaction diffusion models mathematical modeling of infectious diseases and many others Experts scientific practitioners graduate students and professionals working in various interdisciplinary fields will find this book a rich resource for research and applications alike

**Mathematical Modelling and Analysis of Infectious Diseases** Khalid Hattaf,Hemen Dutta,2020-07-30 This book discusses significant research and study topics related to mathematical modelling and analysis of infectious diseases It includes several models and modelling approaches with different aims such as identifying and analysing causes of occurrence

and re occurrence causes of spreading treatments and control strategies A valuable resource for researchers students educators scientists professionals and practitioners interested in gaining insights into various aspects of infectious diseases using mathematical modelling and mathematical analysis the book will also appeal to general readers wanting to understand the dynamics of various diseases and related issues Key Features Mathematical models that describe population prevalence or incidence of infectious diseases Mathematical tools and techniques to analyse data on the incidence of infectious diseases Early detection and risk estimate models of infectious diseases Mathematical models that describe the transmission of infectious diseases and analyse data Dynamical analysis and control strategies for infectious diseases Studies comparing the utility of particular models in describing infected diseases related issues such as social health and economic

**Numerical Methods and Applications** Ivan Georgiev,Maria Datcheva,Krassimir Georgiev,Geno Nikolov,2023-05-15 This book constitutes the thoroughly refereed post conference proceedings of the 10th International Conference on Numerical Methods and Applications NMA 2022 held in Borovets Bulgaria in August 2022 The 30 revised regular papers presented were carefully reviewed and selected from 38 submissions for inclusion in this book The papers are organized in the following topical sections numerical search and optimization problem driven numerical method motivation and application numerical methods for fractional diffusion problems orthogonal polynomials and numerical quadratures and Monte Carlo and Quasi Monte Carlo methods

**Mathematical Methods in Medical and Biological Sciences** Harendra Singh,Hari M Srivastava,2024-11-05 Mathematical Methods in Medical and Biological Sciences presents mathematical methods for computational models arising in the medical and biological sciences The book presents several real life medical and biological models such as infectious and non infectious diseases that can be modeled mathematically to accomplish profound research in virtual environments when the cost of laboratory expenses is relatively high It focuses on mathematical techniques that provide global solutions for models arising in medical and biological sciences by considering their long term benefits In addition the book provides leading edge developments and insights for a range of applications including epidemiological modeling of pandemic dynamics viral infection developments cancer developments blood oxygen dynamics HIV infection spread reaction diffusion models polio infection spread and chaos modeling with fractional order derivatives Presents the mathematical treatment of a wide range of real life medical and biological models including both infectious and non infectious diseases Provides in depth analysis of the spread of Covid 19 polio and HIV including discussion of computational methods and applications Includes computational modeling methods along with their practical applications providing the basis for further exploration and research in epidemiology and applied biomedical sciences

**SIAM Journal on Scientific Computing** ,2001    **Transactions of the Society for Computer Simulation** ,1991    **Proceedings** ,2007

**Abstracts of Papers Presented to the American Mathematical Society** American Mathematical Society,2008  
**Mathematical Reviews** ,2007    **Applications of Mathematics in Engineering and Economics** Michail D.

Todorov,2008-11-19 All papers have been peer reviewed The main goal of this series of conferences is to bring together experts and young talented scientists from Bulgaria and abroad to discuss modern trends and to ensure exchange of views in various applications of mathematics in engineering physics economics biology etc Keeping the main topics of the previous AMEE conferences as well as the big success of AMEE 07 this year s 34th issue was again subject to the motto Nonlinear phenomena mathematical theory and environmental reality The organizing Committee encouraged the participation of senior and postgraduate students and organized a separate youth session The invited speakers organized two special sessions Within the 34th Conference AMEE 08 a Round Table Presentations and Discussion on Mathematics Education in Bachelor Degree Programs and in Master Degree Programs Conference Tutorial Introduction to Software Agents and Their Applications and Workshop on Grid and Scientific Engineering Application GRID SEA took place The publishing promotion and distribution the proceedings among the mathematical and related societies taking an interest in its topics is an integral part of the Conference Advances in Mathematical Sciences and Applications ,2008 **Correct Models of Parallel Computing** S. Noguchi,Masahiro Ōta,1997

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