

# NUMERICAL METHODS

C / KAPPA EXAM 12 / 11/14 / 2022 / 20.00%

## LEAST SQUARES REGRESSION

Goal: minimize the sum of the square of the residual (error).

Residual =  $y_i - \hat{y}_i$

$S_y = \sum_{i=1}^n y_i$ ,  $S_x = \sum_{i=1}^n x_i$ ,  $S_{xy} = \sum_{i=1}^n x_i y_i$

$a_0 = \frac{S_y}{n}$ ,  $a_1 = \frac{S_{xy} - \frac{S_x S_y}{n}}{S_x - \frac{S_x^2}{n}}$

$a_0 = \frac{\sum y_i}{n}$ ,  $a_1 = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2}$

## POLYNOMIAL QUADRATIC REGRESSION

Goal: minimize the sum of the square of the residual (error).

$S_y = \sum_{i=1}^n (y_i - a_0 - a_1 x_i - a_2 x_i^2)^2$

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

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

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

$\begin{bmatrix} \sum 1 & \sum x_i & \sum x_i^2 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum x_i y_i \\ \sum x_i^2 y_i \end{bmatrix}$

$CX = Y$ ,  $C = \begin{bmatrix} \sum 1 & \sum x_i & \sum x_i^2 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix}$ ,  $X = \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix}$ ,  $Y = \begin{bmatrix} \sum y_i \\ \sum x_i y_i \\ \sum x_i^2 y_i \end{bmatrix}$

$X = C^{-1}Y$ ,  $C^{-1} = \frac{1}{\det(C)} \text{adj}(C)$

$\det(C) = \sum_{i=1}^n (x_i - \bar{x})^2$

## PDE'S

### FINITE DIFFERENCE METHOD

Grid spacing  $\Delta x$ ,  $\Delta y$

Central difference

Forward difference

Backward difference

Central difference

Forward difference

Backward difference

Central difference

Forward difference

Backward difference

Central difference

Forward difference

Backward difference

Central difference

Forward difference

Backward difference

## STANDARD ERROR

$S_y = \sqrt{\frac{\sum y_i^2}{n-2}}$ ,  $S_x = \sqrt{\frac{\sum x_i^2}{n-2}}$

## STANDARD DEVIATION

$S_y = \sqrt{\frac{\sum y_i^2}{n-1}}$ ,  $S_x = \sqrt{\frac{\sum x_i^2}{n-1}}$

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

$a_1 = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2}$

$a_2 = \frac{\sum (x_i - \bar{x})^2 (y_i - \bar{y})}{\sum (x_i - \bar{x})^4}$

$a_3 = \frac{\sum (x_i - \bar{x})^3 (y_i - \bar{y})}{\sum (x_i - \bar{x})^6}$

$a_4 = \frac{\sum (x_i - \bar{x})^4 (y_i - \bar{y})}{\sum (x_i - \bar{x})^8}$

$a_5 = \frac{\sum (x_i - \bar{x})^5 (y_i - \bar{y})}{\sum (x_i - \bar{x})^{10}}$

$a_6 = \frac{\sum (x_i - \bar{x})^6 (y_i - \bar{y})}{\sum (x_i - \bar{x})^{12}}$

$a_7 = \frac{\sum (x_i - \bar{x})^7 (y_i - \bar{y})}{\sum (x_i - \bar{x})^{14}}$

$a_8 = \frac{\sum (x_i - \bar{x})^8 (y_i - \bar{y})}{\sum (x_i - \bar{x})^{16}}$

$a_9 = \frac{\sum (x_i - \bar{x})^9 (y_i - \bar{y})}{\sum (x_i - \bar{x})^{18}}$

$a_{10} = \frac{\sum (x_i - \bar{x})^{10} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{20}}$

$a_{11} = \frac{\sum (x_i - \bar{x})^{11} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{22}}$

$a_{12} = \frac{\sum (x_i - \bar{x})^{12} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{24}}$

$a_{13} = \frac{\sum (x_i - \bar{x})^{13} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{26}}$

$a_{14} = \frac{\sum (x_i - \bar{x})^{14} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{28}}$

$a_{15} = \frac{\sum (x_i - \bar{x})^{15} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{30}}$

$a_{16} = \frac{\sum (x_i - \bar{x})^{16} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{32}}$

$a_{17} = \frac{\sum (x_i - \bar{x})^{17} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{34}}$

$a_{18} = \frac{\sum (x_i - \bar{x})^{18} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{36}}$

$a_{19} = \frac{\sum (x_i - \bar{x})^{19} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{38}}$

$a_{20} = \frac{\sum (x_i - \bar{x})^{20} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{40}}$

$a_{21} = \frac{\sum (x_i - \bar{x})^{21} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{42}}$

$a_{22} = \frac{\sum (x_i - \bar{x})^{22} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{44}}$

$a_{23} = \frac{\sum (x_i - \bar{x})^{23} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{46}}$

$a_{24} = \frac{\sum (x_i - \bar{x})^{24} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{48}}$

$a_{25} = \frac{\sum (x_i - \bar{x})^{25} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{50}}$

$a_{26} = \frac{\sum (x_i - \bar{x})^{26} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{52}}$

$a_{27} = \frac{\sum (x_i - \bar{x})^{27} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{54}}$

$a_{28} = \frac{\sum (x_i - \bar{x})^{28} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{56}}$

$a_{29} = \frac{\sum (x_i - \bar{x})^{29} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{58}}$

$a_{30} = \frac{\sum (x_i - \bar{x})^{30} (y_i - \bar{y})}{\sum (x_i - \bar{x})^{60}}$

## INTERPOLATION

Linear interpolation

Quadratic interpolation

Cubic interpolation

Quartic interpolation

Quintic interpolation

Sixth interpolation

Seventh interpolation

Eighth interpolation

Ninth interpolation

Tenth interpolation

Eleventh interpolation

Twelfth interpolation

Thirteenth interpolation

Fourteenth interpolation

Fifteenth interpolation

Sixteenth interpolation

Seventeenth interpolation

Eighteenth interpolation

Nineteenth interpolation

Twentieth interpolation

Twenty-first interpolation

Twenty-second interpolation

Twenty-third interpolation

Twenty-fourth interpolation

Twenty-fifth interpolation

Twenty-sixth interpolation

Twenty-seventh interpolation

Twenty-eighth interpolation

Twenty-ninth interpolation

Thirtieth interpolation

Thirty-first interpolation

Thirty-second interpolation

Thirty-third interpolation

Thirty-fourth interpolation

Thirty-fifth interpolation

## DEGREE 1

Linear interpolation

Quadratic interpolation

Cubic interpolation

Quartic interpolation

Quintic interpolation

Sixth interpolation

Seventh interpolation

Eighth interpolation

Ninth interpolation

Tenth interpolation

Eleventh interpolation

Twelfth interpolation

Thirteenth interpolation

Fourteenth interpolation

Fifteenth interpolation

Sixteenth interpolation

Seventeenth interpolation

Eighteenth interpolation

Nineteenth interpolation

Twentieth interpolation

Twenty-first interpolation

Twenty-second interpolation

Twenty-third interpolation

Twenty-fourth interpolation

Twenty-fifth interpolation

Twenty-sixth interpolation

Twenty-seventh interpolation

Twenty-eighth interpolation

Twenty-ninth interpolation

Thirtieth interpolation

Thirty-first interpolation

Thirty-second interpolation

Thirty-third interpolation

Thirty-fourth interpolation

Thirty-fifth interpolation

## TAYLOR SERIES

$y(x) = y_0 + y'_0 x + \frac{y''_0}{2!} x^2 + \dots$

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## ODE'S

### Runge-Kutta Method

$y_{n+1} = y_n + f(x_n, y_n) \Delta x$

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## Runge-Kutta Method

$y_{n+1} = y_n + f(x_n, y_n) \Delta x$

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# Numerical Methods Numerical Methods

**Rajasekaran S.**



## **Numerical Methods Numerical Methods:**

*Numerical Methods that Work* Forman S. Acton, 1990 A commonsense approach to numerical algorithms for the solution of equations

**Numerical Methods** M. K. Jain, Satteluri R. K. Iyengar, R. K. Jain, 2007 Is An Outline Series Containing Brief Text Of Numerical Solution Of Transcendental And Polynomial Equations System Of Linear Algebraic Equations And Eigenvalue Problems Interpolation And Approximation Differentiation And Integration Ordinary Differential Equations And Complete Solutions To About 300 Problems Most Of These Problems Are Given As Unsolved Problems In The Authors Earlier Book User Friendly Turbo Pascal Programs For Commonly Used Numerical Methods Are Given In The Appendix This Book Can Be Used As A Text Help Book Both By Teachers And Students

*Numerical Methods with Worked Examples* Chris Woodford, C. Woodford, Chris Phillips, 1997-08-31 This book is for students following a module in numerical methods numerical techniques or numerical analysis It approaches the subject from a pragmatic viewpoint appropriate for the modern student The theory is kept to a minimum commensurate with comprehensive coverage of the subject and it contains abundant worked examples which provide easy understanding through a clear and concise theoretical treatment

*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)

**Analysis of Numerical Methods** Eugene Isaacson, Herbert Bishop Keller, 2012-04-26 This excellent text for advanced undergraduate and graduate students covers norms numerical solutions of linear systems and matrix factoring eigenvalues and eigenvectors polynomial approximation and more Many examples and problems 1966 edition

Numerical Methods J. Douglas Faires, Richard L. Burden, 1998 This text emphasizes the intelligent application of approximation techniques to the type of problems that commonly occur in engineering and the physical sciences The authors provide a sophisticated introduction to various appropriate approximation techniques they show students why the methods work what type of errors to expect and when an application might lead to difficulties and they provide information about the

availability of high quality software for numerical approximation routines The techniques covered in this text are essentially the same as those covered in the Sixth Edition of these authors top selling Numerical Analysis text but the emphasis is much different In Numerical Methods Second Edition full mathematical justifications are provided only if they are concise and add to the understanding of the methods The emphasis is placed on describing each technique from an implementation standpoint and on convincing the student that the method is reasonable both mathematically and computationally

**Numerical Methods:** Ram,2010 Numerical Methods is a mathematical tool used by engineers and mathematicians to do scientific calculations It is used to find solutions to applied problems where ordinary analytical methods fail This book is intended to serve for the needs of co Numerical Methods and Software David Kahaner,Cleve B. Moler,Stephen Nash,1988 Mathematics of Computing Numerical Analysis 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 cover partial differential equations All techniques covered in the text are on a program disk included with the book and are written in Fortran 90 These programs are ideal for students researchers and practitioners because they allow for straightforward application of the numerical methods described in the text The code is easily modified to solve new systems of equations Numerical Methods for Differential Equations A Computational Approach also contains a reliable and inexpensive global error code for those interested in global error estimation This is a valuable text for students who will find the derivations of the numerical methods extremely helpful and the programs themselves easy to use It is also an excellent reference and source of software for researchers and practitioners who need computer solutions to differential equations

Numerical Methods for Scientists and Engineers Richard W. Hamming,Richard Wesley Hamming,1986-01-01 This inexpensive paperback edition of a groundbreaking text stresses frequency approach in coverage of algorithms polynomial approximation Fourier approximation exponential approximation and other topics Revised and enlarged 2nd edition

*Numerical Methods in Science and Engineering* □ *A Practical Approach* Rajasekaran S.,2003 During the past two decades owing to the advent of digital computers numerical methods of analysis have become very popular for the solution of complex problems in physical and management sciences and in engineering As the price of hardware keeps decreasing rapidly experts predict that in the near future one may have to pay only for software This underscores the importance of numerical computation to the scientist and engineers and today most undergraduates and postgraduates are being given training in the use of computers and access to the computers for the solution of problems Numerical Methods For Scientific And Engineering Computation M.K. Jain,2003 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      **A First Course in Numerical**

**Methods** Uri M. Ascher,Chen Greif,2011-07-14 Offers students a practical knowledge of modern techniques in scientific computing      *Numerical Methods, with Applications in the Biomedical Sciences* E. H. Twizell,1988      **Numerical**

**Methods in Software and Analysis** John R. Rice,2014-05-19 Numerical Methods Software and Analysis Second Edition introduces science and engineering students to the methods tools and ideas of numerical computation Introductory courses in numerical methods face a fundamental problem there is too little time to learn too much This text solves that problem by using high quality mathematical software In fact the objective of the text is to present scientific problem solving using standard mathematical software This book discusses numerous programs and software packages focusing on the IMSL library including the PROTRAN system and ACM Algorithms The book is organized into three parts Part I presents the background material Part II presents the principal methods and ideas of numerical computation Part III contains material about software engineering and performance evaluation A uniform approach is used in each area of numerical computation First an intuitive development is made of the problems and the basic methods for their solution Then relevant mathematical software is reviewed and its use outlined Many areas provide extensive examples and case studies Finally a deeper analysis of the methods is presented as in traditional numerical analysis texts Emphasizes the use of high quality mathematical software for numerical computation Extensive use of IMSL routines Features extensive examples and case studies

**Numerical Methods** Rajesh Kumar Gupta,2019-05-09 Offers a comprehensive textbook for a course in numerical methods numerical analysis and numerical techniques for undergraduate engineering students      **Numerical Methods** S. Balachandra Rao,C. K. Shantha,2004 The book discusses the important numerical methods which are frequently used in mathematical physical engineering and even biological sciences It will serve as an ideal textbook for the undergraduate and diploma courses The revised edition has a section on C and programs in C      **Discrete Numerical Methods in Physics**

**and Engineering** Greenspan,1974-05-31 Discrete Numerical Methods in Physics and Engineering      Numerical Methods Prof. K. Sambaiah,2020-07-02 One of the important features of this book lies in introducing the procedures like algorithms to implement each of the numerical method were given in the book Also some shortcut methods have been given to solve the boundary value problems Many examples have been given in the chapters to inculcate the concepts of numerical methods in the students This book is useful the students of B Sc M Sc B Tech M Tech and research scholars In this book we discussed types of errors interpolation numerical differentiation numerical integration numerical solutions of differential equation curve fitting approximation of functions methods of solving algebraic and transcendental equations and their convergence

solution of system of linear equations Further the different methods of finding the eigen values and eigen vectors of a matrix have been discussed The solutions of difference equations have been discussed Finally the solutions of boundary value problems have been discussed and short cut methods are introduced to solve boundary value problems

## The Enigmatic Realm of **Numerical Methods Numerical Methods**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing short of extraordinary. Within the captivating pages of **Numerical Methods Numerical Methods** a literary masterpiece penned with a renowned author, readers embark on a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting effect on the hearts and minds of those that partake in its reading experience.

<https://crm.allthingsbusiness.co.uk/files/browse/Documents/black%20friday%20early%20deals%20snapchat%202025.pdf>

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