

NUMERICAL METHODS

C / KAPPA EXAM 12 / 11/19 / 2022 / 20.00

LEAST SQUARES REGRESSION

GOAL: MINIMIZE THE SUM OF THE SQUARES OF THE RESIDUALS (ERRORS)

RESIDUAL: $y_i - \hat{y}_i$

MINIMIZING THE SQUARES OF THE RESIDUALS

FUNCTION: $f(x) = a_0 + a_1x$

RESIDUALS: $r_i = y_i - (a_0 + a_1x_i)$

MINIMIZE: $S = \sum_{i=1}^n r_i^2 = \sum_{i=1}^n (y_i - a_0 - a_1x_i)^2$

1. SET DERIVATIVE OF S TO ZERO

2. SOLVE FOR a_0 AND a_1

STANDARD ERROR:

$$S_y = \sqrt{\frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{n-2}}$$

$$S_x = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-2}}$$

STANDARD DEVIATION:

$$S_y = \sqrt{\frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n-1}}$$

$$S_x = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$$

POLYNOMIAL QUADRATIC REGRESSION:

GOAL: MINIMIZE THE SUM OF THE SQUARES OF THE RESIDUALS

FUNCTION: $f(x) = a_0 + a_1x + a_2x^2$

RESIDUALS: $r_i = y_i - (a_0 + a_1x_i + a_2x_i^2)$

MINIMIZE: $S = \sum_{i=1}^n r_i^2 = \sum_{i=1}^n (y_i - a_0 - a_1x_i - a_2x_i^2)^2$

1. TAKE DERIVATIVE OF S TO EACH COEFFICIENT

2. SET DERIVATIVE TO ZERO

3. SOLVE FOR a_0, a_1, a_2

COEFFICIENT OF DETERMINATION: $R^2 = \frac{SSR}{SST}$

INTERPOLATION

USE A POLYNOMIAL FIT:

LAGRANGE	DEGREE 1	DEGREE 2	DEGREE N
2 PPTS 1 LAGRANGE	2 PPTS 2 LAGRANGE	3 PPTS LAGRANGE	N+1 PPTS N+1 LAGRANGE
$P(x) = a_0 + a_1x + a_2x^2 + \dots + a_nx^n$			
ORDER			
n=1	—	0	
n=2	—	1	
n=3	—	2	
n=4	—	3	
n=5	—	4	
		n-1	

SPINES: $P_1 = \frac{(x-x_2)(x-x_3)\dots(x-x_n)}{(x_1-x_2)(x_1-x_3)\dots(x_1-x_n)}$

ODE'S

EULER METHOD:

$$\frac{dy}{dx} = f(x,y) \quad y_{i+1} = y_i + f(x_i, y_i) \Delta x$$

RUNGE-KUTTA METHOD:

$$y' = f(x,y) \quad y_{i+1} = y_i + \Delta x \left[\frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1})}{2} \right]$$

TAYLOR SERIES:

$$y(x+\Delta x) = y(x) + \Delta x y'(x) + \frac{\Delta x^2}{2} y''(x) + \dots$$

CLASSIC 4th ORDER RUNGE-KUTTA:

$$y_{i+1} = y_i + \Delta x \left[\frac{k_1 + 2k_2 + 2k_3 + k_4}{4} \right]$$

$k_1 = f(x_i, y_i)$

$k_2 = f(x_i + \frac{1}{2}\Delta x, y_i + \frac{1}{2}k_1\Delta x)$

$k_3 = f(x_i + \frac{1}{2}\Delta x, y_i + \frac{1}{2}k_2\Delta x)$

$k_4 = f(x_i + \Delta x, y_i + k_3\Delta x)$

LOCAL TRUNCATION ERROR: Δx^5

GLOBAL TRUNCATION ERROR: Δx^4

EIGEN VALUES

$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$

CHARACTERISTIC EQUATION: $\det(A - \lambda I) = 0$

$$\begin{vmatrix} a-\lambda & b \\ c & d-\lambda \end{vmatrix} = 0 \Rightarrow (a-\lambda)(d-\lambda) - bc = 0$$

$$\lambda^2 - (a+d)\lambda + (ad-bc) = 0$$

EIGEN VALUES: $\lambda = \frac{(a+d) \pm \sqrt{(a+d)^2 - 4(ad-bc)}}{2}$

EIGEN VECTORS: $(A - \lambda I)v = 0$

PDE'S

FINITE DIFFERENCE METHOD:

1D HEAT CONDUCTION:

TEMPERATURE: $T(x,t)$

BOUNDARY: $T(0,t) = T_0, T(L,t) = T_L$

INITIAL: $T(x,0) = T_i(x)$

HEAT SOURCE: $q = q(x,t)$

CONDUCTIVITY: k

DIFFUSION COEFFICIENT: α

CENTRAL DIFFERENCE:

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} + \frac{q}{k}$$

RIGHT BOUNDARY B.C.: $\frac{\partial T}{\partial x} = 0$

LEFT BOUNDARY B.C.: $\frac{\partial T}{\partial x} = 0$

RIGHT BOUNDARY B.C.:

$$\frac{\partial T}{\partial x} = 0 \Rightarrow \frac{T_{i+1} - T_{i-1}}{2\Delta x} = 0 \Rightarrow T_{i+1} = T_{i-1}$$

LEFT BOUNDARY B.C.:

$$\frac{\partial T}{\partial x} = 0 \Rightarrow \frac{T_{i-1} - T_{i+1}}{2\Delta x} = 0 \Rightarrow T_{i-1} = T_{i+1}$$

TOP BOUNDARY B.C.:

$$\frac{\partial T}{\partial y} = 0 \Rightarrow \frac{T_{i,j+1} - T_{i,j-1}}{2\Delta y} = 0 \Rightarrow T_{i,j+1} = T_{i,j-1}$$

BOTTOM BOUNDARY B.C.:

$$\frac{\partial T}{\partial y} = 0 \Rightarrow \frac{T_{i,j-1} - T_{i,j+1}}{2\Delta y} = 0 \Rightarrow T_{i,j-1} = T_{i,j+1}$$

[A] MATRIX:

INTERNAL NODES:

$$-T_{i-1,j} + 4T_{i,j} - T_{i+1,j} - T_{i,j-1} - T_{i,j+1} = -2\Delta x \alpha \frac{\partial^2 T}{\partial x^2} - \Delta y \alpha \frac{\partial^2 T}{\partial y^2} + \frac{q \Delta x \Delta y}{k}$$

BOUNDARY NODES:

TOP: $-T_{i,j-1} - T_{i,j+1} + 4T_{i,j} - 2T_{i,j-2} - 2T_{i,j+2} = -2\Delta x \alpha \frac{\partial^2 T}{\partial x^2} + \frac{q \Delta x \Delta y}{k}$

TRUNCATION ERROR:

CENTERED FINITE-DIFFERENCE:

$$f(x) = \frac{f(x+\Delta x) - f(x-\Delta x)}{2\Delta x} + \frac{f(x) - 3f(x-\Delta x) + 3f(x+\Delta x) - f(x)}{12\Delta x^3} + \dots$$

Numerical Methods In Eng

Karl F. Warnick



Numerical Methods In Eng:

Numerical Methods for Engineers D. Vaughan Griffiths, I.M. Smith, 2006-06-22 Although pseudocodes Mathematica and MATLAB illustrate how algorithms work designers of engineering systems write the vast majority of large computer programs in the Fortran language Using Fortran 95 to solve a range of practical engineering problems **Numerical Methods for Engineers** Second Edition provides an introduction to numerical methods

Numerical Methods In Engineering & Science Carl .E. Pearson, 1986-05-01 This book is designed for an introductory course in numerical methods for students of engineering and science at universities and colleges of advanced education

Applied Numerical Methods for Engineers Terrence J. Akai, 1994 This book is also available through the Introductory Engineering Custom Publishing System If you are interested in creating a course pack that includes chapters from this book you can get further information by calling 212 850 6272 or sending email inquiries to engineerjwiley.com Designed to cover scores of numerical techniques including statistical methods encountered by engineers and technologists Pedagogically sound it uses a conversational style and contains highlighted key words and end of chapter summaries along with method summary pitfalls and recommendations for choice of techniques 80% of the worked examples and case studies are based on applied problems A complete chapter on design features problems relevant to using this tool in engineering practice Offers over 40 pseudocodes for implementing methods discussed Publisher

Numerical Methods For Scientific And Engineering Computation M.K. Jain, 2003

Innovative Numerical Methods in Engineering R.P. Shaw, 1986-04

Numerical Methods for Nonlinear Engineering Models John R. Hauser, 2009-03-24 There are many books on the use of numerical methods for solving engineering problems and for modeling of engineering artifacts In addition there are many styles of such presentations ranging from books with a major emphasis on theory to books with an emphasis on applications The purpose of this book is hopefully to present a somewhat different approach to the use of numerical methods for engineering applications Engineering models are in general nonlinear models where the response of some appropriate engineering variable depends in a nonlinear manner on the plication of some independent parameter It is certainly true that for many types of engineering models it is sufficient to approximate the real physical world by some linear model However when engineering environments are pushed to treme conditions nonlinear effects are always encountered It is also such treme conditions that are of major importance in determining the reliability or failure limits of engineering systems Hence it is essential than engineers have a toolbox of modeling techniques that can be used to model nonlinear engineering systems Such a set of basic numerical methods is the topic of this book For each subject area treated nonlinear models are incorporated into the discussion from the very beginning and linear models are simply treated as special cases of more general nonlinear models This is a basic and fundamental difference in this book from most books on numerical methods

Numerical Methods for Mathematics, Science, and Engineering John H. Mathews, 1992 A modern computer oriented approach to numerical analysis that shows how the mathematics of calculus and

linear algebra are implemented in computer algorithms Computer output is displayed in tables and used to develop topics of computer accuracy pitfalls in computational methods and error estimation

Fundamentals of Engineering Numerical Analysis Parviz Moin,2010-08-30 In this work Parviz Moin introduces numerical methods and shows how to develop analyse and use them A thorough and practical text it is intended as a first course in numerical analysis

Numerical Analysis with Applications in Mechanics and Engineering Petre Teodorescu,Nicolae-Doru Stanescu,Nicolae Pandrea,2013-06-04 NUMERICAL ANALYSIS WITH APPLICATIONS IN MECHANICS AND ENGINEERING A much needed guide on how to use numerical methods to solve practical engineering problems Bridging the gap between mathematics and engineering Numerical Analysis with Applications in Mechanics and Engineering arms readers with powerful tools for solving real world problems in mechanics physics and civil and mechanical engineering Unlike most books on numerical analysis this outstanding work links theory and application explains the mathematics in simple engineering terms and clearly demonstrates how to use numerical methods to obtain solutions and interpret results Each chapter is devoted to a unique analytical methodology including a detailed theoretical presentation and emphasis on practical computation Ample numerical examples and applications round out the discussion illustrating how to work out specific problems of mechanics physics or engineering Readers will learn the core purpose of each technique develop hands on problem solving skills and get a complete picture of the studied phenomenon Coverage includes How to deal with errors in numerical analysis Approaches for solving problems in linear and nonlinear systems Methods of interpolation and approximation of functions Formulas and calculations for numerical differentiation and integration Integration of ordinary and partial differential equations Optimization methods and solutions for programming problems Numerical Analysis with Applications in Mechanics and Engineering is a one of a kind guide for engineers using mathematical models and methods as well as for physicists and mathematicians interested in engineering problems

Numerical Methods in Engineering Pramote Dechaumphai,N. Wansophark,2011 NUMERICAL METHODS IN ENGINEERING Theories with MATLAB Fortran C and Pascal Programs presents a clear easy to understand manner on introduction and the use of numerical methods The book contains nine chapters with materials that are essential for studying the subject The book starts from introducing the numerical methods and describing their importance for analyzing engineering problems The methods for finding roots of linear and nonlinear equations are presented with examples Some of these methods are very effective and implemented in commercial software The methods for interpolation extrapolation and least squares regression are explained Numerical integration and differentiation methods are presented to demonstrate their benefits for solving complicate functions Several methods for analyzing both the ordinary and partial differential equations are then presented These methods are simple and work well for problems that have regular geometry For problems with complex geometry the finite element method is preferred The finite element method for analyzing one and two dimensional problems is explained in the last chapter Numerous examples are

illustrated to increase understanding of these methods for analyzing different types of problems Computer programs corresponding to the computational procedures of these methods are provided The programs are written in MATLAB Fortran C and Pascal so that readers can use the preferred language for their study These computer programs can also be modified to use in other courses and research work

Computational Engineering - Introduction to Numerical Methods Michael Schäfer, 2006-02-20 Introduction Modelling of Continuum Mechanical Problems Discretization of Problem Domain Finite Volume Methods Finite Element Methods Time Discretization Solution of Algebraic Systems of Equations Properties of Numerical Methods Finite Element Methods in Structural Mechanics Finite Volume Methods for Incompressible Flows Acceleration of Computations List of Symbols References Index

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Numerical Methods for Engineers and Scientists, Second Edition, Joe D. Hoffman, Steven Frankel, 2001-05-31 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

Computational Methods in Engineering S. P. Venkateshan, Prasanna Swaminathan, 2023-05-31 The book is designed to serve as a textbook for courses offered to graduate and upper undergraduate students enrolled in mechanical engineering The book attempts to make students with mathematical backgrounds comfortable with numerical methods The book also serves as a handy reference for practicing engineers who are interested in applications The book is written in an easy to understand manner with the essence of each numerical method clearly stated This makes it easy for professional engineers students and early career researchers to follow the material presented in the book The structure of the book has been modeled accordingly It is divided into four modules i solution of a system of equations and eigenvalues which includes linear equations determining eigenvalues and solution of nonlinear equations ii function approximations interpolation data fit numerical differentiation and

numerical integration iii solution of ordinary differential equations initial value problems and boundary value problems and iv solution of partial differential equations parabolic elliptic and hyperbolic PDEs Each section of the book includes exercises to reinforce the concepts and problems have been added at the end of each chapter Exercise problems may be solved by using computational tools such as scientific calculators spreadsheet programs and MATLAB codes The detailed coverage and pedagogical tools make this an ideal textbook for students early career researchers and professionals

Numerical Methods: For Engineering and Science Saumyen Guha, Rajesh Srivastava (Civil engineer), 2010-12 Designed as a textbook for undergraduate and postgraduate students of engineering and science Numerical Methods For Engineering and Science is an attempt to explain the concepts and principles in such a way that the methods can be applied to any discipline

Numerical Methods in Engineering & Science Graham de Vahl Davis, 2012-12-06 This book is designed for an introductory course in numerical methods for students of engineering and science at universities and colleges of advanced education It is an outgrowth of a course of lectures and tutorials problem solving sessions which the author has given for a number of years at the University of New South Wales and elsewhere The course is normally taught at the rate of 11 hours per week throughout an academic year 28 weeks It has occasionally been given at double this rate over half the year but it was found that students had insufficient time to absorb the material and experiment with the methods The material presented here is rather more than has been taught in anyone year although all of it has been taught at some time The book is concerned with the application of numerical methods to the solution of equations algebraic transcendental and differential which will be encountered by students during their training and their careers The theoretical foundation for the methods is not rigorously covered Engineers and applied scientists but not of course mathematicians are more concerned with using methods than with proving that they can be used However they must be satisfied that the methods are fit to be used and it is hoped that students will perform sufficient numerical experiments to convince themselves of this without the need for more than the minimum of theory which is presented here

Numerical Methods for Engineering Karl F. Warnick, 2020-09-26 The revised and updated second edition of this textbook teaches students to create computer codes used to engineer antennas microwave circuits and other critical technologies for wireless communications and other applications of electromagnetic fields and waves Worked code examples are provided for MATLAB technical computing software

Numerical Methods for Engineers Steven C. Chapra, Raymond P. Canale, 2002 The Fourth Edition of Numerical Methods for Engineers continues the tradition of excellence it established as the winner of the ASEE Meriam Wiley award for Best Textbook Instructors love it because it is a comprehensive text that is easy to teach from Students love it because it is written for them with great pedagogy and clear explanations and examples throughout This edition features an even broader array of applications including all engineering disciplines The revision retains the successful pedagogy of the prior editions Chapra and Canale's unique approach opens each part of the text with sections called Motivation Mathematical Background

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Table of Contents Numerical Methods In Eng

1. Understanding the eBook Numerical Methods In Eng
 - The Rise of Digital Reading Numerical Methods In Eng
 - Advantages of eBooks Over Traditional Books
2. Identifying Numerical Methods In Eng
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Numerical Methods In Eng
 - User-Friendly Interface
4. Exploring eBook Recommendations from Numerical Methods In Eng
 - Personalized Recommendations
 - Numerical Methods In Eng User Reviews and Ratings

- Numerical Methods In Eng and Bestseller Lists
- 5. Accessing Numerical Methods In Eng Free and Paid eBooks
 - Numerical Methods In Eng Public Domain eBooks
 - Numerical Methods In Eng eBook Subscription Services
 - Numerical Methods In Eng Budget-Friendly Options
- 6. Navigating Numerical Methods In Eng eBook Formats
 - ePub, PDF, MOBI, and More
 - Numerical Methods In Eng Compatibility with Devices
 - Numerical Methods In Eng Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Numerical Methods In Eng
 - Highlighting and Note-Taking Numerical Methods In Eng
 - Interactive Elements Numerical Methods In Eng
- 8. Staying Engaged with Numerical Methods In Eng
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Numerical Methods In Eng
- 9. Balancing eBooks and Physical Books Numerical Methods In Eng
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Numerical Methods In Eng
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Numerical Methods In Eng
 - Setting Reading Goals Numerical Methods In Eng
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Numerical Methods In Eng
 - Fact-Checking eBook Content of Numerical Methods In Eng
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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