TKU212101

Numerical Methods

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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

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