Solving ODEs using MatLab

A command used to solve ODEs in MatLab (a solver) is ode45

Enter

```
>> help ode45
```

to see information about this command. Note that all commands and variables in MatLab help are written in capitals.

The first argument of ode45 is a function. It is convenient to program it in a separate file.

Consider, for instance the equation

$$y' = \frac{\cos t}{2y - 2}$$

Program the function in the right-hand side of the equation in the file example1.m using MatLab editor.

```
function yprime=example1(t,y)
yprime=cos(t)/(2*y-2);
```

Then type

```
>> [t, y]=ode45(@example1,[0, 4*pi],3);
>> plot(t, y)
```

We will find a table of values of the function y at values of t from 0 to 4π. The initial value of y at $t = 0$ will be 3, which is entered as the last entry of ode45.

The command plot(t, y) will plot the graph of the function y on the interval $[0, 4\pi]$.

Example. Use ode45 to plot the solution of the initial value problem

$$y' + y + y^3 = \cos^2 t, \qquad y(0) = -3$$

Solving Odes With Matlab

Arun R Srinivasa,Sivakumar M Srinivasa

Solving Odes With Matlab:

   Solving ODEs with MATLAB L. F. Shampine,I. Gladwell,S. Thompson,2003-04-28 This concise text first published in 2003 is for a one semester course for upper level undergraduates and beginning graduate students in engineering science and mathematics and can also serve as a quick reference for professionals The major topics in ordinary differential equations initial value problems boundary value problems and delay differential equations are usually taught in three separate semester long courses This single book provides a sound treatment of all three in fewer than 300 pages Each chapter begins with a discussion of the facts of life for the problem mainly by means of examples Numerical methods for the problem are then developed but only those methods most widely used The treatment of each method is brief and technical issues are minimized but all the issues important in practice and for understanding the codes are discussed The last part of each chapter is a tutorial that shows how to solve problems by means of small but realistic examples   **Numerical Solution of Ordinary Differential Equations** Kendall Atkinson,Weimin Han,David E. Stewart,2011-10-24 A concise introduction to numerical methodsand the mathematicalframework neededto understand their performance Numerical Solution of Ordinary Differential Equationspresents a complete and easy to follow introduction to classicaltopics in the numerical solution of ordinary differentialequations The book s approach not only explains the presentedmathematics but also helps readers understand how these numericalmethods are used to solve real world problems Unifying perspectives are provided throughout the text bringingtogether and categorizing different types of problems in order tohelp readers comprehend the applications of ordinary differentialequations In addition the authors collective academic experienceensures a coherent and accessible discussion of key topics including Euler s method Taylor and Runge Kutta methods General error analysis for multi step methods Stiff differential equations Differential algebraic equations Two point boundary value problems Volterra integral equations Each chapter features problem sets that enable readers to testand build their knowledge of the presented methods and a relatedWeb site features MATLAB programs that facilitate theexploration of numerical methods in greater depth Detailedreferences outline additional literature on both analytical andnumerical aspects of ordinary differential equations for furtherexploration of individual topics Numerical Solution of Ordinary Differential Equations isan excellent textbook for courses on the numerical solution ofdifferential equations at the upper undergraduate and beginninggraduate levels It also serves as a valuable reference forresearchers in the fields of mathematics and engineering   **Handbook of Ordinary Differential Equations** Andrei D. Polyanin,Valentin F. Zaitsev,2017-11-15 The Handbook of Ordinary Differential Equations Exact Solutions Methods and Problems is an exceptional and complete reference for scientists and engineers as it contains over 7 000 ordinary differential equations with solutions This book contains more equations and methods used in the field than any other book currently available Included in the handbook are exact asymptotic approximate analytical numerical symbolic and qualitative methods that are used for solving and analyzing linear and nonlinear equations The authors also

present formulas for effective construction of solutions and many different equations arising in various applications like heat transfer elasticity hydrodynamics and more This extensive handbook is the perfect resource for engineers and scientists searching for an exhaustive reservoir of information on ordinary differential equations *Solving Differential Equations in R* Karline Soetaert,Jeff Cash,Francesca Mazzia,2012-06-06 Mathematics plays an important role in many scientific and engineering disciplines This book deals with the numerical solution of differential equations a very important branch of mathematics Our aim is to give a practical and theoretical account of how to solve a large variety of differential equations comprising ordinary differential equations initial value problems and boundary value problems differential algebraic equations partial differential equations and delay differential equations The solution of differential equations using R is the main focus of this book It is therefore intended for the practitioner the student and the scientist who wants to know how to use R for solving differential equations However it has been our goal that non mathematicians should at least understand the basics of the methods while obtaining entrance into the relevant literature that provides more mathematical background Therefore each chapter that deals with R examples is preceded by a chapter where the theory behind the numerical methods being used is introduced In the sections that deal with the use of R for solving differential equations we have taken examples from a variety of disciplines including biology chemistry physics pharmacokinetics Many examples are well known test examples used frequently in the field of numerical analysis *Numerical Methods and Optimization* Éric Walter,2014-07-22 Initial training in pure and applied sciences tends to present problem solving as the process of elaborating explicit closed form solutions from basic principles and then using these solutions in numerical applications This approach is only applicable to very limited classes of problems that are simple enough for such closed form solutions to exist Unfortunately most real life problems are too complex to be amenable to this type of treatment Numerical Methods a Consumer Guide presents methods for dealing with them Shifting the paradigm from formal calculus to numerical computation the text makes it possible for the reader to discover how to escape the dictatorship of those particular cases that are simple enough to receive a closed form solution and thus gain the ability to solve complex real life problems understand the principles behind recognized algorithms used in state of the art numerical software learn the advantages and limitations of these algorithms to facilitate the choice of which pre existing bricks to assemble for solving a given problem and acquire methods that allow a critical assessment of numerical results Numerical Methods a Consumer Guide will be of interest to engineers and researchers who solve problems numerically with computers or supervise people doing so and to students of both engineering and applied mathematics

Mastering MATLAB Cybellium,2023-09-26 Are you ready to revolutionize your approach to scientific computing and data analysis Mastering MATLAB is your ultimate guide to harnessing the full potential of the MATLAB programming language Whether you re a seasoned researcher seeking to enhance your capabilities or a data enthusiast ready to dive into the world of numerical analysis this comprehensive guide will equip you with the knowledge and tools to develop

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differential equations and systems In addition a thorough presentation of general linear methods explores relevant subtopics such as pre consistency consistency stage consistency zero stability convergence order and stage order conditions local discretization error and linear stability theory Subsequent chapters feature coverage of Differential equations and systems Introduction to general linear methods GLMs Diagonally implicit multistage integration methods DIMSIMs Implementation of DIMSIMs Two step Runge Kutta TSRK methods Implementation of TSRK methods GLMs with inherent Runge Kutta stability IRKS Implementation of GLMs with IRKS General Linear Methods for Ordinary Differential Equations is an excellent book for courses on numerical ordinary differential equations at the upper undergraduate and graduate levels It is also a useful reference for academic and research professionals in the fields of computational and applied mathematics computational physics civil and chemical engineering chemistry and the life sciences   <u>Similarity Solutions for the Boundary Layer Flow and Heat Transfer of Viscous Fluids, Nanofluids, Porous Media, and Micropolar Fluids</u> John H. Merkin,Ioan Pop,Yian Yian Lok,Teodor Grosan,2021-09-09 Similarity Solutions for the Boundary Layer Flow and Heat Transfer of Viscous Fluids Nanofluids Porous Media and Micropolar Fluids presents new similarity solutions for fluid mechanics problems including heat transfer of viscous fluids boundary layer flow flow in porous media and nanofluids due to continuous moving surfaces After discussing several examples of these problems similarity solutions are derived and solved using the latest proven methods including bvp4c from MATLAB the Keller box method singularity methods and more Numerical solutions and asymptotic results for limiting cases are also discussed in detail to investigate how flow develops at the leading edge and its end behavior Detailed discussions of mathematical models for boundary layer flow and heat transfer of micro polar fluid and hybrid nanofluid will help readers from a range of disciplinary backgrounds in their research Relevant background theory will also be provided thus helping readers solidify their computational work with a better understanding of physical phenomena Provides mathematical models that address important research themes such as boundary layer flow and heat transfer of micro polar fluid and hybrid nanofluid Gives detailed numerical explanations of all solution procedures including bvp4c from MATLAB the Keller box method and singularity methods Includes examples of computer code that will save readers time in their own work   *MATLAB Manual, Ordinary Differential Equations* John C. Polking,1995

Mathematical Modeling in Chemical Engineering Anders Rasmuson,Bengt Andersson,Louise Olsson,Ronnie Andersson,2014-03-20 A solid introduction to mathematical modeling for a range of chemical engineering applications covering model formulation simplification and validation It explains how to describe a physical chemical reality in mathematical language and how to select the type and degree of sophistication for a model Model reduction and approximation methods are presented including dimensional analysis time constant analysis and asymptotic methods An overview of solution methods for typical classes of models is given As final steps in model building parameter estimation and model validation and assessment are discussed The reader is given hands on experience of formulating new models reducing

the models and validating the models The authors assume the knowledge of basic chemical engineering in particular transport phenomena as well as basic mathematics statistics and programming The accompanying problems tutorials and projects include model formulation at different levels analysis parameter estimation and numerical solution   Introduction to Applied Mathematics for Environmental Science David F. Parkhurst,2007-12-06 For many years first as a student and later as a teacher I have ob served graduate students in ecology and other environmental sci ences who had been required as undergraduates to take calculus courses Those courses have often emphasized how to prove theo rems about the beautiful logical structure of calculus but have ne glected applications Most of the time the students have come out of such courses with little or no appreciation of how to apply calculus in their own work Based on these observations I developed a course de signed in part to re teach calculus as an everyday tool in ecology and other environmental sciences I emphasized derivations working with story problems sometimes quite complex ones in that course and now in this book The present textbook has developed out of my notes for that course Its basic purpose is to describe various types of mathemati cal structures and how they can be apphed in environmental science Thus linear and non linear algebraic equations derivatives and in tegrals and ordinary and partial differential equations are the basic kinds of structures or types of mathematical models discussed For each the discussion follows a pattern something like this 1 An example of the type of structure as apphed to environmental science is given 2 Next a description of the structure is presented 3 Usually this is followed by other examples of how the structure arises in environmental science 4 The analytic methods of solving and learning from the structure are discussed

Mathematical Modelling and Simulation in Chemical Engineering M. Chidambaram,2018-03-09 Written in a clear logical and concise manner this comprehensive resource provides discussion on essential mathematical tools required for upgraded system performance Understanding of basic principles and governing laws is essential to reduce complexity of the system and this guide offers detailed discussion on analytical and numerical techniques to solve mathematical model equations Important concepts including nonlinear algebraic equations initial value ordinary differential equations ODEs and boundary value ODEs are discussed in detail The concepts of optimization methods and sensitivity analysis which are important from subject point of view are explained with suitable examples Numerous problems and MATLAB Scilab exercises are interspersed throughout the text Several case studies involving full details of simulation are offered for better understanding The accompanying website will host additional MATLAB Scilab problems model question papers simulation exercises tutorials and projects This book will be useful for students of chemical engineering mechanical engineering instrumentation engineering and mathematics   Differential Equations Marcelo Viana,José M. Espinar,2021-12-07 This graduate level introduction to ordinary differential equations combines both qualitative and numerical analysis of solutions in line with Poincar s vision for the field over a century ago Taking into account the remarkable development of dynamical systems since then the authors present the core topics that every young mathematician of our time pure and applied alike

ought to learn The book features a dynamical perspective that drives the motivating questions the style of exposition and the arguments and proof techniques The text is organized in six cycles The first cycle deals with the foundational questions of existence and uniqueness of solutions The second introduces the basic tools both theoretical and practical for treating concrete problems The third cycle presents autonomous and non autonomous linear theory Lyapunov stability theory forms the fourth cycle The fifth one deals with the local theory including the Grobman Hartman theorem and the stable manifold theorem The last cycle discusses global issues in the broader setting of differential equations on manifolds culminating in the Poincar Hopf index theorem The book is appropriate for use in a course or for self study The reader is assumed to have a basic knowledge of general topology linear algebra and analysis at the undergraduate level Each chapter ends with a computational experiment a diverse list of exercises and detailed historical biographical and bibliographic notes seeking to help the reader form a clearer view of how the ideas in this field unfolded over time *Ordinary Differential Equations and Integral Equations* C.T.H. Baker,G. Monegato,G. vanden Berghe,2001-06-20 homepage sac cam na2000 index html7 Volume Set now available at special set price This volume contains contributions in the area of differential equations and integral equations Many numerical methods have arisen in response to the need to solve real life problems in applied mathematics in particular problems that do not have a closed form solution Contributions on both initial value problems and boundary value problems in ordinary differential equations appear in this volume Numerical methods for initial value problems in ordinary differential equations fall naturally into two classes those which use one starting value at each step one step methods and those which are based on several values of the solution multistep methods John Butcher has supplied an expert s perspective of the development of numerical methods for ordinary differential equations in the 20th century Rob Corless and Lawrence Shampine talk about established technology namely software for initial value problems using Runge Kutta and Rosenbrock methods with interpolants to fill in the solution between mesh points but the slant is new based on the question How should such software integrate into the current generation of Problem Solving Environments Natalia Borovykh and Marc Spijker study the problem of establishing upper bounds for the norm of the nth power of square matrices The dynamical system viewpoint has been of great benefit to ODE theory and numerical methods Related is the study of chaotic behaviour Willy Govaerts discusses the numerical methods for the computation and continuation of equilibria and bifurcation points of equilibria of dynamical systems Arieh Iserles and Antonella Zanna survey the construction of Runge Kutta methods which preserve algebraic invariant functions Valeria Antohe and Ian Gladwell present numerical experiments on solving a Hamiltonian system of H non and Heiles with a symplectic and a nonsymplectic method with a variety of precisions and initial conditions Stiff differential equations first became recognized as special during the 1950s In 1963 two seminal publications laid to the foundations for later development Dahlquist s paper on A stable multistep methods and Butcher s first paper on implicit Runge Kutta methods Ernst Hairer and Gerhard Wanner deliver a survey which retraces the discovery of the order

stars as well as the principal achievements obtained by that theory Guido Vanden Berghe Hans De Meyer Marnix Van Daele and Tanja Van Hecke construct exponentially fitted Runge Kutta methods with s stages Differential algebraic equations arise in control in modelling of mechanical systems and in many other fields Jeff Cash describes a fairly recent class of formulae for the numerical solution of initial value problems for stiff and differential algebraic systems Shengtai Li and Linda Petzold describe methods and software for sensitivity analysis of solutions of DAE initial value problems Again in the area of differential algebraic systems Neil Biehn John Betts Stephen Campbell and William Huffman present current work on mesh adaptation for DAE two point boundary value problems Contrasting approaches to the question of how good an approximation is as a solution of a given equation involve i attempting to estimate the actual error i e the difference between the true and the approximate solutions and ii attempting to estimate the defect the amount by which the approximation fails to satisfy the given equation and any side conditions The paper by Wayne Enright on defect control relates to carefully analyzed techniques that have been proposed both for ordinary differential equations and for delay differential equations in which an attempt is made to control an estimate of the size of the defect Many phenomena incorporate noise and the numerical solution of **Introduction to Mechanics** Mr. Rohit Manglik,2024-07-27 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels **Inelasticity Of Materials: An Engineering Approach And A Practical Guide** Arun R Srinivasa,Sivakumar M Srinivasa,2009-07-09 With the advent of a host of new materials ranging from shape memory alloys to biomaterials to multiphase alloys acquiring the capacity to model inelastic behavior and to choose the right model in a commercial analysis software has become a pressing need for practicing engineers Even with the traditional materials there is a continued emphasis on optimizing and extending their full range of capability in the applications This textbook builds upon the existing knowledge of elasticity and thermodynamics and allows the reader to gain confidence in extending one s skills in understanding and analyzing problems in inelasticity By reading this textbook and working through the assigned exercises the reader will gain a level of comfort and competence in developing and using inelasticity models Thus the book serves as a valuable book for practicing engineers and senior level undergraduate graduate level students in the mechanical civil aeronautical metallurgical and other disciplines The book is written in three parts Part 1 is primarily focused on lumped parameter models and simple structural elements such as trusses and beams This is suitable for an advanced undergraduate class with just a strength of materials background Part II is focused on small deformation multi dimensional inelasticity and is suitable for a beginning graduate class Sufficient material is included on how to numerically implement an inelastic model and solve either using a simple stress function type of approach or using commercial software Case studies are included as examples There is also an extensive discussion of thermodynamics in the

context of small deformations Part III focuses on more advanced situations such as finite deformation inelasticity thermodynamical ideas and crystal plasticity More advanced case studies are included in this part This textbook takes a new task or scenario based approach to teaching and learning inelasticity The book is written in an active learning style that appeals to engineers and students who wish to design or analyze structures and components that are subject to inelasticity The book incorporates thermodynamical considerations into the modeling right from an early stage Extensive discussions are provided throughout the book on the thermodynamical underpinnings of the models This textbook is the first to make extensive use of MATLAB to implement many inelasticity models It includes the use of concepts such as Airy stress functions to solve plane problems for inelastic materials The MATLAB codes are listed in the appendix for one to modify with their own models and requirements Step by step procedures for formulations and calculations are provided for the reader to readily adapt to the inelastic problems that he or she attempts to solve A large number of problems exercises and projects for one to teach or learn from are included These can be assigned as homework in class exercises or projects The book is written in a modular fashion which provides adequate flexibility for adaptation in classes that cater to different audiences such as senior level students graduate students research scholars and practicing engineers   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   An Invitation to Mathematical Biology David G Costa,Paul J Schulte,2023-09-28 The textbook is designed to provide a non intimidating entry to the field of mathematical biology It is also useful for those wishing to teach an introductory course Although there are many good mathematical biology texts available most books are too advanced mathematically for most biology majors Unlike undergraduate math majors most biology major students possess a limited math background Given that computational biology is a rapidly expanding field more students should be encouraged to familiarize themselves with this powerful approach to understand complex biological phenomena Ultimately our goal with this undergraduate textbook is to provide an introduction to the interdisciplinary field of mathematical biology in a way that does not overly terrify an undergraduate biology major thereby fostering a greater appreciation for the role of mathematics in biology   Modeling and Simulation with Simulink® Dingyü Xue,2022-03-07 The essential intermediate and advanced topics of Simulink are covered in the book The concept of multi domain physical

modeling concept and tools in Simulink are illustrated with examples for engineering systems and multimedia information The combination of Simulink and numerical optimization methods provides new approaches for solving problems where solutions are not known otherwise   Numerical Solution of Differential Equations Zhilin Li,Zhonghua Qiao,Tao Tang,2017-11-30 This introduction to finite difference and finite element methods is aimed at graduate students who need to solve differential equations The prerequisites are few basic calculus linear algebra and ODEs and so the book will be accessible and useful to readers from a range of disciplines across science and engineering Part I begins with finite difference methods Finite element methods are then introduced in Part II In each part the authors begin with a comprehensive discussion of one dimensional problems before proceeding to consider two or higher dimensions An emphasis is placed on numerical algorithms related mathematical theory and essential details in the implementation while some useful packages are also introduced The authors also provide well tested MATLAB codes all available online

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