

*Total number of printed pages-8*

**3 SEM PG (CBCS) MTH AEC 2**

**2025**

( December )

**MATHEMATICS**

Paper : MTH AEC 2

**( Scientific Writing and Computation-II )**

*Full Marks : 30*

Time : Two hours

***The figures in the margin indicate  
full marks for the questions.***

1. (a) Write a LaTeX source file that creates a document containing the following components. Include appropriate text under each section and subsection. The entire document must be single-spaced and well-formatted. 10

*Components to be included :*

- (i) **Title Page** : Title : *Numerical Methods and Their Applications*  
Author : Your Name Affiliation :  
Department of Mathematics,  
Dibrugarh University Abstract:

Write a paragraph that presents a comprehensive guide to integrating numerical methods with document preparation using LaTeX, Beamer, and MATLAB. Mention that you demonstrate the solution of linear systems, plotting of polynomials, and 3D surface visualization. State that the document includes complete implementations, numerical results, and discussion of methodological considerations.

(ii) **Table of Contents.**

(iii) **Section 1 : Introduction** Discuss how numerical linear algebra supports many applied problems in engineering, physics, and data science. Emphasize that clear type-setting and documentation improve communication and reproducibility. State that this work integrates numerical computation with professional documentation using LaTeX and Beamer. Mention that you will solve the system  $Ax = b$ , plot mathematical functions, and create 3D visualizations.

(iv) **Section 2 : Preliminaries** Define the following :

• **Definition 1.** A matrix  $A$  is symmetric if  $A = A^T$ .

• **Definition 2.** The residual  $r$  of a computed solution  $\hat{x}$  is  $r = b - A\hat{x}$ .

• **Definition 3.** The condition number  $\kappa(A) = \|A\| \cdot \|A^{-1}\|$  measures sensitivity to numerical errors.

(v) **Section 3 : Methods** Present the theoretical framework for solving a linear system of equations of the form  $Ax = b$ , using direct methods suitable for small dense matrices. State that solution accuracy is verified through residual analysis and eigenvalue examination. Write the key equation :

$$Ax = b$$

Mention the matrix and vector used in the example :

$$A = \begin{bmatrix} 4 & -1 & 0 & 0 \\ -1 & 4 & -1 & 0 \\ 0 & -1 & 4 & -1 \\ 0 & 0 & -1 & 3 \end{bmatrix}, B = \begin{bmatrix} 15 \\ 10 \\ 10 \\ 10 \end{bmatrix}$$

Write that this matrix represents a discretized second-derivative operator with modified boundary conditions.

Include symbolic computation as follows : Write and verify the indefinite integral

$$\int x^2 e^x dx = e^x(x^2 - 2x + 2) + C$$

through symbolic evaluation.

Include one table for the comparison of numerical methods, as shown below :

Method	Residual Norm	Time(seconds)	ConditionNumber
Gaussian elimination	$1.2 \times 10^{-12}$	0.010	2.608
Built-in solver	$5.0 \times 10^{-15}$	0.005	2.608
LU decomposition	$8.7 \times 10^{-14}$	0.008	2.608

Mention that the built-in solver demonstrates superior accuracy and efficiency.

(vi) **Section 4 : Conclusion** Write that the integration of numerical computation with professional documentation has been successfully demonstrated. Mention that the system was solved with machine precision accuracy, polynomial roots were identified and visualized, and 3D surface plots were generated. State that all components were incorporated into a comprehensive LaTeX document.

(vii) **References :** Include the following :

- Smith J. *Numerical Methods for Linear Systems*. Journal of Numerical Analysis, 2020, 45, 100-120.
- Doe J. *Practical MATLAB*. Tech Press, 2018.
- Golub G. H., Van Loan C.F. *Matrix Computations*. 4th edition, Johns Hopkins University Press, 2013.
- Trefethen L. N., Bau D. *Numerical Linear Algebra*. SIAM, 1997.

- (b) Prepare a Beamer presentation based on the article. Slides must be single-spaced, clear, and concise. Submit the Beamer source (.tex) and the PDF. 5

Beamer components to include :

- (i) **Title Slide.** Title of presentation, author name, affiliation, date.
- (ii) **Slide: Introduction.** One short paragraph on objectives and roadmap.
- (iii) **Slide: Preliminaries.** Short definitions : Symmetric matrix, residual, condition number.
- (iv) **Slide: Methods (I).** Present equation  $Ax=b$  and state the example matrix and vector. Display the matrix in readable form.
- (v) **Slide: Methods (II).** Outline the solution approach in numbered steps : prepare data, choose solver, compute solution, verify residual, report results.
- (vi) **Slide: Symbolic Computation.** State the integral  $\int x^2 e^x dx$  and give the simplified result with *one* verification sentence.

- (vii) **Slide: Numerical Results Table.** Present the comparison table with methods, residual norms, times, and condition number. Provide a one-line interpretation.

- (viii) **Slide: References.** List the same references as in the article.

2. Using MATLAB M-files *or* Mathematica, perform the following computational tasks.

Answer *any three* questions. Each carries *equal* marks : 15

- (a) Plot *four* different mathematical functions, such as  $\sin(x)$ ,  $\cos(x)$ ,  $e^{-x}$ , and  $x^2$ , in a single window using a  $2 \times 2$  subplot arrangement. Label each figure with proper titles and axis descriptions.

- (b) Consider a polynomial of degree 4. Plot the polynomial and its first, second and third derivatives on the same graph. Comment on how the turning points of the polynomial correspond to the zeros of its derivative.

- (c) Solve the linear system :

$$3x - y + 2z = 7, \quad 2x + 4y - z = 1, \quad x + y + z = 4$$

Display the solution vector.

(d) Define the function

$f(x) = \sin(x) + 0.5 \sin(3x)$ . Plot it along with its first derivative over the interval  $[0, 2\pi]$ . Mark the points where  $f'(x) = 0$  and interpret their meaning.

(e) Create a 3D surface plot of

$z = \sin(x^2 + y^2)$  over the range

$-3 \leq x, y \leq 3$ . Include a mesh, contour, and color gradient in the visualization.

---