NUMERICAL METHODS

Course Code: 22BM1113

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Course Objectives:
The objective of this course is to familiarize the students with numerical methods of solving the nonlinear equations, interpolation, differentiation, integration, and ordinary differential equations.

Course Outcomes: At the end of the course, the student will be able to:
CO1: calculate a root of algebraic and transcendental equations. Explain the relation between the finite difference operators **(L3).**
CO2: evaluate interpolating polynomial for the given data **(L4).**
CO3: solve ordinary differential equations numerically using Euler's and **RK** methods **(L3).**
CO4: solve numerically the linear system of equations by direct and iterative methods **(L3).**
COS: discuss eigenvalues and eigenvectors of a matrix using different methods **(L2)..**

UNIT-I **10 Lectures**

Solutions of algebraic and transcendental equations and Finite Differences:
Solutions of algebraic and transcendental equations-Introduction, Bisection Method, Regular Falsi Method, Newton Raphson Method (including error analysis). Finite differences, differences of polynomial (Sections 2.1, 2.2, 2.3, 2.5, 3.3 and 3.5 of the textbook)

Learning Outcomes:
At the end of this unit, the student will be able to
1. determine approximate roots of an equation by using different numerical methods (L3)
2. evaluate the missing terms in given tabular data (L5)
3. explain various discrete operators and find the relation among operators (L2)

UNIT-II **10 Lectures**

Interpolation and Numerical Differentiation:
Interpolation: Introduction, Newton's forward difference interpolation, Newton's backward difference interpolation, Lagrange's interpolation and Newton's divided interpolation, Inverse interpolation.
Numerical Differentiation: Introduction, Derivatives using forward difference formula, backward difference formula. (Sections 3.1, 3.6, 3.9.1, 3.10.1, 3.11, 6.2 [excluding 6.2.1 - 6.2.3] of the textbook)

Learning Outcomes:
At the end of this unit, the student will be able
1. apply Newton forward and backward formulas for equal and unequal intervals (L3)
2. describe how to determine values of derivatives of unknown function at the intermediate points with the given data (L2)
3. evaluate an interpolating polynomial for the given tabular data (L5)

UNIT-III **10 Lectures**

Numerical Integration and Numerical solution of Ordinary Differential Equations:

Numerical Integration: Introduction, Trapezoidal rule, Simpson's *1/3rd* rule, Simpson's *3/8th* rules.

Numerical solution of ordinary differential equations: Introduction, Euler's method, Modified Euler method, Runge-Kutta method (Sections 6.4.1, 6.4.2, 6.4.3, 8.1, 8.4, 8.5 of the textbook)

Learning Outcomes:

At the end of this unit, the student will be able to

1. evaluate the area bounded by non-negative functions by using different numerical Methods (L5)
2. determine the solution of an ODE by Euler's method (L3)
3. illustrate the solution of an ODE using R-K method (L4)

UNIT-IV **10 Lectures**

Numerical Linear Algebra -I

Solution of linear Systems (Iterative Methods) - Gauss elimination, Jacobi Iterative method; Gauss Seidel Iterative Method, LU Factorization- Doolittle's Method, Crout's Method; Cholesky's Method.

(Sections 7.5.1, 7.5.6, 7.6(a),(b) of textbook 1)

Learning Outcomes:

At the end of this unit, the student will be able to

1. solve linear simultaneous equations, by using LU Factorization (L3)
2. illustrate the solution of the linear simultaneous equations using iterative methods (L4)
3. explain Doolittle's, Crout's and Cholesky's Methods (L2)

UNIT-V **10 Lectures**

Numerical Linear Algebra -II:

Rayleigh's power method, Gram Schmidt process, QR Factorization of matrices, Singular Value Decomposition, Principal component analysis (Sections 5.8, 6.4, 7.4, 7.5 of textbook 2)

Learning Outcomes:

At the end of this unit, the student will be able to

1. determine orthogonal set of vectors from the given linear independent set of vectors(L3)
2. evaluate largest eigenvalue and eigenvector using Rayleigh's power method (L5)
3. determine singular values and singular vectors (L3)

TEXTBOOKS:

1. S.S. Sastry, *"Introductory Methods of Numerical Analysis"*, 5th edition, Prentice Hall India Pvt. Limited, 2012.
2. David C. Lay, *"Linear Algebra and Its Applications"*, 4th edition, Addison-Wesley, 2012

REFERENCE BOOKS:

1. M.K. Jain, S.R.K. Iyengar and R.K.Jain, *"Numerical Methods for Scientific and Engineering Computation"*, 4th edition, New Age International (P) Limited, Publishers, 2004
2. Samuel Daniel Conte, Carl W. De Boor, *"Elementary Numerical Analysis: An Algorithmic Approach"*, 3rd edition, McGraw- Hill, 2008.
3. Gilbert Strang, *"Introduction to Linear Algebra"*, 5th edition, Wellesely- Cambridge Press, 2016