

Modeling and Simulation in  
Science, Engineering and Technology

# Scientific Computing with *Mathematica*<sup>®</sup>

Mathematical Problems  
for Ordinary Differential  
Equations

Addolorata Marasco  
Antonio Romano



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# Scientific Computing With Mathematica Mathematical Problems For Ordinary Differential Equations

**Deuflhard**



## **Scientific Computing With Mathematica Mathematical Problems For Ordinary Differential Equations:**

Scientific Computing with Mathematica® Addolorata Marasco, Antonio Romano, 2001-08-09 CD ROM includes Mathematica files ODE m and 11 notebooks Chapter1 nb Chapter10 nb and Package nb      **Scientific Computing with Mathematica®** Addolorata Marasco, Antonio Romano, 2013-04-19 Many interesting behaviors of real physical biological economical and chemical systems can be described by ordinary differential equations ODEs Scientific Computing with Mathematica for Ordinary Differential Equations provides a general framework useful for the applications on the conceptual aspects of the theory of ODEs as well as a sophisticated use of Mathematica software for the solutions of problems related to ODEs In particular a chapter is devoted to the use ODEs and Mathematica in the Dynamics of rigid bodies Mathematical methods and scientific computation are dealt with jointly to supply a unified presentation The main problems of ordinary differential equations such as phase portrait approximate solutions periodic orbits stability bifurcation and boundary problems are covered in an integrated fashion with numerous worked examples and computer program demonstrations using Mathematica Topics and Features Explains how to use the Mathematica package ODE m to support qualitative and quantitative problem solving End of chapter exercise sets incorporating the use of Mathematica programs Detailed description and explanation of the mathematical procedures underlying the programs written in Mathematica Appendix describing the use of ten notebooks to guide the reader through all the exercises This book is an essential text reference for students graduates and practitioners in applied mathematics and engineering interested in ODE s problems in both the qualitative and quantitative description of solutions with the Mathematica program It is also suitable as a self      **Scientific Computing with Ordinary Differential Equations** Peter Deuflhard, Folkmar Bornemann, 2012-12-06 Mathematics is playing an ever more important role in the physical and biological sciences provoking a blurring of boundaries between scientific disciplines and a resurgence of interest in the modern as well as the classical techniques of applied mathematics This renewal of interest both in re search and teaching has led to the establishment of the series Texts in Applied Mathematics TAM The development of new courses is a natural consequence of a high level of excitement on the research frontier as newer techniques such as numeri cal and symbolic computer systems dynamical systems and chaos mix with and reinforce the traditional methods of applied mathematics Thus the purpose of this textbook series is to meet the current and future needs of these advances and to encourage the teaching of new courses TAM will publish textbooks suitable for use in advanced undergraduate and beginning graduate courses and will complement the Applied Mathe matical Sciences AMS series which will focus on advanced textbooks and research level monographs      Scientific Computing with Mathematica® Addolorata Marasco, Antonio Romano, 2012-12-06 Many interesting behaviors of real physical biological economical and chemical systems can be described by ordinary differential equations ODEs Scientific Computing with Mathematica for Ordinary Differential Equations provides a general framework useful for the applications on the conceptual aspects of the

theory of ODEs as well as a sophisticated use of Mathematica software for the solutions of problems related to ODEs. In particular, a chapter is devoted to the use of ODEs and Mathematica in the Dynamics of rigid bodies. Mathematical methods and scientific computation are dealt with jointly to supply a unified presentation. The main problems of ordinary differential equations such as phase portrait, approximate solutions, periodic orbits, stability, bifurcation, and boundary problems are covered in an integrated fashion with numerous worked examples and computer program demonstrations using Mathematica. Topics and Features Explains how to use the Mathematica package ODE m to support qualitative and quantitative problem solving. End of chapter exercise sets incorporating the use of Mathematica programs. Detailed description and explanation of the mathematical procedures underlying the programs written in Mathematica. Appendix describing the use of ten notebooks to guide the reader through all the exercises. This book is an essential text reference for students, graduates, and practitioners in applied mathematics and engineering interested in ODE's problems in both the qualitative and quantitative description of solutions with the Mathematica program. It is also suitable as a self

*Introduction to Computation and Modeling for Differential Equations* Lennart Edsberg, 2015-09-16 Uses mathematical, numerical, and programming tools to solve differential equations for physical phenomena and engineering problems. Introduction to Computation and Modeling for Differential Equations, Second Edition features the essential principles and applications of problem solving across disciplines such as engineering, physics, and chemistry. The Second Edition integrates the science of solving differential equations with mathematical, numerical, and programming tools specifically with methods involving ordinary differential equations, numerical methods for initial value problems (IVPs), numerical methods for boundary value problems (BVPs), partial differential equations (PDEs), numerical methods for parabolic, elliptic, and hyperbolic PDEs, mathematical modeling with differential equations, numerical solutions, and finite difference and finite element methods. The author features a unique Five M approach: Modeling, Mathematics, Methods, MATLAB, and Multiphysics, which facilitates a thorough understanding of how models are created and preprocessed mathematically with scaling, classification, and approximation, and also demonstrates how a problem is solved numerically using the appropriate mathematical methods. With numerous real-world examples to aid in the visualization of the solutions, Introduction to Computation and Modeling for Differential Equations, Second Edition includes new sections on topics including variational formulation, the finite element method, examples of discretization, ansatz methods such as Galerkin's method for BVPs, parabolic and elliptic PDEs, and finite volume methods. Numerous practical examples with applications in mechanics, fluid dynamics, solid mechanics, chemical engineering, heat conduction, electromagnetic field theory, and control theory, some of which are solved with computer programs MATLAB and COMSOL Multiphysics. Additional exercises that introduce new methods, projects, and problems to further illustrate possible applications. A related website with select solutions to the exercises as well as the MATLAB data sets for ordinary differential equations (ODEs) and PDEs. Introduction to Computation and Modeling for Differential Equations, Second Edition is a useful textbook for upper

undergraduate and graduate level courses in scientific computing differential equations ordinary differential equations partial differential equations and numerical methods The book is also an excellent self study guide for mathematics science computer science physics and engineering students as well as an excellent reference for practitioners and consultants who use differential equations and numerical methods in everyday situations Random Differential Equations in Scientific Computing Tobias Neckel, Florian Rupp, 2013-12-17 This book is a holistic and self contained treatment of the analysis and numerics of random differential equations from a problem centred point of view An interdisciplinary approach is applied by considering state of the art concepts of both dynamical systems and scientific computing The red line pervading this book is the two fold reduction of a random partial differential equation disturbed by some external force as present in many important applications in science and engineering First the random partial differential equation is reduced to a set of random ordinary differential equations in the spirit of the method of lines These are then further reduced to a family of deterministic ordinary differential equations The monograph will be of benefit not only to mathematicians but can also be used for interdisciplinary courses in informatics and engineering

**Scientific Computing and Differential Equations: An Introduction to Numerical Methods** Gene H. Golub, James M. Ortega, 1991-09 Scientific Computing and Differential Equations An Introduction to Numerical Methods is an excellent complement to Introduction to Numerical Methods by Ortega and Poole The book emphasizes the importance of solving differential equations on a computer which comprises a large part of what has come to be called scientific computing It reviews modern scientific computing outlines its applications and places the subject in a larger context This book is appropriate for upper undergraduate courses in mathematics electrical engineering and computer science it is also well suited to serve as a textbook for numerical differential equations courses at the graduate level An introductory chapter gives an overview of scientific computing indicating its important role in solving differential equations and placing the subject in the larger environment Contains an introduction to numerical methods for both ordinary and partial differential equations Concentrates on ordinary differential equations especially boundary value problems Contains most of the main topics for a first course in numerical methods and can serve as a text for this course Uses material for junior senior level undergraduate courses in math and computer science plus material for numerical differential equations courses for engineering science students at the graduate level

**Numerical Methods and Scientific Computing** Norbert Köckler, 1994 This introduction to software packages is written specifically for scientists and engineers who write programmes to get numerical results It covers the whole range of numerical mathematics from linear equations to ordinary differential equations with short sections on the calculus of error and partial differential equations As it aims to give a unified approach to theory algorithms applications and the use of software the emphasis is on examples and applications rather than proofs This book is appearing at the same time as PAN software that contains all the programs described in the book and additional useful software such as help systems and utility tools as well as an enlarged hypertext

version of the text     *Modelling with Ordinary Differential Equations* Alfio Borzi, 2020-04-13 *Modelling with Ordinary Differential Equations* A Comprehensive Approach aims to provide a broad and self contained introduction to the mathematical tools necessary to investigate and apply ODE models The book starts by establishing the existence of solutions in various settings and analysing their stability properties The next step is to illustrate modelling issues arising in the calculus of variation and optimal control theory that are of interest in many applications This discussion is continued with an introduction to inverse problems governed by ODE models and to differential games The book is completed with an illustration of stochastic differential equations and the development of neural networks to solve ODE systems Many numerical methods are presented to solve the classes of problems discussed in this book Features Provides insight into rigorous mathematical issues concerning various topics while discussing many different models of interest in different disciplines biology chemistry economics medicine physics social sciences etc Suitable for undergraduate and graduate students and as an introduction for researchers in engineering and the sciences Accompanied by codes which allow the reader to apply the numerical methods discussed in this book in those cases where analytical solutions are not available

**Scientific Computing with Case Studies** Dianne P. O'Leary, 2009-03-19 This book is a practical guide to the numerical solution of linear and nonlinear equations differential equations optimization problems and eigenvalue problems It treats standard problems and introduces important variants such as sparse systems differential algebraic equations constrained optimization Monte Carlo simulations and parametric studies Stability and error analysis are emphasized and the Matlab algorithms are grounded in sound principles of software design and understanding of machine arithmetic and memory management Nineteen case studies provide experience in mathematical modeling and algorithm design motivated by problems in physics engineering epidemiology chemistry and biology The topics included go well beyond the standard first course syllabus introducing important problems such as differential algebraic equations and conic optimization problems and important solution techniques such as continuation methods The case studies cover a wide variety of fascinating applications from modeling the spread of an epidemic to determining truss configurations     **An Invitation to Applied Mathematics**

Carmen Chicone, 2016-09-24 *An Invitation to Applied Mathematics* Differential Equations Modeling and Computation introduces the reader to the methodology of modern applied mathematics in modeling analysis and scientific computing with emphasis on the use of ordinary and partial differential equations Each topic is introduced with an attractive physical problem where a mathematical model is constructed using physical and constitutive laws arising from the conservation of mass conservation of momentum or Maxwell's electrodynamics Relevant mathematical analysis which might employ vector calculus Fourier series nonlinear ODEs bifurcation theory perturbation theory potential theory control theory or probability theory or scientific computing which might include Newton's method the method of lines finite differences finite elements finite volumes boundary elements projection methods smoothed particle hydrodynamics or Lagrangian methods is developed

in context and used to make physically significant predictions The target audience is advanced undergraduates who have at least a working knowledge of vector calculus and linear ordinary differential equations or beginning graduate students Readers will gain a solid and exciting introduction to modeling mathematical analysis and computation that provides the key ideas and skills needed to enter the wider world of modern applied mathematics Presents an integrated wealth of modeling analysis and numerical methods in one volume Provides practical and comprehensible introductions to complex subjects for example conservation laws CFD SPH BEM and FEM Includes a rich set of applications with more appealing problems and projects suggested

Modern Methods in Scientific Computing and Applications Gert Sabidussi, 2002 One half of this book focuses on the techniques of scientific computing domain decomposition the absorption of boundary conditions and one way operators convergence analysis of multi grid methods and other multi grid techniques dynamical systems and matrix analysis The remainder of the book is concerned with combining techniques with concrete applications stochastic differential equations image processing and thin films

*Computer Algebra in Scientific Computing CASC 2001* Viktor G. Ganzha, Ernst W. Mayr, Evgenii V. Vorozhtsov, 2012-12-06 CASC 2001 continues a tradition started in 1998 of international conferences on the latest advances in the application of computer algebra systems to the solution of various problems in scientific computing The three earlier CASC conferences in this sequence CASC 98 CASC 99 and CASC 2000 were held Petersburg Russia in Munich Germany and in Samarkand respectively in St Uzbekistan and proved to be very successful We have to thank the program committee listed overleaf for a tremendous job in soliciting and providing reviews for the submitted papers There were more than three reviews per submission on average The result of this job is reflected in the present volume which contains revised versions of the accepted papers The collection of papers included in the proceedings covers various topics of computer algebra methods algorithms and software applied to scientific computing In particular five papers are devoted to the implementation of the analysis of involutive systems with the aid of CASs The specific examples include new efficient algorithms for the computation of Janet bases for monomial ideals involutive division involutive reduction method etc A number of papers deal with application of CASs for obtaining and validating new exact solutions to initial and boundary value problems for partial differential equations in mathematical physics Several papers show how CASs can be used to obtain analytic solutions of initial and boundary value problems for ordinary differential equations and for studying their properties

**Introduction to Computation and Modeling for Differential Equations with Surface Science 2E** Set Edsberg, 2008-08-28 An introduction to scientific computing for differential equations Introduction to Computation and Modeling for Differential Equations provides a unified and integrated view of numerical analysis mathematical modeling in applications and programming to solve differential equations which is essential in problem solving across many disciplines such as engineering physics and economics This book successfully introduces readers to the subject through a unique Five M approach Modeling Mathematics Methods MATLAB R and Multiphysics R This approach facilitates a thorough understanding

of how models are created and preprocessed mathematically with scaling classification and approximation and it also illustrates how a problem is solved numerically using the appropriate mathematical methods The book's approach of solving a problem with mathematical numerical and programming tools is unique and covers a wide array of topics from mathematical modeling to implementing a working computer program The author utilizes the principles and applications of scientific computing to solve problems involving Ordinary differential equations Numerical methods for Initial Value Problems IVPs Numerical methods for Boundary Value Problems BVPs Partial Differential Equations PDEs Numerical methods for parabolic elliptic and hyperbolic PDEs Mathematical modeling with differential equations Numerical solution Finite difference and finite element methods Real world examples from scientific and engineering applications including mechanics fluid dynamics solid mechanics chemical engineering electromagnetic field theory and control theory are solved through the use of MATLAB R and the interactive scientific computing program Comsol Multiphysics R Numerous illustrations aid in the visualization of the solutions and a related Web site features demonstrations solutions to problems MATLAB R programs and additional data Introduction to Computation and Modeling for Differential Equations is an ideal text for courses in differential equations ordinary differential equations partial differential equations and numerical methods at the upper undergraduate and graduate levels The book also serves as a valuable reference for researchers and practitioners in the fields of mathematics engineering and computer science who would like to refresh and revive their knowledge of the mathematical and numerical aspects as well as the applications of scientific computation

**Computer Algebra in Scientific Computing CASC'99** Victor G. Ganzha, Ernst W. Mayr, Evgenii V. Vorozhtsov, 2012-12-06 The development of powerful computer algebra systems has considerably extended the scope of problems of scientific computing which can now be solved successfully with the aid of computers However as the field of applications of computer algebra in scientific computing becomes broader and more complex there is a danger of separation between theory systems and applications For this reason we felt the need to bring together the researchers who now apply the tools of computer algebra for the solution of problems in scientific computing in order to foster new and closer interactions CASC 99 is the second conference devoted to applications of computer algebra in scientific computing The first conference in this sequence CASC 98 was held 20-24 April 1998 in St Petersburg Russia This volume contains revised versions of the papers submitted by the participants and accepted by the program committee after a thorough reviewing process The collection of papers included in the proceedings covers various topics of computer algebra methods algorithms and software applied to scientific computing symbolic numeric analysis and solving differential equations efficient computations with polynomials groups matrices and other related objects special purpose programming environments application to physics mechanics optics and to other areas In particular a significant group of papers deals with applications of computer algebra methods for the solution of current problems in group theory which mostly arise in mathematical physics

**Numerical Methods for Ordinary Differential**

**Equations** David F. Griffiths, Desmond J. Higham, 2010-11-11 Numerical Methods for Ordinary Differential Equations is a self contained introduction to a fundamental field of numerical analysis and scientific computation Written for undergraduate students with a mathematical background this book focuses on the analysis of numerical methods without losing sight of the practical nature of the subject It covers the topics traditionally treated in a first course but also highlights new and emerging themes Chapters are broken down into lecture sized pieces motivated and illustrated by numerous theoretical and computational examples Over 200 exercises are provided and these are starred according to their degree of difficulty Solutions to all exercises are available to authorized instructors The book covers key foundation topics o Taylor series methods o Runge Kutta methods o Linear multistep methods o Convergence o Stability and a range of modern themes o Adaptive stepsize selection o Long term dynamics o Modified equations o Geometric integration o Stochastic differential equations The prerequisite of a basic university level calculus class is assumed although appropriate background results are also summarized in appendices A dedicated website for the book containing extra information can be found via [www.springer.com](http://www.springer.com)

*Scientific Computing with MATLAB* Dingyu Xue, YangQuan Chen, 2018-09-03 Scientific Computing with MATLAB Second Edition improves students ability to tackle mathematical problems It helps students understand the mathematical background and find reliable and accurate solutions to mathematical problems with the use of MATLAB avoiding the tedious and complex technical details of mathematics This edition retains the structure of its predecessor while expanding and updating the content of each chapter The book bridges the gap between problems and solutions through well grouped topics and clear MATLAB example scripts and reproducible MATLAB generated plots Students can effortlessly experiment with the scripts for a deep hands on exploration Each chapter also includes a set of problems to strengthen understanding of the material

Large Scale Scientific Computing Deuflhard, 2012-12-06 In this book the new and rapidly expanding field of scientific computing is understood in a double sense as computing for scientific and engineering problems and as the science of doing such computations Thus scientific computing touches at one side mathematical modelling in the various fields of applications and at the other side computer science As soon as the mathematical models describe the features of real life processes in sufficient detail the associated computations tend to be large scale As a consequence interest more and more focusses on such numerical methods that can be expected to cope with large scale computational problems Moreover given the algorithms which are known to be efficient on a traditional computer the question of implementation on modern supercomputers may get crucial The present book is the proceedings of a meeting on Large Scale Scientific Computing that was held at the Oberwolfach Mathematical Institute July 14 19 1985 under the auspices of the Sonderforschungsbereich 123 of the University of Heidelberg Participants included applied scientists with computational interests numerical analysts and experts on modern parallel computers The purpose of the meeting was to establish a common understanding of recent issues in scientific computing especially in view of large scale problems Fields of applications which have been covered included

semi conductor design chemical combustion flow through porous media climatology seismology fluid dynamics tomography rheology hydro power plant optimization subwily control space technology

**Practical Numerical and Scientific Computing with MATLAB® and Python** Eihab B. M. Bashier, 2020-03-18 Practical Numerical and Scientific Computing with MATLAB and Python concentrates on the practical aspects of numerical analysis and linear and non linear programming. It discusses the methods for solving different types of mathematical problems using MATLAB and Python. Although the book focuses on the approximation problem rather than on error analysis of mathematical problems, it provides practical ways to calculate errors. The book is divided into three parts covering topics in numerical linear algebra, methods of interpolation, numerical differentiation and integration, solutions of differential equations, linear and non linear programming problems and optimal control problems. This book has the following advantages: It adopts the programming languages MATLAB and Python which are widely used among academics, scientists and engineers for ease of use and contain many libraries covering many scientific and engineering fields. It contains topics that are rarely found in other numerical analysis books such as ill conditioned linear systems and methods of regularization to stabilize their solutions, nonstandard finite differences methods for solutions of ordinary differential equations and the computations of the optimal controls. It provides a practical explanation of how to apply these topics using MATLAB and Python. It discusses software libraries to solve mathematical problems such as software Gekko, pulp and pyomo. These libraries use Python for solutions to differential equations and static and dynamic optimization problems. Most programs in the book can be applied in versions prior to MATLAB 2017b and Python 3.7.4 without the need to modify these programs. This book is aimed at newcomers and middle level students as well as members of the scientific community who are interested in solving math problems using MATLAB or Python.

**Modelling Mathematical Methods and Scientific Computation** Nicola Bellomo, Luigi Preziosi, 1994-12-22 Addressed to engineers, scientists and applied mathematicians, this book explores the fundamental aspects of mathematical modelling in applied sciences and related mathematical and computational methods. After providing the general framework needed for mathematical modelling, definitions, classifications, general modelling procedures and validation methods, the authors deal with the analysis of discrete models. This includes modelling methods and related mathematical methods. The analysis of models is defined in terms of ordinary differential equations. The analysis of continuous models, particularly models defined in terms of partial differential equations, follows. The authors then examine inverse type problems and stochastic modelling. Three appendices provide a concise guide to functional analysis, approximation theory and probability, and a diskette included with the book includes ten scientific programs to introduce the reader to scientific computation at a practical level.

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