

Syllabus for Semester II (1447-1448 H)

**An Introduction to Numerical Methods and Analysis Using  
MATLAB**

| Chapters                                      | Sections                                                 | subsections                                    | Sub-subsections | Covered in the Lecture |              |
|-----------------------------------------------|----------------------------------------------------------|------------------------------------------------|-----------------|------------------------|--------------|
|                                               |                                                          |                                                |                 | Female section         | Male Section |
| <b>1</b><br>Introduction to Numerical Methods | 1.1 Introduction                                         | 1.1.0.1 Types of Numerical Methods             |                 | ✓                      | ✓            |
|                                               | 1.2 Error Analysis                                       | 1.2.0.1 What is Error                          |                 | ✓                      | ✓            |
|                                               | 1.3 Sources of Errors                                    | 1.3.1 Human Error                              |                 | ✓                      | ✓            |
|                                               |                                                          | 1.3.2 Truncation Error                         |                 | ✓                      | ✓            |
|                                               |                                                          | 1.3.3 Round-off Error                          |                 | ✓                      | ✓            |
| <b>2</b> Solution of Nonlinear Equations      | 2.1 Introduction                                         | 2.1.0.1 Location of Roots                      |                 | ✓                      | ✓            |
|                                               |                                                          | 2.1.0.2 Graphical Method                       |                 | ✓                      | ✓            |
|                                               |                                                          | 2.1.0.3 Method of Tabulation                   |                 | ✓                      | ✓            |
|                                               |                                                          | 2.1.0.4 A Trial Method for Tabulation          |                 | ✓                      | ✓            |
|                                               |                                                          | 2.1.0.5 A Systematic Process for Tabulation    |                 | ✓                      | ✓            |
|                                               |                                                          | 2.1.0.6 Types of Roots of a Nonlinear Equation |                 | ✓                      | ✓            |
|                                               | 2.2 Approximation of Simple Root of a Nonlinear Equation | 2.2.1 Bisection Method                         |                 | ✓                      | ✓            |
|                                               |                                                          | 2.2.2 Fixed-Point Method                       |                 | ✓                      | ✓            |
|                                               |                                                          | 2.2.3 Newton's Method                          |                 | ✓                      | ✓            |
|                                               |                                                          | 2.2.4 Secant Method                            |                 | ✓                      | ✓            |
|                                               | 2.3 Approximation of Multiple Root of                    | 2.3.0.1 Multiplicity of a Multiple Root        |                 | ✓                      | ✓            |
|                                               |                                                          | 2.3.1 First Modified Newton's Method           |                 | ✓                      | ✓            |

|                                                |                                                         |                                                                           |                                                                        |                                |               |
|------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------|--------------------------------|---------------|
|                                                | a Nonlinear Equation                                    | 2.3.2 Second Modified Newton's Method                                     |                                                                        | ✓                              | ✓             |
|                                                |                                                         | 2.3.2.1 Problems with Multiple Roots                                      |                                                                        | ✓                              | ✓             |
|                                                | 2.4 Convergence of Iterative Methods                    | Order of convergence                                                      | Tell only order (without proof) and gives examples                     | ✓                              | ✓             |
|                                                |                                                         | 2.4.1 Convergence of Bisection Method                                     |                                                                        | ✓                              | ✓             |
|                                                |                                                         | 2.4.2 Convergence of Fixed-point Method                                   |                                                                        | ✓                              | ✓             |
|                                                |                                                         | 2.4.3 Convergence of Newton's Method                                      |                                                                        | ✓                              | ✓             |
|                                                |                                                         | 2.4.4 Convergence of the Secant Method                                    |                                                                        | ✓                              | ✓             |
|                                                | 2.5 Systems of Nonlinear Equations                      | 2.5.1 Newton's Method for Solving Nonlinear Systems (of 2 equations only) |                                                                        | ✓                              | ✓             |
| <b>3</b> Systems of Linear Algebraic Equations | 3.1 Introduction                                        |                                                                           |                                                                        | Students Done in M-107 + M-244 | Students      |
|                                                | 3.2 Properties of Matrices and Determinants             |                                                                           |                                                                        |                                | Done in       |
|                                                | 3.3 Solutions of Linear Systems of Equations            |                                                                           |                                                                        |                                | M-107 + M-244 |
|                                                | 3.4 Direct Numerical Methods for Solving Linear Systems | 3.4.1 Gaussian Elimination Method                                         | 3.4.1.1 Simple Gaussian Elimination Method (or Without Pivoting)       | ✓                              | ✓             |
|                                                |                                                         |                                                                           | 3.4.1.2 Inverse of a Matrix by Simple Gaussian Elimination Method      | ✓                              | ✓             |
|                                                |                                                         |                                                                           | 3.4.1.3 Pivoting Strategies Using Gaussian Elimination Method          | ✓                              | ✓             |
|                                                |                                                         |                                                                           | 3.4.1.4 Partial Pivoting                                               | ✓                              | ✓             |
|                                                |                                                         |                                                                           | 3.4.1.5 Inverse of a Matrix by Gauss Elimination with Partial Pivoting | ✓                              | ✓             |
|                                                |                                                         | 3.4.2 Gauss-Jordan Method                                                 | (Discuss only to find inverse of a matrix)                             | No                             | No            |
|                                                |                                                         | 3.4.3 LU Decomposition Method                                             | 3.4.3.1 Doolittle's Method                                             | ✓                              | ✓             |

|                                              |                                                  |                                                             |                                                         |    |    |
|----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------|----|----|
|                                              |                                                  |                                                             | 3.4.3.2 Inverse of a Matrix by using Doolittle's Method | No | No |
|                                              |                                                  |                                                             | 3.4.3.3 Crout's Method                                  | ✓  | ✓  |
|                                              |                                                  |                                                             | 3.4.3.4 Inverse of a Matrix by using Crout's Method     | No | No |
|                                              | 3.5 Norms of Vectors and Matrices                | 3.5.1 Vector Norms                                          | $l-\infty$ norm only                                    | ✓  | ✓  |
|                                              |                                                  | 3.5.2 Matrix Norms                                          | $l-\infty$ norm only                                    | ✓  | ✓  |
|                                              | 3.6 Iterative Methods for Solving Linear Systems | 3.6.1 Jacobi Iterative Method                               |                                                         | ✓  | ✓  |
|                                              |                                                  | 3.6.2 Gauss-Seidel Iterative Method                         |                                                         | ✓  | ✓  |
|                                              |                                                  | 3.6.3 Matrix Forms of Iterative Methods for a Linear System | 3.6.3.1 Jacobi Iterative Method                         | ✓  | ✓  |
|                                              |                                                  |                                                             | 3.6.3.2 Gauss-Seidel Iterative Method                   | ✓  | ✓  |
|                                              |                                                  | 3.6.4 Convergence Criteria of Iterative Methods             | Using Two Sufficient Conditions                         | ✓  | ✓  |
| 4 Polynomial Interpolation and Approximation | 3.7 Errors in Solving Linear Systems             | 3.7.1 Ill-Conditioned Linear Systems                        | Definition and Examples                                 | ✓  | ✓  |
|                                              |                                                  | 3.7.2 Method to Solve Ill-Conditioned System                |                                                         | No | No |
|                                              | 4.1 Introduction                                 |                                                             |                                                         | ✓  | ✓  |
|                                              | 4.2 Polynomial Interpolation                     | 4.2.1 Lagrange Interpolating Polynomials                    | 4.2.1.1 Linear Lagrange Interpolating Polynomial        | ✓  | ✓  |
|                                              |                                                  |                                                             | 4.2.1.2 Quadratic Lagrange Interpolating Polynomial     | ✓  | ✓  |
|                                              |                                                  |                                                             | 4.2.1.3 Cubic Lagrange Interpolating Polynomial         | ✓  | ✓  |
|                                              |                                                  |                                                             | 4.2.1.4 Nth Degree Lagrange Interpolating Polynomial    | ✓  | ✓  |
|                                              |                                                  |                                                             | 4.2.1.5 Uniqueness of Lagrange Interpolating Polynomial | ✓  | ✓  |
|                                              |                                                  |                                                             | 4.2.1.6 Error Formula of Lagrange Polynomial            | ✓  | ✓  |
|                                              |                                                  |                                                             | 4.2.2.1 Divided Differences of a Function               | ✓  | ✓  |

|                                                    |                                         |                                                  |                                                                                  |   |   |
|----------------------------------------------------|-----------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------------|---|---|
|                                                    |                                         | 4.2.2 Newton's General Interpolating Formula     | 4.2.2.2 Linear Newton's Interpolating Polynomial                                 | ✓ | ✓ |
|                                                    |                                         |                                                  | 4.2.2.3 Quadratic Newton's Interpolating Polynomial                              | ✓ | ✓ |
|                                                    |                                         |                                                  | 4.2.2.4 Cubic Newton's Interpolating Polynomial                                  | ✓ | ✓ |
|                                                    |                                         |                                                  | 4.2.2.5 Nth Degree Newton's Interpolating Polynomial                             | ✓ | ✓ |
|                                                    |                                         |                                                  | 4.2.2.6 Newton's Interpolation at Repeated Data Points                           | ✓ | ✓ |
|                                                    | 4.3 Interpolation with Spline Functions | 4.3.1 Piecewise Linear Interpolation             |                                                                                  | ✓ | ✓ |
| <b>5</b> Numerical Differentiation and Integration | 5.1 Introduction                        |                                                  |                                                                                  | ✓ | ✓ |
|                                                    | 5.2 Numerical Differentiation           |                                                  |                                                                                  | ✓ | ✓ |
|                                                    | 5.3 Numerical Differentiation Formulas  | 5.3.0 Differentiation of the Lagrange Polynomial |                                                                                  | ✓ | ✓ |
|                                                    |                                         | 5.3.1 First Derivative Numerical Formulas        | 5.3.1.1 Two-point Formula                                                        | ✓ | ✓ |
|                                                    |                                         |                                                  | 5.3.1.2 Error Term and Error Bound of Two-point Formula                          | ✓ | ✓ |
|                                                    |                                         |                                                  | 5.3.1.3 Three-point Central Difference Formula                                   | ✓ | ✓ |
|                                                    |                                         |                                                  | 5.3.1.4 Error Formula and Error Bound Formula of Central Difference Formula      | ✓ | ✓ |
|                                                    |                                         |                                                  | 5.3.1.5 Three-point Forward and Backward Difference Formulas with Error Formulas | ✓ | ✓ |
|                                                    |                                         | 5.3.2 Second Derivative Numerical Formula        | 5.3.2.1 Three-point Central Difference Formula                                   | ✓ | ✓ |
|                                                    |                                         |                                                  | 5.3.2.2 Error Bound for Three Point Central Difference Formula                   | ✓ | ✓ |
|                                                    | 5.4 Numerical Integration               |                                                  |                                                                                  | ✓ | ✓ |

|                                                                |                                                          |                                                |                                                    |    |    |
|----------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------|----------------------------------------------------|----|----|
|                                                                | 5.5 Closed Newton-Cotes Formulas                         | 5.5.1 Trapezoidal Rule                         | 5.5.1.1 Simple Trapezoidal Rule                    | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.1.2 Composite Trapezoidal Rule                 | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.1.3 Error Terms for Trapezoidal Rule           | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.1.4 Error Bound for Simple Trapezoidal Rule    | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.1.5 Error Term for Composite Trapezoidal Rule  | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.1.6 Error Bound for Composite Trapezoidal Rule | ✓  | ✓  |
|                                                                |                                                          | 5.5.2 Simpson's Rule                           | 5.5.2.1 Simple Simpson's Rule                      | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.2.2 Error Terms for Simpson's Rule             | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.2.3 Error Bound for Simple Simpson's Rule      | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.2.4 Composite Simpson's Rule                   | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.2.5 Error Term for Composite Simpson's Rule    | ✓  | ✓  |
|                                                                |                                                          |                                                | 5.5.2.6 Error Bound for Composite Simpson's Rule   | ✓  | ✓  |
| <b>6</b> Numerical Solution of Ordinary Differential Equations | 6.1 Introduction                                         |                                                | Basic Definitions                                  | ✓  | ✓  |
|                                                                | 6.2 Ordinary Differential Equations                      |                                                |                                                    |    |    |
|                                                                |                                                          | 6.2.1 Classification of Differential Equations | Ordinary Differential Equations                    | ✓  | ✓  |
|                                                                | 6.3 Numerical Methods for Solving Differential Equations |                                                |                                                    |    |    |
|                                                                |                                                          | 6.3.1 Euler's Method                           | Formula and Examples                               | ✓  | ✓  |
|                                                                |                                                          |                                                | 6.3.1.1 Analysis of Euler's Method                 | No | No |
|                                                                |                                                          | 6.3.2 Higher-Order Taylor Methods              | Taylor's Method of Order Two and Three             | ✓  | ✓  |
|                                                                |                                                          | 6.3.3 Second-Order Runge-Kutta Method          |                                                    |    |    |
|                                                                |                                                          |                                                | 6.3.3.1 Modified Euler's Method                    | ✓  | ✓  |

## About the 10 Tutorial Marks

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|------------------------|-----------|
| 1. Computer Assignment | = 2 Marks |
| 2. Two Quizzes         | = 8 Marks |

## Computer Assignment

Write a computer program of the Simple Gauss Elimination Method for Linear Systems (Chapter 3)

## Dates of Midterm and Final Examinations

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|-------------------------|----------|-----------------------------------|-----------------------|
| 1. First Midterm Exam:  | 25 Marks | Wednesday: 13-10-1447(01-04-2026) | Time: 5:00 - 6:30 PM  |
| 2. Second Midterm Exam: | 25 Marks | Wednesday: 19-11-1447(06-05-2026) | Time: 5:00 - 6:30 PM  |
| 3. Final Exam:          | 40 Marks | Wednesday: 02-01-1448(17-06-2026) | Time: 8:00 - 11:00 PM |

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