3 Numerical Solution of Differential Equations

One of the simplest mathematical models known in epidemiology is so-called SIRD model[1]. It is defined by the following system of differential equations

$$
\begin{cases}
S'(t) = -\dfrac{\beta}{N} I(t) S(t) \\[2mm]
I'(t) = \dfrac{\beta}{N} I(t) S(t) - \alpha I(t) - \gamma I(t) \\[2mm]
R'(t) = \alpha I(t) \\[2mm]
D'(t) = \gamma I(t)
\end{cases}
$$

where $S(t)$ denotes the number of susceptible individuals, $I(t)$ denotes the number of infected individuals, $R(t)$ denotes the number of recovered individuals, $D(t)$ denotes the number of deceased individuals, β is the infection rate, α is the recovery rate, γ is the mortality rate, and $N = S + I + R + D$. Assume that $S(0) = 997$, $I(0) = 3$, $R(0) = 0$, $D(0) = 0$, $\beta = 0.4$, $\alpha = 0.035$, $\gamma = 0.005$, and $t \in [0, 150]$.

- Use Matlab ODE solver *ode45* to calculate the numerical solution of SIRD model with given parameters and initial conditions. Plot in one frame the numerical solutions of $S(t)$, $I(t)$, $R(t)$, and $D(t)$ against time. What do you observe from the plots and how do you interpret the dynamics of the system?

- Write the code implementing the third order Runge–Kutta method (*RK3*) given by the following Butcher table:

0			
1/2	1/2		
1	−1	2	
	1/6	2/3	1/6

Use *RK3* method with stepsize $\tau = 10^{-3}$ to find the numerical solution of SIRD model with given parameters and initial conditions. Plot in one frame the numerical solutions of $S(t)$, $I(t)$, $R(t)$, and $D(t)$ against time. Make a qualitative comparison with the results obtained with *ode45* solver.

Numerical Solution Of Differential Equat

Christian Drosten

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    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   Numerical Solution Of Ordinary And Partial Differential Equations, The (3rd Edition) Granville Sewell,2014-12-16 This book presents methods for the computational solution of differential equations both ordinary and partial time dependent and steady state Finite difference methods are introduced and analyzed in the first four chapters and finite element methods are studied in chapter five A very general purpose and widely used finite element program PDE2D which implements many of the methods studied in the earlier chapters is presented and documented in Appendix A The book contains the relevant theory and error analysis for most of the methods studied but also emphasizes the practical aspects involved in implementing the methods Students using this book will actually see and write programs FORTRAN or MATLAB for solving ordinary and partial differential equations using both finite differences and finite elements In addition they will be able to solve very difficult partial differential equations using the software PDE2D presented in Appendix A PDE2D solves very general steady state time dependent and eigenvalue PDE systems in 1D intervals general 2D regions and a wide range of simple 3D regions The Windows version of PDE2D comes free with every purchase of this book More information at www pde2d com contact   **Numerical Methods for Differential Equations** J.R. Dormand,2018-05-04 With emphasis on modern techniques Numerical Methods for Differential Equations A Computational Approach covers the development and application of methods for the numerical solution of ordinary differential equations Some of the methods are extended to

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are therefore needed which use quite simple mathematics but which nevertheless communicate the essence of the numerical sense which is exhibited by the real computing experts and which is surely needed at least to some extent by all who use modern computers and modern numerical software In that book we treated at no great length a variety of computational problems in which the material on ordinary differential equations occupied about 50 pages At that time it was quite common to find books on numerical analysis with a little on each topic ofthat field whereas today we are more likely to see similarly sized books on each major topic for example on numerical linear algebra numerical approximation numerical solution ofordinary differential equations numerical solution of partial differential equations and so on These are needed because our numerical education and software have improved and because our relevant problems exhibit more variety and more difficulty Ordinary differential equa tions are obvious candidates for such treatment and the current book is written in this sense

Numerical Methods for Engineers and Scientists Joe D. Hoffman,Steven Frankel,2018-10-03 Emphasizing the finite difference approach for solving differential equations the second edition of Numerical Methods for Engineers and Scientists presents a methodology for systematically constructing individual computer programs Providing easy access to accurate solutions to complex scientific and engineering problems each chapter begins with objectives a discussion of a representative application and an outline of special features summing up with a list of tasks students should be able to complete after reading the chapter perfect for use as a study guide or for review The AIAA Journal calls the book a good solid instructional text on the basic tools of numerical analysis *Differential-algebraic Equations* Peter Kunkel,2006 Differential algebraic equations are a widely accepted tool for the modeling and simulation of constrained dynamical systems in numerous applications such as mechanical multibody systems electrical circuit simulation chemical engineering control theory fluid dynamics and many others This is the first comprehensive textbook that provides a systematic and detailed analysis of initial and boundary value problems for differential algebraic equations The analysis is developed from the theory of linear constant coefficient systems via linear variable coefficient systems to general nonlinear systems Further sections on control problems generalized inverses of differential algebraic operators generalized solutions and differential equations on manifolds complement the theoretical treatment of initial value problems Two major classes of numerical methods for differential algebraic equations Runge Kutta and BDF methods are discussed and analyzed with respect to convergence and order A chapter is devoted to index reduction methods that allow the numerical treatment of general differential algebraic equations The analysis and numerical solution of boundary value problems for differential algebraic equations is presented including multiple shooting and collocation methods A survey of current software packages for differential algebraic equations completes the text The book is addressed to graduate students and researchers in mathematics engineering and sciences as well as practitioners in industry A prerequisite is a standard course on the numerical solution of ordinary differential equations Numerous examples and exercises make the book suitable as a course textbook or for self study **Proceedings**

of the Conference on the Numerical Solution of Ordinary Differential Equations D.G. Bettis,1974-01-25

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