



RAMAIAH
Institute of Technology

Department of Mathematics



Open elective Syllabus

(Academic year 2025-26 onwards)

Ramaiah Institute of Technology
(Autonomous Institute, Affiliated to VTU)
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Linear Algebra and Applications

Course code: MAOE01

Course Credits: 3:0:0

Course Coordinator: Dr. A Sreevallabha Reddy

Contact hours: 45

Course contents

Unit – I

Matrices and Linear Equations: Matrices, Vectors and Linear Equations; Rules for Matrix Operations, Geometric interpretation of solution of linear equations, Inverse matrices, Gauss Jordan and Gauss elimination methods, Factorization $A = LU$, Applications to Electric Circuits, Graphs, Cryptography and Curve Fitting

Unit – II

The Four Fundamental Subspaces: Linear combinations of vectors, Linear independence of vectors, Vector spaces, Basis and dimension, The Null space of A , Solving $Ax=0$, $Ax=b$, $Ux=c$ and $Rx=d$. The Four Fundamental Subspaces; Bases, dimensions and orthogonality of the Four Subspaces

Unit – III

Projections and Least Squares Approximation: Projections, Orthonormal bases and Gram-Schmidt method, Factorization into $A = QR$, Least squares approximations, Determinants, Permutations and cofactors, Cramer's rule, Applications to inverse and volumes

Unit – IV

Linear Transformations and Hermitian Matrices: Fundamentals, Matrices of linear transformation, Rotation, Reflection, Dilation and contraction, Co-ordinate vectors and change of basis, Eigenvalues and Eigenvectors, Complex matrices, Hermitian and Unitary matrices, Similarity and diagonalization

Unit – V

Singular Value Decomposition: Symmetric matrices, Diagonalization of symmetric matrices, Quadratic forms and conic sections, Singular Value Decomposition (SVD), Principal Component Analysis (PCA), Applications to Constrained optimization, Linear recurrence relations, Markov chains

Text Books:

1. **Gilbert Strang** - Linear Algebra and its Applications, CENGAGE Learning, 5th edition, 2016.
2. **David C Lay** - Linear Algebra and its Applications, Pearson, 5th edition, 2015.

Reference Books:

1. **Edgar Goodaire**, Contents of ,Linear Algebra: Pure and Applied, World Scientific Publishers (2013)
2. **Sheldon Axler**, Linear Algebra Done Right, Springer International Publication, Third Edition (2015).

Course Outcomes:

At the end of the course the student will be able to

1. Solve systems of linear equations using multiple methods, including Factorization $A=LU$, inversion and matrix operations. **(PO-1,2)**
2. Demonstrate understanding of the concepts of vector space and subspace. **(PO-1,2)**
3. Demonstrate understanding of Gram-Schmidt technique and linear transformation. **(PO-1, 2)**
4. Determine eigenvalues, eigenvectors and solve eigenvalue problems. **(PO-1,2)**
5. Understand the PCA by SVD. **(PO-1,2)**

Applied Number Theory

Course code: MAOE02

Course Credits: 3:0:0

Course Coordinator: Dr. Y S Kalyan Chakravarthy

Contact hours: 45

Course Objectives:

The student will

1. Learn to solve greatest integer function, divisibility, greatest common divisor, least common multiple of numbers, Prime counting function.
2. Learn to evaluate congruences, linear congruences, linear Diophantine equations and Pythagorean equations.
3. Learn to solve Dirichlet product, Dirichlet inverse, Moebius function and Euler's theorem.
4. Learn to evaluate the existence of primitive roots and to obtain the solution of Quadratic Congruences.
5. Learn to encipher the cipher text using different cipher techniques.

Course contents:

Unit-I

Divisibility: Introduction, divisibility, greatest common divisor, least common multiple. Euclid's algorithm, divisor via Euclid's algorithm.

Primes: Introduction, primes, prime counting function, prime number theorem, test of primality by trial division. Sieve of Eratosthenes, canonical factorization, Fundamental theorem of arithmetic.

Unit-II

Congruences: Introduction, congruences and equivalence relations, linear congruences, linear Diophantine equations and the Chinese remainder theorem, modular arithmetic, Fermat's theorem, Wilson's theorem and Fermat numbers. Pythagorean equations.

Unit-III

Arithmetic Functions: Introduction, sigma function, tau function, Dirichlet product, Dirichlet inverse, Moebius function, Euler's function, Euler's theorem, an application to algebra.

Unit-IV

Primitive Roots: Introduction, definition and properties of primitive roots, existence of primitive roots, Indices.

Quadratic Congruences: Introduction, Quadratic residues and the Legendre symbol, Gauss lemma and the Law of Quadratic Reciprocity, solution of Quadratic Congruences.

Unit-V

Applications to Cryptography: Introduction, Affine Ciphers, Caesar Cipher, Shift Ciphers, Affine Ciphers, Hill Ciphers, Exponentiation Ciphers. Introduction to RSA Cryptosystem and examples.

Text Books:

1. **Thomas Koshy**, Elementary Number Theory with Applications, 2nd edition (2008).
2. **David M Burton**, Elementary Number Theory, Tata McGrawHill Publications, 7th edition (2017).
3. **Neal Koblitz**, A Course in Number Theory and Cryptography, Springer-Verlag New York (1994).

Reference Books:

1. **Tom M Apostol**, Introduction to Analytic Number Theory, Springer (2010).
2. **Gareth A. Jones and J. Mary Jones**, Elementary Number Theory, Springer, 8th edition (2005).

Course Outcomes:

At the end of the course the student will be able to

1. Understand the concepts of divisibility, greatest common divisor, primes and prime factorization. **(PO-1,2)**
2. Understand the concepts of congruences, linear congruences, linear Diophantine equations, Fermat's theorem, Wilson's theorem and Fermat numbers. **(PO-1,2)**
3. Apply the concepts sigma function, Dirichlet product, Dirichlet inverse, Euler's function and Euler's theorem to algebra. **(PO-1,2)**
4. Analyze the importance of primitive roots, existence of primitive roots, Quadratic residues and the Legendre symbol, Gauss lemma and the Law of Quadratic Reciprocity. **(PO-1,2)**
5. Apply the concepts of different ciphering techniques to decipher the cipher text. **(PO-1,2)**

Numerical Methods with Python

Course code: MAOE03

Course Credits: 3:0:0

Course Coordinator: Dr. B. Azghar Pasha

Contact hours: 45

Course Objectives:

The student will learn

1. The technique of solving algebraic and transcendental equations numerically
2. The concept of interpolation, differentiation and integration of a tabulated data.
3. To solve the linear, non-linear and tridiagonal system of equations and find Eigenvalues and Eigenvectors of a given square matrix.
4. The technique of solving IVP's and BVP's numerically.
5. The finite difference method to solve PDE's.

Course contents

Unit-I

Numerical solution of Algebraic and Transcendental equations: Review of Bisection, Regula-Falsi and Newton-Raphson techniques. Fixed point iteration method, Geometrical interpretation of spiral and stair-case Convergence/divergence of fixed-point iteration method. Ramanujan's method, Aitken's Δ^2 method, Horner's method, Grafee's root squaring method, Birge-Vieta method & Bairstow's method.

Python: Introduction to Python, Programming with Python and problem solving.

Unit-II

Interpolation: Hermite and cubic spline interpolation, Bivariate Interpolation-Lagrange's bivariate interpolation, Newton's bivariate interpolation for equispaced data.

Numerical differentiation: Derivatives using forward and backward differences up to error of second order and central differences up to error of fourth order.

Numerical integration: Richardson extrapolation, Romberg integration, Gaussian quadrature, Double integration by Trapezoidal and Simpson's $(1/3)^{rd}$ rules.

Python: Problem solving.

Unit-III

Solution of System of equations: Introduction to ill conditioned and well behaved system of equations. Solution of system of equations using LU factorization method, Partition method. Solution of Tridiagonal systems.

Eigen values and Eigenvectors: Bounds for Eigen values, Gerschgorin's circle theorem, Jacobi's method, Given's method, Rutishauser method.

Python: Problem solving.

Unit-IV

Numerical solutions of ODE: Introduction to the numerical solution of first order ODE. Picard's method of Successive approximations for first order, simultaneous and second order IVP's. Taylor's series method for simultaneous first order ODE's and second order ODE's, Runge-Kutta method for simultaneous first order ODE's and second order ODE's. Solution of boundary value problems using finite difference method and linear shooting method.

Python: Problem solving.

Unit-V

Solution of PDE's using Finite difference method: Solution of one dimensional heat equation using Schmidt method and Crank Nicolson method. Explicit method for one dimensional wave equations, Von – Neumann stability of finite difference methods for wave and diffusion equations. Numerical solution of two dimensional Laplace and Poisson equations. Numerical solutions of two dimensional wave equation by ADE method, Numerical solution of two dimensional heat equation by ADE/ADI method.

Python: Problem solving

Text Books:

1. **Richard. L. Burden, J. Douglas Faires, Annette M. Burden**, Numerical Analysis, Brooks Cole, 10th edition, 2015.
2. **M.K. Jain, S.R.K. Iyengar and R.K. Jain**, Numerical methods for scientific and Engineering computation, New Age International Publisher, 6th edition, 2012.

Reference Books:

1. **Anthony Ralston, Philip Rabinowitz**, A first course in Numerical Analysis, McGraw Hill Publication, 2nd edition, 2001.
2. **B.S Grewal**, Numerical Methods in Engineering and Science with programs in C, C++ & MATLAB, Khanna Publishers, 11th edition, 2013.
3. **Steven C. Chapra**, Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw Hill Publications, 3rd edition, 2011.

Course Outcomes

On completion of this course, students will have the improved ability to

1. Determine roots of algebraic and transcendental equations. **(PO-1,2)**
2. Interpolate, differentiate and integrate a function for a given set of tabulated data. **(PO-1,2)**
3. Solve the system of equations and find eigenvalues and eigenvectors. **(PO-1,2)**
4. Solve the initial and boundary value problems. **(PO-1,2)**
5. Solve PDE's arising in science and engineering using finite difference method. **(PO-1,2)**

Applied Graph Theory

Course code: MAOE04

Course Credits: 3:0:0

Course Coordinator: Dr. B. Azghar Pasha

Contact hours: 45

Course Objectives:

The student will learn

1. The basic definitions and types of graphs and the properties associated with them
2. The concepts of spanning trees and planarity
3. Matrix representation of graphs and properties
4. The concepts of Directed graphs, Euler digraphs, Hamiltonian digraphs and tournaments
5. The application of graph theory in Engineering and Science.

Course Contents

Unit-I

Introduction to Graph Theory: Basic concepts of graphs, types of graphs, graph isomorphism, connected & disconnected graphs, Operations on Graphs, Euler graphs, Hamiltonian Paths and Circuits. Trees, properties of trees, Rooted & Binary Trees.

Unit-II

Spanning trees, Connectivity and Planarity: Spanning trees, fundamental circuits, Cut Sets & properties, Fundamental Cut Sets, Connectivity and Separability. Planar graphs: basic concepts & detection of planarity. Vertex and map coloring.

Unit-III

Matrix Representation of Graphs: Incidence Matrix, Reduced incidence matrix, Circuit Matrix, Fundamental Circuit Matrix, Cut-Set matrix, Fundamental cut-set matrix, Relationships among A_f , B_f , C_f . Path Matrix, Adjacency Matrix.

Directed Graphs: Basic concepts and types of directed graphs, Digraphs and binary relations, Directed paths and connectedness, trees with directed edges, Matrix representation of digraphs.

Unit-IV

Applications of Graph Theory-01: Travelling salesman problem, Seating arrangement problem, Breadth-first search, Depth-first search algorithms, Kruskal's and Prim's algorithms for minimal spanning tree, Dijkstra's algorithm, Bellman Ford Algorithm, Job sequencing problems.

Unit-V

Applications of Graph Theory-02: Prefix codes, Optima prefix codes. Electrical network analysis by graph theory, Graph theory in operations research: Transport networks, Max-flow min-cut theorem (No proof), Graphs in contact networks, Graph theory in Markov Processes: Multi step Transition Probabilities.

Text Books:

1. **Narsingh Deo** - Graph theory with Application to Engineering and Computer science, PHI Learning Private Limited, 2010.
2. **Harary, F.** - Graph Theory. Addison - Wesley, Reading, Mass, 1969.

Reference Books:

1. **J. A. Bondy and U.S.R. Murty** - Graph theory, Springer, 2008.
2. **R. Diestel**, Graph theory, 5th edition, Springer, 2017.

Course Outcomes

Students will be able to

1. Analyze various types of graphs and determine the existence of Euler line, Hamiltonian path & circuits. **(PO-1,2)**
2. Apply the graph theoretic algorithms to determine the minimal spanning tree **(PO-1,2)**
3. Analyze characteristics of a graph through its matrix representations **(PO-1,2)**
4. Determine strong connectedness of graphs using the properties of digraphs **(PO-1,2)**
5. Apply the concepts of graph theory to solve Engineering and Science problems **(PO-1,2)**