

TKU212101
Numerical Methods
Metode Numeris

BASIC INFORMATION

Course Credit	3 / 150 minutes per Week
Course Type	Required
Course Classification	Engineering Topics
Prerequisites	Single-Variable & Multi-Variable Calculus; Vector and Matrix Theory; Linear Algebra; Differential Equations; Data Structures & Algorithms

STUDENT AND LEARNING OUTCOMES

Covered Student Outcomes

Development of Engineering Solution (KP.2) Engineering Design (KP.3)

Learning Outcomes

- LO1** Students are able to solve mathematical problems using numerical methods.
- LO2** Students are able to analyze the advantages and disadvantages of different approaches to solve a mathematical problem.

COURSE DESCRIPTION

This course introduces various numerical techniques related to mathematical modelling, including solving linear equations, root solver, eigenproblems, polynomial approximation and interpolation, integration, and differentiation, and differential equations.

TOPICS

1. Basic Tools of Numerical Analysis

- 1.1 Systems of Linear Algebraic Equations
- 1.2 Eigenproblems
- 1.3 Nonlinear Equations
- 1.4 Polynomial Approximation and Interpolation
- 1.5 Numerical Differentiation and Difference Formulas
- 1.6 Numerical Integration

2. Systems of Linear Algebraic Equations

- 2.1 Introduction
- 2.2 Properties of Matrices and Determinants
- 2.3 Direct Elimination Methods
- 2.4 LU Factorization
- 2.5 Tridiagonal Systems of Equations
- 2.6 Pitfalls of Elimination Methods

2.7 Iterative Methods

3. Eigenproblems

3.1 Introduction

3.2 Mathematical Characteristics of Eigenproblems

3.3 The Power Method

3.4 The Direct Method

3.5 The QR Method

3.6 Eigenvectors

3.7 Other Methods

4. Nonlinear Equations

4.1 Introduction

4.2 General Features of Root Finding

4.3 Closed Domain (Bracketing) Methods

4.4 Open Domain Methods

4.5 Polynomials

4.6 Pitfalls of Root Finding Methods and Other Methods of Root Finding

4.7 Systems of Nonlinear Equations

5. Polynomial Approximation and Interpolation

5.1 Introduction

5.2 Properties of Polynomials

5.3 Direct Fit Polynomials

5.4 Lagrange Polynomials

5.5 Divided Difference Tables and Divided Difference Polynomials

5.6 Difference Tables and Difference Polynomials

5.7 Inverse Interpolation

5.8 Multivariate Approximation

5.9 Cubic Splines

5.10 Least Squares Approximation

6. Numerical Differentiation and Difference Formulas

6.1 Introduction

6.2 Unequally Spaced Data

6.3 Equally Spaced Data

6.4 Taylor Series Approach

6.5 Difference Formulas

6.6 Error Estimation and Extrapolation

7. Numerical Integration

7.1 Introduction

7.2 Direct Fit Polynomials

7.3 Newton-Cotes Formulas

- 7.4 Extrapolation and Romberg Integration
- 7.5 Adaptive Integration
- 7.6 Gaussian Quadrature
- 7.7 Multiple Integrals

8. Ordinary Differential Equations

- 8.1 Introduction
- 8.2 General Features of Ordinary Differential Equations
- 8.3 Classification of Ordinary Differential Equations
- 8.4 Classification of Physical Problems
- 8.5 Initial-Value Ordinary Differential Equations
- 8.6 Boundary-Value Ordinary Differential Equations

9. One-Dimensional Initial-Value Ordinary Differential Equations

- 9.1 Introduction
- 9.2 General Features of Initial-Value ODEs
- 9.3 The Taylor Series Method
- 9.4 The Finite Difference Method
- 9.5 The First-Order Euler Methods
- 9.6 Consistency, Order, Stability, and Convergence
- 9.7 Single-Point Methods
- 9.8 Extrapolation methods
- 9.9 Multipoint Methods
- 9.10 Summary of Methods and Results
- 9.11 Nonlinear Implicit Finite Difference Equations
- 9.12 Higher-Order Ordinary Differential Equations
- 9.13 Systems of First-Order Ordinary Differential Equations
- 9.14 Stiff Ordinary Differential Equations

10. One-Dimensional Boundary-Value Ordinary Differential Equations

- 10.1 Introduction
- 10.2 General Features of Boundary-Value ODEs
- 10.3 The Shooting (Initial-Value) Method
- 10.4 The Equilibrium (Boundary-Value) Method
- 10.5 Derivative (and Other) Boundary Conditions
- 10.6 Higher-Order Equilibrium Methods
- 10.7 The Equilibrium Method for Nonlinear Boundary-Value Problems
- 10.8 The Equilibrium Method on Nonuniform Grids
- 10.9 Eigenproblems

REFERENCES

- [1] Joe D. Hoffman, Joe D. Hoffman, Steven Frankel., 2001., Numerical Methods for Engineers and Scientists