NUMERICAL METHODS

LEAST SQUARES REGRESSION:

$$S_r = \sum e_i^2 = \sum (z_i - a_0 - a_1 x_i)^2$$

$$a_1 = \frac{n\sum(x_i y_i) - \sum x_i \sum z_i}{n\sum(x_i^2) - (\sum x_i)^2}$$

$$a_0 = \frac{\sum z_i}{n}, \quad a_1 = \frac{\sum x_i}{n} \Rightarrow a_0 = \bar{z} - a_1 \bar{x}$$

STANDARD ERROR:

$$S_y = \sqrt{\frac{S_r}{n-2}} \qquad S_{y/x} = \sqrt{\frac{\sum(z_i - y_i^m)^2}{n-2}}$$

STAND. DEVIATION:

$$S_y = \sqrt{\frac{S_t}{n-1}} \qquad S_z = \sqrt{\frac{\sum(z_i - \bar{z})^2}{n-1}}$$

$$a_0 = \bar{z} - a_1 \bar{x}$$
$$y = a_0 + a_1 x$$

POLYNOMIAL (QUADRATIC) REGRESSION:

$$S_r = \sum (y_i - a_0 - a_1 x_i - a_2 x_i^2)^2$$

$$\frac{\partial S_r}{\partial a_0} = -2\left(\sum y_i - \sum a_0 - a_1 \sum x_i - a_2 \sum x_i^2\right) = 0$$

$$\frac{\partial S_r}{\partial a_1} = -2\left(\sum y_i x_i - \sum a_0 x_i - a_1 \sum x_i^2 - a_2 \sum x_i^3\right) = 0$$

$$\frac{\partial S_r}{\partial a_2} = -2\left(\sum y_i x_i^2 - \sum a_0 x_i^2 - a_1 \sum x_i^3 - a_2 \sum x_i^4\right) = 0$$

$$\sum a_0 = a_0 n$$

$$[A][X] = [B]$$

$$S_{y/x} = \sqrt{\frac{S_r}{n-3}}$$

COEFFICIENT OF DETERMINATION:
$$r^2 = \frac{S_t - S_r}{S_t}$$

INTERPOLATION

USE A POLYNOMIAL FIT:

DEGREE 1	DEGREE 2	DEGREE 3	DEGREE n
2 PTS	3 PTS	4 PTS	n+1 PTS

$$P_n(x) = a_0 + a_1 x + a_2 x^2 + \dots + a_n x^n$$

ORDER / TURNS
n=1	0
n=2	1
n=3	2
n=n	n-1

SPLINES:
$$m_i = \frac{f(x_{i+1}) - f(x_i)}{x_{i+1} - x_i}$$

ODE'S

EULER'S METHOD:
$$\frac{dy}{dx} = f(x,y)$$
$$y_{i+1} = y_i + f(x_i, y_i)h$$

HEUN'S METHOD:
$$\frac{dy}{dx} = f(x,y)$$
$$x_{i+1} = y_i + f(x_i, y_i)\Delta x$$

$$\frac{dy}{dx} = y_i^0 = f(x_i, y_i)$$

$$\frac{dy}{dx} = y_i^0 = f(x_i, y_i)$$

$$y' = \frac{y_i^0 + y_{i+1}}{2}, \quad \frac{f(x_i,y_i) + f(x_{i+1}, y_{i+1}^0)}{2}$$

$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^0)}{2}\Delta x$$

TAYLOR SERIES:
$$y(x + \Delta x) = y(x) + \frac{dy}{dx}(x_0)\Delta x$$
$$y(x + \Delta x) = y(x) + f(x_0, y_0)\Delta x$$

CLASSIC 4TH ORDER RUNGE-KUTTA:
$$y_{i+1} = y_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)\Delta x$$
$$k_1 = f(x_i, y_i)$$
$$k_2 = f\left(x_i + \tfrac{1}{2}\Delta x, \; y_i + \tfrac{1}{2}k_1 \Delta x\right)$$
$$k_3 = f\left(x_i + \tfrac{1}{2}\Delta x, \; y_i + \tfrac{1}{2}k_2 \Delta x\right)$$
$$k_4 = f\left(x_i + \Delta x, \; y_i + k_3 \Delta x\right)$$

DORMAND-PRINCE RUNGE-KUTTA:
$$y_{i+1} = y_i + \Delta x \sum a_i k_i$$
$$y_{i+1} = y_i + \Delta x \sum a_i k_i$$

EIGEN VALUES

$\lambda = $ EIGEN VALUE

SINGLE 2×2:
$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$
$$[A]^{-1} = \frac{1}{ad - bc}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$
$$[A] = \frac{1}{ad-bc}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$
$$\begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$\lambda = \frac{(a+d) \pm \sqrt{(a+d)^2 - 4(ad-bc)}}{2}$$

PDE'S

FINITE DIFFERENCE METHOD:

TEMPERATURE

CENTRAL DIFFERENCE:
$$u_{xx}(x,y) = \frac{u(x - \Delta x, y) - 2u(x,y) + u(x + \Delta x, y)}{\Delta x^2}$$
$$u_{yy}(x,y) = \frac{u(x, y - \Delta y) - 2u(x,y) + u(x, y + \Delta y)}{\Delta y^2}$$

[A] MATRIX:

LEFT:
$$-2u_{i-1,j} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x \bar{q}_3$$

TOP CHANGED:
$$-2u_{i-1,j} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x \bar{q}_3$$

BOTTOM:
$$-2u_{i-1,j} - u_{i,j} + 4u_{i,j} = 2u_{i,j+1} = -2\Delta x \bar{q}_3$$

TOP:
$$-u_{i-1,j} - u_{i+1,j} + 4u_{i,j} - 2u_{i,j-1} = -2\Delta x \bar{q}_3$$

NEUMANN:
BC:
CENTRAL DIFFERENCE:
$$\frac{\partial u}{\partial x} = q_0 = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$

RIGHT NEUMANN B.C.:
$$\frac{\partial u}{\partial x} = q_0 = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$
$$u_{i+1,j} = u_{i-1,j} + 2\Delta x \bar{q}_0$$

BOTTOM NEUMANN B.C.:
$$\frac{\partial u}{\partial y} = q_0 = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta x}$$
$$u_{i,j-1} = u_{i,j+1} - 2\Delta x \bar{q}_0$$

TOP NEUMANN BC:
$$\frac{\partial u}{\partial y} = q_0 = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta x}$$
$$u_{i,j+1} = u_{i,j-1} + 2\Delta x \bar{q}_0$$

LEFT NEUMANN B.C.:
$$u_{i-1,j} = u_{i+1,j} - 2\Delta x \bar{q}_0$$

5TH ROW OF A MATRIX:
$$\begin{bmatrix} 0 & -1 & 0 & -1 & 4 & -1 & 0 & -1 & 0 \end{bmatrix}[u] = 0$$

MISC EQN'S:
CENTERED FINITE-DIVIDED-DIFFERENCE:
FIRST:
$$f'(x_i) = \frac{f(x_{i+1}) - f(x_{i-1})}{2h}$$
$$f'(x_i) = \frac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12h}$$

Numerical Mathematics

Germund Dahlquist,Ake Bjorck

Numerical Mathematics:

Numerical Mathematics Alfio Quarteroni,Riccardo Sacco,Fausto Saleri,2010-11-30 This book provides the mathematical foundations of numerical methods and demonstrates their performance on examples exercises and real life applications This is done using the MATLAB software environment which allows an easy implementation and testing of the algorithms for any specific class of problems The book is addressed to students in Engineering Mathematics Physics and Computer Sciences In the second edition of this extremely popular textbook on numerical analysis the readability of pictures tables and program headings has been improved Several changes in the chapters on iterative methods and on polynomial approximation have also been An Introduction to Numerical Mathematics Eduard L. Stiefel,2014-05-12 An Introduction to Numerical Mathematics provides information pertinent to the fundamental aspects of numerical mathematics This book covers a variety of topics including linear programming linear and nonlinear algebra polynomials numerical differentiation and approximations Organized into seven chapters this book begins with an overview of the solution of linear problems wherein numerical mathematics provides very effective algorithms consisting of finitely many computational steps This text then examines the method for the direct solution of a definite problem Other chapters consider the determination of frequencies in freely oscillating mechanical or electrical systems This book discusses as well eigenvalue problems for oscillatory systems of finitely many degrees of freedom which can be reduced to algebraic equations The final chapter deals with the approximate representation of a function f x given by I values as in the form of a table This book is a valuable resource for physicists mathematicians theoreticians engineers and research workers Lectures on Numerical Mathematics H. Rutishauser,2012-12-06 The present book is an edition of the manuscripts to the courses Numerical Methods I and Numerical Mathematics I and II which Professor H Rutishauser held at the E T H in Zurich The first named course was newly conceived in the spring semester of 1970 and intended for beginners while the two others were given repeatedly as elective courses in the sixties For an understanding of most chapters the funda mentals of linear algebra and calculus suffice In some places a little complex variable theory is used in addition However the reader can get by without any knowledge of functional analysis The first seven chapters discuss the direct solution of systems of linear equations the solution of nonlinear systems least squares prob lems interpolation by polynomials numerical quadrature and approxima tion by Chebyshev series and by Remez algorithm The remaining chapters include the treatment of ordinary and partial differential equa tions the iterative solution of linear equations and a discussion of eigen value problems In addition there is an appendix dealing with the qd algorithm and with an axiomatic treatment of computer arithmetic **Fundamentals of Numerical Mathematics for Physicists and Engineers** Alvaro Meseguer,2020-05-14 Introduces the fundamentals of numerical mathematics and illustrates its applications to a wide variety of disciplines in physics and engineering Applying numerical mathematics to solve scientific problems this book helps readers understand the mathematical and algorithmic elements that lie beneath numerical and

computational methodologies in order to determine the suitability of certain techniques for solving a given problem It also contains examples related to problems arising in classical mechanics thermodynamics electricity and quantum physics Fundamentals of Numerical Mathematics for Physicists and Engineers is presented in two parts Part I addresses the root finding of univariate transcendental equations polynomial interpolation numerical differentiation and numerical integration Part II examines slightly more advanced topics such as introductory numerical linear algebra parameter dependent systems of nonlinear equations numerical Fourier analysis and ordinary differential equations initial value problems and univariate boundary value problems Chapters cover Newton s method Lebesgue constants conditioning barycentric interpolatory formula Clenshaw Curtis quadrature GMRES matrix free Krylov linear solvers homotopy numerical continuation differentiation matrices for boundary value problems Runge Kutta and linear multistep formulas for initial value problems Each section concludes with Matlab hands on computer practicals and problem and exercise sets This book Provides a modern perspective of numerical mathematics by introducing top notch techniques currently used by numerical analysts Contains two parts each of which has been designed as a one semester course Includes computational practicals in Matlab with solutions at the end of each section for the instructor to monitor the student s progress through potential exams or short projects Contains problem and exercise sets also with solutions at the end of each section Fundamentals of Numerical Mathematics for Physicists and Engineers is an excellent book for advanced undergraduate or graduate students in physics mathematics or engineering It will also benefit students in other scientific fields in which numerical methods may be required such as chemistry or biology   *Basic Numerical Mathematics* J. Todd,2013-03-13 There is no doubt nowadays that numerical mathematics is an essential component of any educational program It is probably more efficient to present such material after a strong grasp of at least linear algebra and calculus has already been attained but at this stage those not specializing in numerical mathematics are often interested in getting more deeply into their chosen field than in developing skills for later use An alternative approach is to incorporate the numerical aspects of linear algebra and calculus as these subjects are being developed Long experience has persuaded us that a third attack on this problem is the best and this is developed in the present two volumes which are however easily adaptable to other circumstances The approach we prefer is to treat the numerical aspects separately but after some theoretical background This is often desirable because of the shortage of persons qualified to present the combined approach and also because the numerical approach provides an often welcome change which however in addition can lead to better appreciation of the fundamental concepts For instance in a 6 quarter course in Calculus and Linear Algebra the material in Volume 1 can be handled in the third quarter and that in Volume 2 in the fifth or sixth quarter   *The Concept of Stability in Numerical Mathematics* Wolfgang Hackbusch,2014-02-06 In this book the author compares the meaning of stability in different subfields of numerical mathematics Concept of Stability in numerical mathematics opens by examining the stability of finite algorithms A more

precise definition of stability holds for quadrature and interpolation methods which the following chapters focus on The discussion then progresses to the numerical treatment of ordinary differential equations ODEs While one step methods for ODEs are always stable this is not the case for hyperbolic or parabolic differential equations which are investigated next The final chapters discuss stability for discretisations of elliptic differential equations and integral equations In comparison among the subfields we discuss the practical importance of stability and the possible conflict between higher consistency order and stability **Concise Numerical Mathematics** Robert Plato,2003 This book succinctly covers the key topics of numerical methods While it is basically a survey of the subject it has enough depth for the student to walk away with the ability to implement the methods by writing computer programs or by applying them to problems in physics or engineering The author manages to cover the essentials while avoiding redundancies and using well chosen examples and exercises The exposition is supplemented by numerous figures Work estimates and pseudo codes are provided for many algorithms which can be easily converted to computer programs Topics covered include interpolation the fast Fourier transform iterative methods for solving systems of linear and nonlinear equations numerical methods for solving ODEs numerical methods for matrix eigenvalue problems approximation theory and computer arithmetic In general the author assumes only a knowledge of calculus and linear algebra The book is suitable as a text for a first course in numerical methods for mathematics students or students in neighboring fields such as engineering physics and computer science **Numerical Mathematics and Advanced Applications 2011** Andrea Cangiani,Ruslan L Davidchack,Emmanuil Georgoulis,Alexander N. Gorban,Jeremy Levesley,Michael V. Tretyakov,2013-01-20 The European Conferences on Numerical Mathematics and Advanced Applications ENUMATH are a series of conferences held every two years to provide a forum for discussion of new trends in numerical mathematics and challenging scientific and industrial applications at the highest level of international expertise ENUMATH 2011 was hosted by the University of Leicester UK from the 5th to 9th September 2011 This proceedings volume contains more than 90 papers by speakers of the conference and gives an overview of recent developments in scientific computing numerical analysis and practical use of modern numerical techniques and algorithms in various applications New results on finite element methods multiscale methods numerical linear algebra and finite difference schemes are presented A range of applications include computational problems from fluid dynamics materials image processing and molecular dynamics **An Introduction to Numerical Methods and Analysis** James F. Epperson,2007-09-17 Praise for the First Edition outstandingly appealing with regard to its style contents considerations of requirements of practice choice of examples and exercises Zentrablatt Math carefully structured with many detailed worked examples The Mathematical Gazette an up to date and user friendly account Mathematika An Introduction to Numerical Methods and Analysis addresses the mathematics underlying approximation and scientific computing and successfully explains where approximation methods come from why they sometimes work or don t work and when to use one of the many techniques that are available Written in a style that

emphasizes readability and usefulness for the numerical methods novice the book begins with basic elementary material and gradually builds up to more advanced topics A selection of concepts required for the study of computational mathematics is introduced and simple approximations using Taylor s Theorem are also treated in some depth The text includes exercises that run the gamut from simple hand computations to challenging derivations and minor proofs to programming exercises A greater emphasis on applied exercises as well as the cause and effect associated with numerical mathematics is featured throughout the book An Introduction to Numerical Methods and Analysis is the ideal text for students in advanced undergraduate mathematics and engineering courses who are interested in gaining an understanding of numerical methods and numerical analysis **A Survey of Numerical Mathematics, Volume I** David M. Young,Robert Todd Gregory,2012-08-09 Volume 1 of two volume set Broad self contained coverage of computer oriented numerical algorithms for solving various types of mathematical problems in linear algebra ordinary and partial differential equations much more Exercises Basic Numerical Methods R. E. Scraton,1984 Numbers errors and accuracy Iterative methods Solution of equations Simultaneous equations I Simultaneous equations II Numerical integration Differential equations I Differential equations II *Numerical Methods with MATLAB* Gerald W. Recktenwald,2000 Designed to give undergraduate engineering students a practical and rigorous introduction to the fundamentals of numerical computation This book is a thoroughly modern exposition of classic numerical methods using MATLAB The fundamental theory of each method is briefly developed Rather than providing a detailed numerical analysis the behavior of the methods is exposed by carefully designed numerical experiments The methods are then exercised on several nontrivial example problems from engineering practice The material in each chapter is organized as a progression from the simple to the complex This leads the student to an understanding of the sophisticated numerical methods that are part of MATLAB An integral part of the book is the Numerical Methods with MATLAB NMM Toolbox which provides 150 programs and over forty data sets The NMM Toolbox is a library of numerical techniques implemented in structured and clearly written code **Numerical Methods that Work** Forman S. Acton,1990 A commonsense approach to numerical algorithms for the solution of equations **Numerical Mathematics and Advanced Applications** Miloslav Feistauer,Vit Dolejší,Peter Knobloch,Karel Najzar,2004-08-12 These proceedings collect the major part of the lectures given at ENU MATH2003 the European Conference on Numerical Mathematics and Ad vanced Applications held in Prague Czech Republic from 18 August to 22 August 2003 The importance of numerical and computational mathematics and sci entific computing is permanently growing There is an increasing number of different research areas where numerical simulation is necessary Let us men tion fluid dynamics continuum mechanics electromagnetism phase transi tion cosmology medicine economics finance etc The success of applications of numerical methods is conditioned by changing its basic instruments and looking for new appropriate techniques adapted to new problems as well as new computer architectures The ENUMATH conferences were established in order to provide a fo rum

for discussion of current topics of numerical mathematics They seek to convene leading experts and young scientists with special emphasis on con tributions from Europe Recent results and new trends are discussed in the analysis of numerical algorithms as well as in their applications to challenging scientific and industrial problems The first ENUMATH conference was organized in Paris in 1995 then the series continued by the conferences in Heidelberg 1997 Jyvaskyla 1999 and Ischia Porto 2001 It was a great pleasure and honour for the Czech numerical community that it was decided at Ischia Porto to organize the ENUMATH2003 in Prague It was the first time when this conference crossed the former Iron Courtain and was organized in a postsocialist country   Differential Equations and Numerical Mathematics Guriĭ Ivanovich Marchuk,1982 Cubature formulae and functional analysis Differential equations Numerical mathematics   **Numerical Methods in Scientific Computing** Germund Dahlquist,Ake Bjorck,2008-01-01 This new book from the authors of the classic book Numerical methods addresses the increasingly important role of numerical methods in science and engineering More cohesive and comprehensive than any other modern textbook in the field it combines traditional and well developed topics with other material that is rarely found in numerical analysis texts such as interval arithmetic elementary functions operator series convergence acceleration and continued fractions Although this volume is self contained more comprehensive treatments of matrix computations will be given in a forthcoming volume A supplementary Website contains three appendices an introduction to matrix computations a description of Mulprec a MATLAB multiple precision package and a guide to literature algorithms and software in numerical analysis Review questions problems and computer exercises are also included For use in an introductory graduate course in numerical analysis and for researchers who use numerical methods in science and engineering   **Numerical Methods in Economics** Kenneth L. Judd,2023-04-04 To harness the full power of computer technology economists need to use a broad range of mathematical techniques In this book Kenneth Judd presents techniques from the numerical analysis and applied mathematics literatures and shows how to use them in economic analyses The book is divided into five parts Part I provides a general introduction Part II presents basics from numerical analysis on R n including linear equations iterative methods optimization nonlinear equations approximation methods numerical integration and differentiation and Monte Carlo methods Part III covers methods for dynamic problems including finite difference methods projection methods and numerical dynamic programming Part IV covers perturbation and asymptotic solution methods Finally Part V covers applications to dynamic equilibrium analysis including solution methods for perfect foresight models and rational expectation models A website contains supplementary material including programs and answers to exercises   **Elementary Numerical Mathematics for Programmers and Engineers** Gisbert Stoyan,Agnes Baran,2016-11-09 This book covers the basics of numerical methods while avoiding the definition theorem proof style and instead focusing on numerical examples and simple pseudo codes The book is divided into ten chapters Starting with floating number calculations and continuing up to ordinary differential equations including Euler backwards

The final chapter discusses practical error estimations Exercises including several in MATLAB are provided at the end of each chapter Suitable for readers with minimal mathematical knowledge the book not only offers an elementary introduction to numerical mathematics for programmers and engineers but also provides supporting material for students and teachers of mathematics   Numerical Methods for Two-Point Boundary-Value Problems Herbert B. Keller,2018-11-14 Elementary yet rigorous this concise treatment is directed toward students with a knowledge of advanced calculus basic numerical analysis and some background in ordinary differential equations and linear algebra 1968 edition   **Mathematical and Numerical Methods for Partial Differential Equations** Joël Chaskalovic,2014-05-16 This self tutorial offers a concise yet thorough introduction into the mathematical analysis of approximation methods for partial differential equation A particular emphasis is put on finite element methods The unique approach first summarizes and outlines the finite element mathematics in general and then in the second and major part formulates problem examples that clearly demonstrate the techniques of functional analysis via numerous and diverse exercises The solutions of the problems are given directly afterwards Using this approach the author motivates and encourages the reader to actively acquire the knowledge of finite element methods instead of passively absorbing the material as in most standard textbooks This English edition is based on the Finite Element Methods for Engineering Sciences by Joel Chaskalovic

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