NUMERICAL METHODS

INTERPOLATION
USE A POLYNOMIAL FIT:

DEGREE 1	DEGREE 2	DEGREE 3	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
n = 1
n = 2
n = 3
n = 4

TURNS
0
1
2
n-1

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

LEAST SQUARES REGRESSION

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

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

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

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

$$y = a_0 + a_1 x$$

STANDARD ERROR:
$$S_{y} = \sqrt{\frac{S_r}{n-2}} \qquad S_{y/x} = \sqrt{\frac{\sum(y_i - y_i^{est})^2}{n-2}}$$

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

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

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

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

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

$$\sum_{i=0}^{n} a_i a_n$$

$$[A][X] = [B] \quad \rightarrow \quad X = A/B$$

$$S_{y/x} = \sqrt{\frac{S_r}{n-(m+1)}}$$

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

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

HEUN'S METHOD:
$$\frac{dy}{dx} = f(x,y)$$
$$x_{i+1} = y_i + f(x_i, y_i) \Delta x$$
$$\frac{dy_i}{dx} = y_i' = f(x_i, y_i)$$
$$\frac{dy_{i+1}}{dx} = y_{i+1}' = f(x_{i+1}, y_{i+1})$$
$$y_{i+1}' = \frac{y_i' + y_{i+1}'}{2} \qquad f(x_i, y_i) + f(x_{i+1}, y_{i+1}^{0})}{2}$$
$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1})}{2} \Delta x$$

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:
$$y_{i+1} = y_i + \Delta x \sum_{j=1}^{7} a_j k_j$$
$$y_{i+1} = y_i + \Delta x \sum_{j=1}^{7} a_j k_j$$

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

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

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

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

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

$$X_1 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} \\ \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$\begin{bmatrix} x_2 \end{bmatrix} = \begin{bmatrix} \\ \end{bmatrix}$$

PDE'S
FINITE DIFFERENCE METHOD:

TEMPERATURE

DIRICHLET:
$T = BOUNDARY$

BC:
- TEMP KNOWN @ BOUNDARY

GOVERNING HEAT EQN:
$$u_t = K(u_{xx} + u_{yy} + u_{zz}) + q$$
$$q = 0, \quad K = 1$$
$$u_{xx} + u_{yy} = 0$$

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

5TH ROW OF A MATRIX:
$$[0 \; -1 \; 0 \; -1 \; 4 \; -1 \; 0 \; -1 \; 0][u] = 0$$

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:
$$-2u_{i-1,j} - u_{i,j} + 4u_{i,j} - 2u_{i,j+1} = -2\Delta x q_y$$

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

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 Methods In Engineering Applied Science

Srinivasa Rao

Numerical Methods In Engineering Applied Science:

Numerical Methods in Engineering and Applied Science Bruce Irons,Nigel Shrive,1987 Numerical Methods in Engineering and Applied Science Bruce Irons,Nigel Shrive,1987 Applied Numerical Methods with MATLAB for Engineers and Scientists Steven C. Chapra,2022-01-24 **Loose Leaf for Applied Numerical Methods with MATLAB for Engineers and Scientists** Steven C. Chapra, Dr.,2017-02-13 Applied Numerical Methods with MATLAB is written for students who want to learn and apply numerical methods in order to solve problems in engineering and science As such the methods are motivated by problems rather than by mathematics That said sufficient theory is provided so that students come away with insight into the techniques and their shortcomings McGraw Hill s Connect is also available as an optional add on item Connect is the only integrated learning system that empowers students by continuously adapting to deliver precisely what they need when they need it how they need it so that class time is more effective Connect allows the professor to assign homework quizzes and tests easily and automatically grades and records the scores of the student s work Problems are randomized to prevent sharing of answers an may also have a multi step solution which helps move the students learning along if they experience difficulty *Applied Numerical Methods with MATLAB for Engineers and Scientists* Steven C. Chapra,2023 This book is designed to support a one semester course in numerical methods It has been written for students who want to learn and apply numerical methods in order to solve problems in engineering and science As such the methods are motivated by problems rather than by mathematics That said sufficient theory is provided so that students come away with insight into the techniques and their shortcomings Virtual Element Methods in Engineering Sciences Peter Wriggers,Fadi Aldakheel,Blaž Hudobivnik,2023-10-28 This book provides a comprehensive treatment of the virtual element method VEM for engineering applications focusing on its application in solid mechanics Starting with a continuum mechanics background the book establishes the necessary foundation for understanding the subsequent chapters It then delves into the VEM s Ansatz functions and projection techniques both for solids and the Poisson equation which are fundamental to the method The book explores the virtual element formulation for elasticity problems offering insights into its advantages and capabilities Moving beyond elasticity the VEM is extended to problems in dynamics enabling the analysis of dynamic systems with accuracy and efficiency The book also covers the virtual element formulation for finite plasticity providing a framework for simulating the behavior of materials undergoing plastic deformation Furthermore the VEM is applied to thermo mechanical problems where it allows for the investigation of coupled thermal and mechanical effects The book dedicates a significant portion to the virtual elements for fracture processes presenting techniques to model and analyze fractures in engineering structures It also addresses contact problems showcasing the VEM s effectiveness in dealing with contact phenomena The virtual element method s versatility is further demonstrated through its application in homogenization offering a means to understand the effective behavior of composite materials and heterogeneous structures Finally the book

concludes with the virtual elements for beams and plates exploring their application in these specific structural elements Throughout the book the authors emphasize the advantages of the virtual element method over traditional finite element discretization schemes highlighting its accuracy flexibility and computational efficiency in various engineering contexts

EBOOK: Applied Numerical Methods with MATLAB for Engineers and Scientists Steven Chapra,2011-05-16 Steven Chapra s Applied Numerical Methods with MATLAB third edition is written for engineering and science students who need to learn numerical problem solving Theory is introduced to inform key concepts which are framed in applications and demonstrated using MATLAB The book is designed for a one semester or one quarter course in numerical methods typically taken by undergraduates The third edition features new chapters on Eigenvalues and Fourier Analysis and is accompanied by an extensive set of m files and instructor materials   Numerical Methods in Engineering Gyanendra Nath Pande,J. Middleton,1990   Mathematical Analysis for Engineering and Applied Sciences Hemen Dutta,Ahmet Ocak Akdemir,2025-03-10 The book explores a range of mathematical topics essential for application in engineering and applied sciences It explores both the theoretical and practical aspects providing a comprehensive foundation for the development of robust theories applicable to engineering and applied sciences Mathematical Analysis for Engineering and Applied Sciences Foundational and Fundamental Aspects discusses the essential mathematical principles that underpin the fields of applied science and engineering This comprehensive book explores a blend of pure and applied mathematics demonstrating how mathematical tools and techniques can be utilized to create a wide range of models for practical applications in these disciplines It addresses the challenges of handling complex phenomena and provides algorithms methods and logical concepts that are invaluable for bioengineering cryptosystems surface modeling and various other engineering applications Individual researchers educators students and department libraries will find this book of interest   Computing Methods in Applied Sciences and Engineering R. Glowinski,A. Lichnewsky,1990-01-01 Proceedings of the Ninth International Conference on Computing Methods in Applied Sciences and Engineering Paris France January 29 February 2 1990 T p verso

    Computing Methods in Applied Sciences and Engineering, 1977. Third International Symposium, December 5-9, 1977, IRIA LABORIA, Institut de Recherche d`Informatique et d`Automatique R. Glowinski,J.L. Lions,2006-11-15   Boundary Element Methods in Engineering and Sciences M. H. Aliabadi,P. H. Wen,2011 The boundary element method BEM also known as the boundary integral equation method BIEM is a modern numerical technique It is an established alternative to traditional computational methods of engineering analysis This book provides a comprehensive account of the method and its application to problems in engineering and science   **Numerical Analysis for Applied Science** Myron B. Allen, III,Eli L. Isaacson,2019-04-05 Pragmatic and Adaptable Textbook Meets the Needs of Students and Instructors from Diverse Fields Numerical analysis is a core subject in data science and an essential tool for applied mathematicians engineers and physical and biological scientists This updated and expanded edition of Numerical Analysis for Applied Science follows the tradition of

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