# NUMERICAL METHODS

r/KAPPY | EXAM 2 | 11/14/2022

## INTERPOLATION
USE A POLYNOMIAL FIT:

| 1. LINEAR: | DEGREE 1: | DEGREE 2: | DEGREE n: |
|---|---|---|---|
| 2 PTS | 3 PTS | 4 PTS | n+1 PTS |

$$f_n(x) = a_0 + a_1 x + a_2 x^2 + \cdots + a_n x^n$$

ORDER | TURNS
n = 1 → 0
n = 2 →
n = 3 →
n = 4 →
n = 5 → n-1

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

## LEAST SQUARES REGRESSION:
GOAL: MINIMIZE THE SUM OF THE SQUARE OF THE RESIDUAL ERRORS

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

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

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

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

## STANDARD ERROR:
$$S_y = \sqrt{\frac{S_t}{n-2}} \qquad S_{y/x} = \sqrt{\frac{\sum (y_i - y_i^*)^2}{n-2}}$$

## STAND. DEVIATION:
$$S = \sqrt{\frac{S_t}{n-1}} \qquad S = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n-1}}$$

## POLYNOMIAL (QUADRATIC) REGRESSION:
$$S_r = \sum (y_i - a_0 - a_1 x_i - a_2 x_i^2)^2$$

TAKE DERIVATIVE OF $S_r$ TO FIND THE ERRORS

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

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

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

$$\sum a_0 = a_0 n$$

$$[A][x] = [B]$$

$$x = A \backslash B$$

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

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

## 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:
$$\frac{dy}{dx} = f(x, y)$$
$$x_{i+1} - y_i = f(x_i, y_i) \Delta x$$
$$\frac{dy}{dx} = y_i' = f(x_i, y_i)$$
$$\frac{dy}{dx} = y_i' = f(x_i, y_i)$$
$$y_i' = \frac{y_i' + y_{i+1}'}{2}, \quad \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^*)}{2}$$
$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^*)}{2} \Delta x$$

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

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

### 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
$$\lambda = \text{EIGEN VALUE}$$

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} a_{11} - \lambda & a_{12} & a_{13} \\ a_{21} & a_{22} - \lambda & a_{23} \\ a_{31} & a_{32} & a_{33} - \lambda \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

SOLVE 2x2:
$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \qquad [A]^{-1} = \frac{1}{\det(A)} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$[A]^{-1} = \frac{1}{\det(A)} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$\begin{bmatrix} a - \lambda & b \\ c & d - \lambda \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

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

$$\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$x_1 + x_2 = 0 \quad x_1 = -x_2$$
$$x_1 + x_2 = 0 \quad x_2 = -x_1$$
EIGENVECTOR
$$x_1 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} -1 & -1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$-x_1 + x_2 = 0 \quad x_1 = x_2$$
$$x_1 - x_2 = 0 \quad x_1 = x_2$$
2ND EIGENVECTOR
$$x_2 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

## PDE'S
### FINITE DIFFERENCE METHOD:

TEMPERATURE

DIRICHLET:
BC:
- TEMP KNOWN @ BOUNDARY

SIMPLIFIED HEAT EQN:
$$u_t = k(u_{xx} + u_{yy}) + q$$
$$q = 0 \quad k = 1$$
$$u_{xx} + u_{yy} = 0$$

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

NEUMANN:
BC:
- TEMP DERIVATIVE KNOWN ON BOUNDARY

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

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

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

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

TOP NEUMANN BC:
$$\frac{\partial u}{\partial y} = q_y = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$
$$u_{i,j+1} = u_{i,j-1} + 2\Delta y q_y$$

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

[A] MATRIX:
LEFT:
$$u_{i-1,j} + 4u_{i,j} - u_{i,j+1} - u_{i,j-1} = 2\Delta x q_x$$
$$-2u_{i+1,j} + 4u_{i,j} - u_{i,j+1} - u_{i,j-1} = -2\Delta x q_x$$
RIGHT:
$$-2u_{i-1,j} + 4u_{i,j} - u_{i,j+1} - u_{i,j-1} = -2\Delta x q_x$$
BOTTOM:
$$-2u_{i,j+1} - u_{i-1,j} + 4u_{i,j} = 2\Delta y q_y$$
TOP:
$$-u_{i-1,j} - u_{i+1,j} + 4u_{i,j} - 2u_{i,j-1} = -2\Delta y q_y$$

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

# Numerical Methods For Mathematics Science And Engineering

Huangqi Zhang

**Numerical Methods For Mathematics Science And Engineering:**

*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 **Numerical Methods for Science and Engineering. --** Ralph G Stanton,2021-09-09 This work has been selected by scholars as being culturally important and is part of the knowledge base of civilization as we know it This work is in the public domain in the United States of America and possibly other nations Within the United States you may freely copy and distribute this work as no entity individual or corporate has a copyright on the body of the work Scholars believe and we concur that this work is important enough to be preserved reproduced and made generally available to the public To ensure a quality reading experience this work has been proofread and republished using a format that seamlessly blends the original graphical elements with text in an easy to read typeface We appreciate your support of the preservation process and thank you for being an important part of keeping this knowledge alive and relevant **Numerical Analysis For Applied Mathematics, Science, And Engineering** Donald Greenspan,Vincenzo Casulli,1988-01-21 This book is designed for a first course in numerical analysis It differs considerably from other such texts in its choice of topics

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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

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 **Integral Methods in Science and Engineering** Mario Paul Ahues,Alain R. Largillier,2011-06-28 An outgrowth of The Seventh International Conference on Integral Methods in Science and Engineering this book focuses on applications of integration based analytic and numerical techniques The contributors to the volume draw from a number of physical domains and propose diverse treatments for various mathematical models through the use of integration as an essential solution tool Physically meaningful problems in areas related to finite and boundary element techniques conservation laws hybrid approaches ordinary and partial differential equations and vortex methods are explored in a rigorous accessible manner The new results provided are a good starting point for future exploitation of the interdisciplinary potential of integration as a unifying methodology for the investigation of mathematical models

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matrix eigenvalue problem which entails numerical methods to approximate a few or all eigenvalues of a matrix The book then deals with the numerical solution of partial differential equations specifically those that frequently arise in engineering and science The book presents a user defined function or a MATLAB script file for each method followed by at least one fully worked out example When available MATLAB built in functions are executed for confirmation of the results A large set of exercises of varying levels of difficulty appears at the end of each chapter The concise approach with strong up to date MATLAB integration provided by this book affords readers a thorough knowledge of the fundamentals of numerical methods utilized in various disciplines *Numerical Methods for Solving Partial Differential Equations* George F. Pinder,2018-02-05 A comprehensive guide to numerical methods for simulating physical chemical systems This book offers a systematic highly accessible presentation of numerical methods used to simulate the behavior of physical chemical systems Unlike most books on the subject it focuses on methodology rather than specific applications Written for students and professionals across an array of scientific and engineering disciplines and with varying levels of experience with applied mathematics it provides comprehensive descriptions of numerical methods without requiring an advanced mathematical background Based on its author s more than forty years of experience teaching numerical methods to engineering students Numerical Methods for Solving Partial Differential Equations presents the fundamentals of all of the commonly used numerical methods for solving differential equations at a level appropriate for advanced undergraduates and first year graduate students in science and engineering Throughout elementary examples show how numerical methods are used to solve generic versions of equations that arise in many scientific and engineering disciplines In writing it the author took pains to ensure that no assumptions were made about the background discipline of the reader Covers the spectrum of numerical methods that are used to simulate the behavior of physical chemical systems that occur in science and engineering Written by a professor of engineering with more than forty years of experience teaching numerical methods to engineers Requires only elementary knowledge of differential equations and matrix algebra to master the material Designed to teach students to understand appreciate and apply the basic mathematics and equations on which Mathcad and similar commercial software packages are based Comprehensive yet accessible to readers with limited mathematical knowledge Numerical Methods for Solving Partial Differential Equations is an excellent text for advanced undergraduates and first year graduate students in the sciences and engineering It is also a valuable working reference for professionals in engineering physics chemistry computer science and applied mathematics **Variational Methods in Mathematics, Science and Engineering** K. Rektorys,1980-02-29 Hilbert space Variational methods Application of variational methods to the solution of boundary value problems in ordinary and partial differential equations Theory of boundary value problems in differential equations based on the concept of a weak solution and on the lax milgram theorem The eigenvalue problem Some special methods Regularity of the weak solution *Numerical Methods for Engineers and Scientists* J. N. Sharma (M.A.),2004 The desire for numerical answers to applied

problems has increased manifold with the advances made in various branches of science and engineering and rapid development of high speed digital computers Although numerical methods have always been useful their role in the present day scientific computations and research is of fundamental importance numerous distinguishing features The contents of the book have been organized in a logical order and the topics are discussed in a systematic manner concepts algorithms and numerous exercises at the end of each chapter helps students in problem solving both manually and through computer programming an exhaustive bibliography and an appendix containing some important and useful iterative methods for the solution of nonlinear complex equations     *Numerical Modeling in Materials Science and Engineering* Michel Rappaz,Michel Bellet,Michel O. Deville,2002-11-05 Computing application to materials science is one of the fastest growing research areas This book introduces the concepts and methodologies related to the modeling of the complex phenomena occurring in materials processing It is intended for undergraduate and graduate students in materials science and engineering mechanical engineering and physics and for engineering professionals or researchers

**Numerical Methods For Mathematics Science And Engineering** Book Review: Unveiling the Power of Words

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