

**SHAILABALA WOMEN'S (AUTONOMOUS) COLLEGE
CUTTACK**









**SYLLABUS FOR
UNDER GRADUATE
COURSE IN MATHEMATICS
(BACHELOR OF ARTS EXAMINATION)**

**2023-2024
(ADMISSION BATCH)**

UNDER CHOICE BASED CREDIT SYSTEM

**MAPPING OF
COURSES WITH LOCAL, NATIONAL, REGIONAL AND
GLOBAL NEEDS**

Mapping color index:

	Local
	National
	Regional
	Global
	Local, National
	National, Regional, Global

PROGRAM OUTCOME OF MATHEMATICS

Each graduate in mathematics should be able to demonstrate fundamental systematic knowledge of mathematics and its applications in engineering, science, technology and mathematical sciences. It should also enhance the subject specific knowledge and help in creating jobs in various sectors.

PO-1: DISCIPLINARY KNOWLEDGE:

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate programme of study. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

PO-2: COMMUNICATIONS SKILLS:

- i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
- ii. Ability to use mathematics as a precise language of communication in other branches of human knowledge.
- iii. Ability to communicate long standing unsolved problems in mathematics.
- iv. Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.
- v. Ability to explain the development of mathematics in the civilizational context and its role as queen of all sciences.
- vi. Demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.

PO-3: CRITICAL THINKING AND ANALYTICAL REASONING:

- i. Ability to employ critical thinking in understanding the concepts in every area of mathematics.
- ii. Ability to analyze the results and apply them in various problems appearing in different branches of mathematics.
- iii. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.

PO-4: PROBLEM SOLVING:

- i. Capability to solve problems in computer graphics using concepts of linear algebra.
- ii. Capability to solve various models such as growth and decay models, radioactive decay model, drug assimilation, LCR circuits and population models using techniques of differential equations.
- iii. Ability to solve linear system of equations, linear programming problems and network flow problems. Ability to provide new solutions using the domain knowledge of Mathematics acquired during this program.
- iv. Apply knowledge, understanding and skills to identify the difficult/unsolved problems in mathematics and to collect the required information in possible range of sources and try to analyse and evaluate these problems using appropriate methodologies.

PO-5: RESEARCH-RELATED SKILLS:

- i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
- ii. To know about the advances in various branches of mathematics.
- iii. Fulfil one's learning requirements in mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences

PO-6: INFORMATION/DIGITAL LITERACY:

- i. Capability to use appropriate software to solve system of equations and differential equations.
- ii. Capability to understand and apply the programming concepts of C++ to mathematical investigations and problem solving.

PO-7: Self-directed learning:

Ability to work independently and do in-depth study of various notions of mathematics. Apply one's disciplinary knowledge and skills in mathematics in newer domains and uncharted areas. Identify challenging problems in mathematics and obtain well-defined solutions.

PO-8: Moral and ethical awareness/reasoning:

Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

PO-9: Lifelong learning:

Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning. exhibit subject-specific transferable

knowledge in mathematics relevant to job trends and employment opportunities. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.

PO-10: Employability and Higher Study:

It also provides an enthusiasm of students to the best of their potential in the higher studies.

PROGRAMME SPECIFIC OUTCOME

After successful completion of three-year degree program in Mathematics a student should be able to:

PSO-1: Students undergoing this programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others.

PSO-2: This helps them to learn behave responsibly in a rapidly changing interdependent society. Students undergoing this programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

PSO-3: Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.

PSO-4: Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.

PSO-5: This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

COURSE STRUCTURE FOR MATHEMATICS HONORS

Semester	Course	Course Name	Credits
I	AECC-I	AECC-I	04
	C-I	Calculus – I (P)	04
	C-I	Practical	02
	C-II	Algebra - I	05
	C-II	Tutorial	01
	GE-I	GE-I	05
	GE-I	Tutorial	01
II	AECC-II	AECC-II	04
	C-III	Real Analysis (Analysis – I)	05
	C-III	Tutorial	01
	C-IV	Differential equations (P)	04
	C-IV	Practical	02
	GE-II	GE-II	05
	GE-II	Tutorial	01
III	C-V	Theory of Real functions (Analysis – II)	05
	C-V	Tutorial	01
	C-VI	Group Theory (Algebra-II)	05
	C-VI	Tutorial	01
	C-VII	Partial differential equations and systems of ODEs (P)	04
	C-VII	Practical	02
	GE-III	GE-III	05
	GE-III	Tutorial	01
	SEC-I	SEC-I	04
			28
Semester	Course	Course Name	Credits
IV	C-VIII	Numerical Methods (P)	04
	C-VIII	Practical	02

	C-IX	Riemann Integration and Series & Functions (Analysis – III)	05
	C-IX	Tutorial	01
	C-X	Ring Theory and Linear Algebra (Algebra-III)	05
	C-X	Tutorial	01
	GE-IV	GE-IV (Theory)	05
	GE-IV	Tutorial	01
	SEC-II	SEC-II	04
			28
V	C-XI	Multivariate Calculus (Calculus-II)	05
	C-XI	Tutorial	01
	C-XII	Programming in C++	04
	C-XII	Practical	02
	DSE-I	Discrete Mathematics	05
	DSE-I	Tutorial	01
	DSE-II	Number Theory	05
	DSE-II	Tutorial	01
			24
Semester	Course	Course Name	Credits
VI	C-XIII	Metric spaces and Complex analysis (Analysis –IV)	05
	C-XIII	Tutorial	01
	C-XIV	Linear Programming	05
	C-XIV	Tutorial	01
	DSE-III	Differential Geometry	05
	DES-III	Tutorial	01
	DES-IV	Project	06
			24
		TOTAL	148

B.A./B.SC.(HONOURS)-MATHEMATICS

HONOURS PAPERS:

Core course – 14 papers

Discipline Specific Elective – 4 papers (out of the 5 papers suggested)

Generic Elective for Non Mathematics students – 4 papers. In case University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper.

Marks per paper –

For practical paper: Midterm : 15 marks, End term : 60 marks, Practical- 25 marks

For non practical paper: Midterm : 20 marks, End term : 80 marks

Total – 100 marks Credit per paper – 6

Teaching hours per paper –

Practical paper-40 hour theory classes + 20 hours Practical classes

Non Practical paper-50 hour theory classes + 10 hours tutorial

CORE PAPER - I
CALCULUS
Core-I, Calculus-I (Total Marks: 100)
Part-I (Marks:75)
(Theory 60 Marks + Mid-Sem: 15 Marks)

CO-1:

- ❖ After completing the course, students are expected to be able to use Leibnitz's rule to evaluate derivatives of higher order.

CO-2:

- ❖ Learn the geometry of various types of functions its curvature and asymptotes & able to trace curve of cartesian curve, polar curve.

CO-3:

- ❖ Evaluate the area, volume using the techniques of integrations and gain details about conic and how to sketch conic.

CO-4:

- ❖ Able to identify the difference between scalar and vector, acquired knowledge on some the basic properties of vector functions and its limit, Continuity and derivative.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	2	3	3	2	3	3	2	2
CO3	3	3	3	3	3	3	3	3	3	2
CO4	3	3	2	3	3	3	3	3	3	2
C05	3	2	2	3	2	2	3	2	3	2

Unit - I

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of the type $e^{ax+b} \sin x, e^{ax+b} \cos x, (ax + b)^n \sin x, (ax + b)^n \cos x$
 Derivative of Arcs, Curvature, Asymptotes, Curve Tracing, indeterminate form using L Hospitals rule.

Unit - II

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx, \int \cos^n x dx, \int \tan^n x dx, \int \cot^n x dx, \int \sec^n x dx, \int \operatorname{cosec}^n x dx, \int \log^n x dx,$

$\int \sin^p x \cos^q x dx$, Rectification, Quadrature, Volumes and Surface Area of revolution.

Unit - III

Conics, Reflection properties of conics, rotation of axes and second-degree equations, classification into conics using the discriminated, polar equations of conics.

Unit - IV

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, gradient, Divergence and Curl.

Part - II (Practical, Marks: 25)

List of Practical's (Using any software) Practical / Lab work to be performed on a computer.

1. Plotting the graphs of the functions e^{ax+b} and illustrate the effect of a and b on the graph.
2. Plotting the graphs of the functions $\log(ax+b)$ and illustrate the effect of a and b on the graph.
3. Plotting the graphs of the functions $\frac{1}{ax+b}$ and illustrate the effect of a and b on the graph.
4. Plotting the graphs of the functions $\sin(ax+b)$ and illustrate the effect of a and b on the graph.
5. Plotting the graphs of the function's $\cos(ax+b)$ and illustrate the effect of a and b on the graph.
6. Plotting the graphs of the functions $|ax+b|$ and illustrate the effect of a and b on the graph.
7. Tracing of the conic Parabola.
8. Tracing of the conic Hyperbola.
9. Tracing of the conic Ellipse.

Books Recommended:

1. Text Book of Calculus, Part-II - Shanti Narayan, S. Chand & Co. Ch-8,10 (33-37), 6
2. Text Book of Calculus, Part-III-Shantinarayan, S. Chand & Co. Ch-1 ,3,5,6. (15 restricted)
3. Higher Calculus -I, G. Samal, S. Jena and T. Biswal, Vidyapuri Publication, Chapter: 1,2,7 18,19 and 20

Books for Reference:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
3. Shanti Narayan and P.K. Mittal-Analytical Solid Geometry, S. Chand & Company Pvt. Ltd., New Delhi.

CORE PAPER - II

Algebra - I

Total Marks: 100 Theory: 80 Marks + Mid - Sem: 20 Marks

5 Lectures, 1 Tutorial (Per week)

CO-1:

- ❖ Introduction to complex analysis. Understand the importance of roots of real and complex polynomials and learn various methods of obtaining roots. Employ De Moivre's theorem in a number of applications to solve numerical problems

CO-2:

- ❖ Familiarize with relations, equivalence relations and partitions.
- ❖ Gain knowledge about integer, divisibility, Congruence, Prime.

CO-3:

- ❖ Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix.
- ❖ Learn basic about vector space, Linear Independence & Dependence and Rank & Linear Transformation of Vector Space.

CO-4:

- ❖ Find eigenvalues and corresponding eigenvectors for a square matrix. Rank

nullity of Matrix and its properties

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	3	2	2	3
CO2	2	3	2	3	3	2	3	3	2	3
CO3	3	3	3	3	3	2	2	3	2	2
CO4	2	2	3	2	2	3	3	2	3	3
C05	3	2	2	3	2	3	3	2	3	2

Unit-I

Polar representation of complex numbers, nth root of unity, Demoivre's theorem for rational indices and applications

Unit-II

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Unit-III

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation $Ax = b$, solution sets of linear systems, applications of linear systems, linear independence.

Unit-IV

Introduction to linear transformations matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n , dimension of subspaces of R^n and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

Books Recommended:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006. Chapter:2

2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005. Chapters:2(2.4), 3, 4(4.1 (4.1.1 – 4.1.6), 4.2 (4.2.1 – 4.2.12), 4.3 (4.3.9), 4.4 (4.4.1 – 4.4.9)), 5 (5.1 (5.1.1 – 5.1.4 excluding Mathematical Induction and well ordering).
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007. Chapters:1(1.1-1.9), 2(2.1-2.3, 2.8, 2.9), 5(5.1,5.2)

Semester –II
CORE PAPER – III

Real Analysis (Analysis-I)

Total Marks: 100 Theory: 80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (Per week)

This course will enable the students to:

CO-1:

- ❖ Comprehend rigorous arguments developing the theory underpinning real analysis.
- ❖ Understand many properties of the real line \mathbb{R} and learn to define sequence in terms of functions from \mathbb{R} to a subset of \mathbb{R} .

CO-2:

- ❖ Learn Countability of set and Interval in \mathbb{R} . Density and Archimedean property of Field.

CO-3:

- ❖ Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

CO-4:

- ❖ Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	2	3	3	3	3	2	3	3	3	2
CO3	3	3	2	3	3	2	2	3	3	2
CO4	3	2	3	2	3	3	3	3	3	3
C05	3	2	2	3	3	2	3	3	3	2

Unit-I

Review of Algebraic and Order Properties of \mathbb{R} , Neighborhood of a point in \mathbb{R} , bounded above sets, bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima. The Completeness Property of \mathbb{R}

Unit-II

The Archimedean Property, Density of Rational (and Irrational) numbers in \mathbb{R} ,

Intervals. Idea of countable sets, uncountable sets and uncountability of \mathbb{R} .

Unit-III

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion. Limit superior, limit inferior

Unit-IV

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy n-th root test, Integral test.

Book Recommended:

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, TMH Publishing Co. Chapters: 2(2.1 to 2.4, 2.6), 3(3.1-3.4), 4(4.1 to 4.7, 4.10, 4.11)

Books for References:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
4. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.
5. S.C. Mallik and S. Arora-Mathematical Analysis, New Age International Publications.
6. D. Smasundaram and B. Choudhury-A First Course in Mathematical Analysis, Narosa Publishing House.
7. S.L. Gupta and Nisha Rani-Real Analysis, Vikas Publishing House Pvt. Ltd., New Delhi.

CORE PAPER – IV
Differential Equations (Total Marks:100)
Part-I(Marks:75)
Theory:60 Marks+ Mid-Sem:15 Marks
04 Lectures (per week)

The course will enable the students to:

CO-1:

- ❖ Understand the genesis of ordinary differential equations and its types, order & degree & formulation of ODE.
- ❖ Learn various techniques of getting exact solutions of solvable first order differentialequations and linear differential equations of higher order.

CO-2:

- ❖ Learn how to handle linear differential equation with constant coefficient and variable coefficient & know how to solve series solution of special function.

CO-3:

- ❖ Learn to handle power series solution of second order ODE.

CO-4:

- ❖ Learn The Laplace Transformation, its properties and inverse of Laplace Form.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	3	2	2	3
CO2	2	3	2	3	3	2	3	3	2	2
CO3	2	3	3	3	2	2	2	3	2	2
CO4	3	3	3	2	2	3	3	3	3	3
C05	3	2	2	3	2	2	3	2	3	2

Unit-I

Differential equations and mathematical models. First order and first degree ODE (variables separable, homogeneous, exact, and linear). Equations of first order but of higher degree.

Unit-II

Second order linear equations(homogeneous and non-homogeneous) with constant coefficients, variation of parameters, method of undetermined coefficients, equations reducible to linear equations with constant coefficients, Euler's equation.

Unit-III

Second order equations with variable coefficients Power series solutions of second order differential equations.

Unit-IV

Laplace transforms and its applications to solutions of differential equations.

Part-II (Practical: Marks:25)

List of Practicals (Using any Software) Practical/Lab work to be performed on a Computer.

1. Growth model (exponential case only).
2. Decay model (exponential case only)
3. Oxygen debt model
4. Economic model-1
5. Economic model-2
6. Vibration problems

Book Recommended:

1. J. Sinha Roy and S. Padhy, A Course of Ordinary and Partial Differential Equations, Kalyani Publishers, New Delhi. Chapters: 1, 2(2.1 to 2.7), 3, 4(4.1 to 4.8), 5, 7(7.1-7.3.1), 9 (9.1-9.6, 9.10, 9.11, 9.13 (excluding 9.13.1)).

Books for References:

1. Martin Braun, Differential Equations and their Applications, Springer International.
2. M.D. Raisinghania-Advanced Differential Equations, S. Chand & Company Ltd., New Delhi.
3. G. Dennis Zill-A First Course in Differential Equations with Modeling Applications, Cengage Learning India Pvt. Ltd.

Semester – III

CORE PAPER –V

Theory of Real Functions (Analysis –II)

Total Marks: 100 Theory: 80 Marks + Mid-Sem: 20 Marks

5 Lectures,

1 Tutorial (per week)

CO-1:

- ❖ Understand limits and their use in sequences, series. Continuity & Discontinuity - Continuity of function and their properties & theorem based on limit.

CO-2:

- ❖ Student will be to understand Differentiation and Fundamental Theorem in Differentiation and various rules.

CO-3:

- ❖ Geometrical representation and problem solving on MVT, Rolle's theorem, Cauchy theorem.

CO-4:

- ❖ Expansion of a function using Taylor series and Mac-Laurine Series.
- ❖ Finding extreme values of function of one variable.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	3	3	3	3	3	3
CO2	3	2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	2	2	3	2	3
CO4	3	2	3	2	2	3	3	3	3	3
CO5	3	3	2	3	2	2	3	2	3	2

Unit-I

Limits of functions (ϵ - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity, Algebra of continuous functions.

Unit-II

Composition of continuous functions. Bounded function, Discontinuity, Continuous functions on an interval, intermediate value theorem, Preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity

theorem.

Unit-III

Differentiability of a function at a point and in an interval, algebra of differentiate functions. Rolles theorem, Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Taylors theorem to inequalities.

Unit-IV

Cauchys mean value theorem. Taylors theorem with Lagranges form of remainder, Taylors theorem with Cauchys form of remainder, application of Taylors theorem to convex functions, relative extreme. Taylors series and Maclaurins series expansions of exponential and trigonometric functions In $(1 + x)$, $1/(ax + b)$ and $(1 + x)^n$.

Book Recommended:

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, TMH Publishing Co., Chapters:6(6.1-6.9),7(7.1-7.7),

Books for References:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and BV Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

CORE PAPER - VI Group Theory (Algebra-II)

Total Marks:100 Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

CO-1:

- ❖ Recognize the Mathematical objects called groups.
- ❖ Link the fundamental concepts of groups and symmetries of geometrical objects.
- ❖ Generate groups using given Specific Conditions, Order of Group, Order of

Elements in Group & Different Properties of Group.

- ❖ Learn About Subgroup and Test of Subgroup, Centre and Centralizer of Group.

CO-2:

- ❖ Learn about Special Types of Groups Such as Abelian Group, Cyclic Group Symmetry Group, Permutation Groups.

CO-3:

- ❖ Explain the significance of the notions of cosets, normal subgroups, and factor groups.
- ❖ Analyze consequences of Lagrange's theorem. Learn about structure preserving maps between groups and their consequences.

CO-4:

- ❖ Detail Study on Group Homomorphism & Group Isomorphism.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	2	3	2	3	3	2	2	3
CO2	3	2	2	2	3	2	3	3	3	2
CO3	3	2	2	3	3	3	2	3	3	3
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit - I

Definitions and examples of groups including permutation groups. Elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

Unit - II

Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, properties of cosets, Lagranges theorem and consequences including Fermats Little theorem.

Unit - III

Normal subgroups, factor groups, Cauchys theorem for finite abelian groups.

Unit - IV

Group homomorphisms, properties of homomorphisms, Cayleys theorem, properties

of isomorphisms, First, Second and Third isomorphism theorems (Statement only)

Book Recommended:

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.Ch-2(2.1-2.7,2.9, 2.10)

Books for References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
4. Joseph A. Gallian, Contemporary Abstract Algebra(4th Edn.), Narosa Publishing House, New Delhi

CORE PAPER - VII

**Partial Differential Equations and Systems of Ordinary Differential Equations
(Total Marks : 100)**

Part - I(Marks:75)

Theory:60 Marks+Mid-Sem:15 Marks

04 Lectures (per week)

CO-1:

- ❖ Learn about basic of PDE and its Order & Degree. Procedure to formulate PDE and its Working Rules to Solve the PDE using Pfaffian methods.

CO-2:

- ❖ A Student will be able to take more Courses Non-Linear partial differential equations of first order.

Co-3:

- ❖ Learn to solve linear PDE with constant coefficient (reducible/irreducible) and both homogeneous and non-homogeneous category.

Co-4:

- ❖ Learn to solve $Rr + Ss + Tt = V$ type PDE by using Monge's Method and Laplace Equation.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	3	2	2	3
CO2	3	2	3	3	3	2	3	3	3	2
CO3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	2	3	3	3
C05	3	3	2	3	2	3	3	2	3	2

Unit-I

Simultaneous linear first order equations in three variables, methods of solution, Pfaffian differential equations, methods of solutions of Pfaffian differential equations in three variables.

Unit-II

Formation of first order partial differential equations, Linear and non-linear partial differential equations of first order, special types of first-order equations, Solutions of partial differential equations of first order satisfying given conditions.

Unit-III

Linear partial differential equations with constant coefficients, Equations reducible to linear partial differential equations with constant coefficients, Partial differential equations with variable coefficients. Monge's method of integrating $Rr+Ss+Tt=V$ form.

Unit-IV

System of linear differential Equation, Laplace equation, Solution of Laplace equation by separation of variables.

Part-II (Practical: Marks:25)

List of Practicals (Using any Software) Practical/Lab work to be performed on a Computer.

1. To find the general solution of a first order linear PDE.
2. To find the general solution of Cauchy problem for a first order PDE
3. To find the general solution of a homogeneous system of the form

$$\frac{dx}{dt} = a_1x + b_1y, \frac{dy}{dt} = a_2x + b_2y.$$

4. To find the general solution of the non-homogeneous system of the form:

$$\frac{dx}{dt} = a_1x + b_1y + f_1(t) \quad \frac{dy}{dt} = a_2x + b_2y + f_2(t) \quad \text{with given conditions.}$$

5. Plotting the integral surfaces of a given first order PDE with initial data.

Book Recommended:

1. J. Sinha Roy and S. Padhy, A Course on Ordinary and Partial Differential Equations, Kalyani Publishers, New Delhi, Ludhiana, 2012. Chapters: 11, 12, 13(13.1-13.5, 13.7), 15(15.1, 15.5 (excluding 15.5.1)) 8(8.1-8.4),

Books for References:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.

Semester - IV
CORE PAPER - VIII
Numerical Methods (Total Marks:100)
Part-I (Marks:75)
Theory: 60 Marks+Mid-Sem:15 Marks
04 Lectures (per week)

This course will enable the students to:

CO-1:

- ❖ Learn about number system, Different types of error & Floating-point representation.
- ❖ Obtain numerical solutions of algebraic and transcendental equations.

CO-2:

- ❖ Find numerical solutions of system of linear equations and check the accuracy of the solutions.

CO-3:

- ❖ Learn about various interpolating and extrapolating methods.

CO-4:

- ❖ Learn about numerical integration using newton cotes rules for different number of nodes.
- ❖ Solve initial and boundary value problems in differential equations using numerical methods.
- ❖ Apply various numerical methods in real life problems.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	2	2	3	3	3	2	3	3	3	3
CO3	2	3	2	3	2	2	2	2	2	3
CO4	3	2	3	2	2	3	3	3	3	3
CO5	3	3	2	3	2	2	3	2	3	2

Unit-I

Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newtons method, Secant method. Rate of convergence of these methods.

Unit-II

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods.

Unit-III

Interpolation: Lagrange and Newtons methods. Error bounds. Finite difference operators.

Unit-IV

Numerical Integration: Trapezoidal rule, Simpsons rule, Simpsons 3/8th rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpsons rule. Ordinary Differential Equations: Eulers method.

Part-II (Practical: Marks:25)

List of Practicals (Using any Software) Practical/Lab work to be performed on a computer.

1. Bisection Method.
2. Regulai Falsi Method.
3. Secant Method.
4. Newton Raphson Method.
5. Lagrange Interpolation Method.
6. Newton Interpolation Method.
7. Compound Trapezoidal rule.
8. Compound Simpson's rule.

Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

Book Recommended:

1. B.P. Acharya and R.N. Das, A Course on Numerical Analysis, Kalyani Publishers, New Delhi, Ludhiana. Chapters: 0 (0.2), 1 (1.8), 2(2.1 - 2.4, 2.6-2.9), 3(3.1 - 3.4, 3.6 - 3.9), 6(6.1-6.5), 7(7.1- 7.4),8(8.1- 8.3)

Books for References:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
3. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
4. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012 .

CORE PAPER - IX**Riemann Integration and Series of Functions (Analysis-III)****Total Marks:100****Theory:80 Marks+Mid-Sem:20 Marks****5 Lectures, 1 Tutorial (per week)****CO-1:**

- ❖ Learn About Riemann Integration, Its Properties & Fundamental Theorem of Calculus.

CO-2:

- ❖ Learn What Is IMPOPER Integral, Its Types and How to Handle It. What Is the Relation Between Converge And Improper Integral And Convergence Of BETA & GAMMA Function?

CO-3:

- ❖ Gain knowledge about uniform continuity & uniform converge and relation between them. And how to test UC of function.

CO-4:

- ❖ Detail study of power series and its radius of convergence, Able's summation formula.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	2	3	2	2	2	3
CO2	3	2	2	3	3	3	3	3	3	2
CO3	2	3	3	2	3	2	2	3	3	3
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus.

Unit-II

Improper integrals; Convergence of Beta and Gamma functions.

Unit-III

Point wise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

Unit-IV

Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abels Theorem; Weierstrass Approximation Theorem.

Book Recommended:

1. G. Das and S. Pattanayak-Fundamentals of Mathematical Analysis, TMH Publishing Co., Chapters: 4(4.14), 8(8.1 - 8.6) 9(9.1 - 9.6, 9.8)

Books for References:

1. KA Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
4. S.C. Mallik and S. Arora-Mathematical Analysis, New Age International Ltd., New Delhi.
5. Shanti Narayan and M.D. Raisinghania-Elements of Real Analysis, S. Chand & Co. Pvt. Ltd.

CORE PAPER - X

Ring Theory and Linear Algebra (Algebra-III)

Total Marks : 100

Theory : 80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

CO-1:

- ❖ Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
- ❖ Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.

CO-2:

- ❖ Learn about Ring Homomorphism and integral Domain.

CO-3:

- ❖ Understand The Concepts Of Vector Spaces, Subspaces, Bases, Dimension And Their Properties.
- ❖ Recognize Consistent And Inconsistent Systems Of Linear Equations By The Row Echelon Form Of The Augmented Matrix, Using Rank.
- ❖ Find Eigenvalues and Corresponding Eigenvectors For A Square Matrix.

CO-4:

- ❖ Relate Matrices and Linear Transformations, Compute Eigen Values and Eigen Vectors of linear transformations.
- ❖ Learn Properties of Inner Product Spaces and Determine Orthogonality in Inner Product Spaces.

- ❖ Realize importance of Adjoint of a Linear Transformation and its Canonical Form.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	2	2	2	3	3	2	2	3
CO2	2	2	2	3	3	2	3	3	3	2
CO3	3	3	3	3	3	2	3	3	2	3
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

Unit-II

Ring homomorphisms, properties of ring homomorphisms, field of quotients of an integral domain.

Unit-III

Vector Space, Subspace, Algebra of Subspace, Linear Combination of vectors, Linear Span, Linear Independence, Basis and Dimension, Dimension of Subspaces.

Unit-IV

Linear transformations. Null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformation

Book Recommended:

1. I.N Herstein, Topics in Algebra, Willey Estern limited, India Ch-3 (3.1-3.6)
2. V krishnamurty, V.P mainra, J.L Arora- An introduction to Linear algebra, East West Press, Ch-3(ex 3.4), 4(4.1-4.3), 5(5.1-5.2)

Books for References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

3. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
4. Gilbert Strang, Linear Algebra and its Applications, Cengage Learning India Pvt. Ltd.
5. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
6. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
7. Joseph A. Gallian, Contemporary Abstract Algebra(4th Edn.), Narosa Publishing House, New Delhi. Chapters : 12, 13, 14, 15. 16, 17, 18, 24

Semester-V

CORE PAPER – XI

Multivariate Calculus (Calculus-II)

Total Marks : 100 Theory : 80 Marks + Mid - Sem : 20 Marks

5 Lectures, 1 Tutorial (per week)

This Course will enable the Students to:

CO-1:

- ❖ Learn Conceptual Variations While Advancing From One Variable To Several Variables In Calculus.
- ❖ Limit, Continuity and Partial Differentiation Of Function Of Two Or More Variable.

Co-2:

- ❖ Extreme Value $f(x, y, z)$ Using subsidiary condition and Lagrange Multiplier Method.

Co-3:

- ❖ Learn about multiple integral, Inter-Relationship Amongst The Line Integral, Double And Triple Integral Formulations.

Co-4:

- ❖ Introduction To Vector Function and Vector Calculus Such as Directional Derivative, Grad, Divergence, Curl and Limit, Continuity, Derivative and Integration
- ❖ Realize Importance of Green, Gauss and Stokes' Theorems in Other Branches of Mathematics.
- ❖ Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	3	2	3	3	2	2	3
CO2	2	2	2	2	3	2	3	3	3	2
CO3	3	3	3	3	3	3	2	3	2	3
CO4	3	2	3	2	3	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Functions of several variables, limit and continuity of functions of two variables

Partial differentiation, total differentiation and differentiability, sufficient condition

for differentiability. Chain rule for one and two independent parameters,

Unit-II

Extreme of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

Unit-III

Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals.

Unit-IV

Definition vector field, or gradient, maximal & normal property of the gradient, directional derivative equation of tangent plane & normal lines, divergence & curl. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. Green's theorem surface integrals, integrals over parametrically defined surfaces. Stokes's theorem & the Gauss Divergence theorem (only statement).

Books Recommended:

1. Advanced Higher Calculus by G. Samal, S.C. Jena, T. Biswal & D. K. Dalai, Vidyapuri Publication (12, 13, 14, 16, 17, 20)

Books for References :

1. M.J. Strauss, G.L. Bradley and K.J. Smith: Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007. Chapters: 11(11.1 (Pages: 541-543), 11.2-11.6, 11.7 (Pages: 598-605), 11.8 (Pages : 610-614), 12 (12.1-12.3, 12.4 (Pages : 652-660), 12.5, 12.6), 13 (13.1-13.3, 13.4 (Pages 712-716, 718-720), 13.5 (Pages : 723-726; 729-730), 13.6 (Pages : 733-737), 13.7 (Pages : 742-745))
2. G.B. Thomas and R.L. Finney : Calculus, 9th Ed., Pearson Education, Delhi, 2005.

CORE PAPER – XII

Programming in C++

Part-I (Marks:75)

(Theory:60 Marks+Mid-Sem:15 Marks)

(4- Lectures per week)

This course will enable the students to:

CO1:

- ❖ Understand and apply the structured programming concepts of C++ which is important for mathematical investigation and problem solving.

CO2:

- ❖ Use different library functions for computational objectives also operators and expressions.

CO3:

- ❖ Represent the outputs of programs visually in terms of well formatted text and plots.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	2	3	3	2	2	3
CO2	3	2	2	2	3	2	2	3	3	2
CO3	3	3	3	3	3	2	2	3	2	3
CO4	3	2	3	2	3	3	3	3	3	3
C05	2	3	2	3	2	2	3	3	3	2

Unit - I

Introduction to structured programming: data types- simple data types, floating data types, character data types, string data types, arithmetic operators and operators precedence, variables and constant declarations, expressions.

Unit - II

Input using the extraction operator cin, output using the insertion operator and cout, preprocessor directives, increment(++) and decrement(-) operations, creating a C++ program, input, output, relational operators, logical operators and logical expressions.

Unit - III

If and if-else statement, switch and break statements. for, while and do-while loops and continue statement, nested control statement.

UNIT - IV

Value returning functions, value versus reference parameters, local and global variables, one dimensional array, two dimensional array, pointer data and pointer variables.

Book Recommended:

1. G.K Baluja and G.S Baluja, Object Oriented Programming using C++ Chapters 1, 2 (Excluding 2.9, 2.14 & 2.20), 3, 4, 5 (5.1 – 5.7, 5.9, 5.10 & 5.13)

Books for References:

1. E. Balaguruswami: Object oriented programming with C++, fifth edition, Tata McGraw Hill Education Pvt. Ltd.
2. R. Johnsonbaugh and M. Kalin-Applications Programming in ANSI C, Pearson Education.
3. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
4. Bjarne Stroustrup , The C++ Programming Language, 3rd Ed., Addison Welsley.

Part-II (Practical, Marks:25)

List of Practicals (Using any software) Practical/Lab work to be performed on a Computer.

1. Calculate the sum $1/1 + 1/2 + 1/3 + 1/4 + \dots + 1/N$.
2. Calculate the factorial of any natural number.
3. Read floating numbers and compute two averages : the average of negative numbers and the average of positive numbers.
4. Write a program that prompts the user to input a positive integer. It should then output a message indicating whether the number is a prime number.

5. Write a program that prompts the user to input the value of a, b and c involved in the equation $ax^2 + bx + c = 0$ and outputs the type of the roots of the equation. Also the program should outputs all the roots of the equation.
6. Write a program that prompts the user to input five decimal numbers. The program should then add the five decimal numbers, convert the sum to the nearest integer, and print the result.
7. Write a program that prompts the user to enter the lengths of three sides of a triangle and then outputs a message indicating whether the triangle is a right triangle or a scalene triangle.
8. Write a function that takes as a parameter an integer (as a long. value) and returns the number of odd, even, and zero digits. Also write a program to test your function.

Semester- VI

CORE PAPER - XIII

Metric Spaces and Complex Analysis (Analysis-IV)

Total Marks: 100 Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

This course will enable the students to:

Co-1:

- ❖ Details study of topology of metric space and behavior of sequence in a metric as well as complete metric space.

Co-2:

- ❖ Visualize complex numbers as points of \mathbb{R}^2 and stereographic projection of complex plane on the Riemann sphere.
- ❖ Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations.

Co-3:

- ❖ Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.

Co-4:

- ❖ Apply Liouville's theorem in fundamental theorem of algebra.
- ❖ Understand the convergence, term by term integration and differentiation of a power series.
- ❖ Learn Taylor and Laurent series expansions of analytic functions.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	2	3	2	2	3
CO2	3	2	3	3	3	2	3	3	3	2
CO3	2	3	3	3	3	3	2	3	2	3
CO4	3	2	2	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighborhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantors theorem.

Unit-II

Properties of complex numbers, regions in the complex plane, functions of complex

variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Unit-III

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula.

Unit-IV

Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

Books Recommended:

1. S.C. Mallik and S. Arora-Mathematical Analysis, New Age International Publications.Ch-19 – 1, 2, 3 (Upto Theorem 11)
2. Complex analysis Dr. S Arumugam, I.G, Thangapadi Ch- 1, 2 (2.1 - 2.8), 4 (4.4), 6, 7 (7.1 - 7.2)

Books for References:

1. Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
3. S. Ponnusamy-Foundations of Complex Analysis, Alpha Science international Ltd.
4. J.B. Conway-Functions of one complex variable, Springer.
5. N. Oas- Complex Function Theory, Allied Publishers Pvt. Ltd., Mumbai.

CORE PAPER – XIV

Linear Programming

Total Marks: 100 Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

This course will enable the students to:

Co-1:

- ❖ Analyze and solve linear programming models of real-life situations.
- ❖ Provide graphical solutions of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
- ❖ Understand the theory of the simplex method.

Co-2:

- ❖ Know about the relationships between the primal and dual problems, and to understand sensitivity analysis.

Co-3:

- ❖ Learn about the applications to transportation problem.

Co-4:

- ❖ Learn about the applications to Assignment problem.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	2	3	3	2	2	3
CO2	2	2	2	3	3	2	3	3	3	2
CO3	3	3	3	3	2	3	2	3	2	2
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	3

Unit-I

Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tabular format, introduction to artificial variables, two phase method, Big M method.

Unit-II

Duality, formulation of the dual problem, primal-dual relationships.

Unit-III

Transportation problem and its mathematical formulation, northwest corner method least cost method and Vogel approximation method for determination of starting

basic solution, algorithm for solving transportation problem,

Unit-IV

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

Recommended Books:

1. Kanti Swarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt. Ltd. Ch-4 (4.1-4.4), 5(5.1-5.4), 10(10.1-10.3, 10.5, 10.9) 11 (11.1-11.3)

Books for Reference:

1. F.S. HiHier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009. Chapter: 14
2. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice Hall India, 2006. Chap- ter:5(5.1, 5.3, 5A).
3. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
4. NVR. Naidu, G. Rajendra and T. Krishna Rao-Operations Research, I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.
5. R. Veerachamy and V. Ravi Kumar-Operations Research- I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.

Discipline Specific Elective Paper - I

DSE - I

Discrete Mathematics

This course will enable the students to:

CO1:

- ❖ Learn about partially ordered sets, lattices and their types, Mathematical Induction, Counting Principle.

CO2:

- ❖ Understand Boolean algebra and Boolean functions, logic gates, their applications.

CO3:

- ❖ Assimilate various graph theoretic concepts and familiarize with their

applications.

CO-4:

- ❖ Know basic concepts of Graphs.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	2	3	3	2	3	2	2	3	2	3
CO4	3	2	3	2	2	3	3	3	3	3
CO5	3	3	2	3	2	2	3	2	3	2

Unit-I

Logic, propositional equivalence, predicates and quantifiers, nested quantifiers, methods of proof. Boolean algebra, Boolean Function, Representing Boolean Functions, Logic Gates, Minimization of circuits.

Unit-II

Counting: The basic counting, the Pigeon-hole principle, Permutation and combination, Generalized Permutations and Combinations.

Unit-III

Recurrence relations, Counting using recurrence relations, solving linear homogeneous recurrence relations with constant coefficients, generating functions, solving recurrence relations using generating functions. Relations and their properties, n-ary relation and their applications. Partially ordered sets, Hasse diagram of partially ordered sets, maps between ordered sets, duality principle,

Unit-IV

Graphs: Basic concepts and graph terminology, representing graphs and graph isomorphism. Distance in a graph, Cut-vertices and Cut-edges, Connectivity, Euler and Hamiltonian path.

Book Recommended:

1. Kenneth H. Rosen, Discrete Mathematics and Applications, Tata McGraw Hill Publications, 7th Edition, Chapters: 1(1.1 - 1.4, 1.6), 4 (4.1), 5 (5.1, 5.2, 5.3,5.5), 6 (6.1, 6.2, 6.4), 7 (7.1, 7.2, 7.6), 8 (8.1-8.5), 10 (10.1,10.2, 10.3 & 10.4).

Books for References:

1. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory (2nd Edition}, Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gnter Pilz, Applied Abstract Algebra (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. D.S. Malik-Discrete Mathematics: Theory & Applications, Cengage Learning India Pvt. Ltd.
5. Kevin Ferland-Discrete Mathematical Structures, Cengage Learning India Pvt. Ltd .

Discipline Specific Elective Paper - II**DSE-II****Number Theory**

This course will enable the students to:

CO-1:

- ❖ Learn about some important results in the theory of numbers including the prime number theorem.
- ❖ Learn about number theoretic functions, modular arithmetic and their applications.
- ❖ Familiarize with modular arithmetic and find primitive roots of prime and composite numbers.

CO-2:

- ❖ Know about open problems in number theory, namely, the Goldbach conjecture and twin-prime conjecture.

CO-3:

- ❖ Study congruence and Chinese remainder theorem.

CO-4:

- ❖ Wilson's theorem and their consequences and Euler's Function and its application.
- ❖ Apply public crypto systems, in particular, RSA.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	2	2	3	3	2	3	3	3	2
CO3	3	3	3	3	3	2	2	3	2	2
CO4	2	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Divisibility theorem in integers, Primes and their distributions, Fundamental theorem of arithmetic, Greatest common divisor, Euclidean algorithms, Modular arithmetic,

Unit-II

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture.

Unit-III

Introduction to congruences, Linear Congruences, Chinese Remainder theorem, Polynomial congruences, System of linear congruences, complete set of residues.

Unit-IV

Fermat's little theorem, Wilson's theorem. Eulers phi function, Eulers theorem, reduced set of residues, some properties of Eulers phi-function.

Book Recommended:

1. D.M. Burton-Elementary Number Theory, McGraw Hill, Chapters: 2(2.1 to 2.5), 3(3.1 to 3.3), 4 (4.1 to 4.4), 5(5.1 to 5.3), 7 (7.1 to 7.4).

Book for References :

1. K.H. Rosen-Elementary Number Theory & its Applications, Pearson Addition Wesley.
2. I. Niven and H.S. Zuckerman-An Introduction to Theory of Numbers, Wiley Eastern Pvt. Ltd.

Discipline Specific Elective Paper - III

DSE-III

Differential Geometry

Total Marks:100 Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

This course will enable the students to:

CO-1:

- ❖ Explain the basic concepts of tensors.
- ❖ Understand role of tensors in differential geometry.
- ❖ Learn various properties of curves including Frenet-Serret formulae and their applications.

CO-2:

- ❖ Study about osculating circle and sphere, Evolutes and Involutives of Curve.

CO-3:

- ❖ Know the Interpretation of the curvature developable associated with space curves and curves on surface, Minimal surface.

CO-4:

- ❖ Understand the role of Gauss's Theorem Egregious and its consequences.
- ❖ Apply problem-solving with differential geometry to diverse situations in physics, engineering and in other mathematical contexts

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	2	2	3
CO2	3	2	3	3	3	2	3	3	3	2
CO3	3	3	2	3	3	2	2	3	2	3
CO4	2	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Theory of Space Curves: Space curves, Planar curves, Curvature, torsion and Serret-Frenet formulae.

Unit-II

Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

Unit-III

Developable: Developable associated with space curves and curves on surfaces, Minimal surfaces.

Unit-IV

Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Eulers theorem. Rodrigues formula.

Book Recommended:

1. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003. Chapters.1(1-4, 7,8,10,11),2(13,14,16,17),3,4(29-31,35)

Books for References

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. S. Lang, Fundamentals of Differential Geometry, Springer, 1999,
3. B. O'Neill, Elementary Differential Geometry, 2nd Ed" Academic Press, 2006.
4. A.N, Pressley-Elementary Differential Geometry, Springer,
5. B.P, Acharya and R.N. Das-Fundamentals of Differential Geometry, Kalyani Publishers, Ludhiana, New Delhi.

Discipline Specific Elective Paper-IV

PROJECT

DSE-IV Project Work (Compulsory)

Total Marks : 100 (Project : 75 Marks + Viva Voice : 25 Marks)

Guidelines for +3(CBCS) Under Graduate(B.A./B.Sc.) Mathematics(Honours)

Project

1. Any student registering for doing project is required to inform the HOD, Mathematics the name of his/her project supervisor(s) at the time of pre-registration.
2. By the last date of add and drop, the student must submit the “Project Registration Form”, appended as Annexure-I to this document, to the HOD, Mathematics. This form requires a project title, the signature of the student, signature(s) of the supervisor(s) and the signature of the HOD, Mathematics of the college/university.
3. The project supervisor(s) should normally be a faculty member(s) of the Department of Mathematics and the topic of the project should be relevant to Mathematical Sciences. If a student desires to have a Project Supervisor from another department of the institute, the prior approval for the same should be sought from the HOD, Mathematics.
4. A student may have at the most two Project Supervisors. If a student desires to have two supervisors, at least one of these should be from the Department of Mathematics.
5. The student(s) will be required to submit one progress report and a final report of the Project to the HOD, Mathematics. The progress report is to be submitted in the sixth week of the semester in which the project is undertaken. The hard copy and an electronic version of the final report of the project should be submitted two weeks before the end semester examination of the sixth semester. In addition the student will be required to make an oral presentation in front of a committee (Under Graduate (B.A./B.Sc.) Mathematics (Honours) Project committee of the college in which supervisor is one of the members) constituted for this purpose by the Department of Mathematics of the college.

6. The student is expected to devote about 100 hours. The project will be evaluated by a committee of faculty members at the end of the sixth semester. The committee will be constituted by the Under Graduate (B.A./B.Sc.) Mathematics (Honours) Project committee of the college keeping in mind the areas of project they will cover.
7. In each semester the grade of a student will be awarded by the committee in consultation with his/her project supervisor(s). The project is evaluated on the basis of the following components: First Progress Reports: 20%; second/Final Report: 30%; Presentation: 30%; Viva:20%.
8. Project progress reports should normally be no longer than 250 words and final report should not be longer than 40 A4 size pages in double spacing. Each final project report need to contain the following: (i) Abstract (ii) Table of contents (iii)Review of literature (iv) Main text(v) List of references. It may be desirable to arrange the main text as an introduction, the main body and conclusions.

GUIDELINES FOR STRUCTURING CONTENTS

Sequence of Contents:

The following sequence for the thesis organization should be followed:

(i) Preliminaries	Title Page Certificate Abstract/Synopsis Acknowledgement and/ or Dedication Table of Contents List of Figures, Tables, Illustrations, Symbols, etc (wherever applicable)
(ii) Text of Thesis	Introduction The body of the thesis, summary and conclusions
(iii) Reference Material	List of References, Bibliography
(iv) Appendices	

NOTE:

1. Synopsis/Abstract should be self-complete and contain no citations for which the thesis has to be referred.

2. The Text of the Thesis

(a) Introduction:

Introduction may be the first chapter or its first major division. In either case, it should contain a brief statement of the problem investigated. It should outline the scope, aim, general character of the research and the reasons for the student's interest in the problem.

(b) The body of Thesis

This is the substance of the dissertation inclusive of all divisions, subdivisions,

tables, figures, etc.

(c) Summary and conclusions

If required, these are given as the last major division (chapter) of the text. A further and final subdivision titled “Scope for Further Work” may follow.

(d) Reference material

The list of references should appear as a consolidated list with references listed either alphabetically or sequentially as they appear in the text of the thesis.

For referencing an article in a scientific journal the suggested format should contain the following information: authors, title, name of journal, volume number, page numbers and year. For referencing an article published in a book, the suggested format should contain, authors, the title of the book, editors, publisher, year, page number of the article in the book being referred to. For referencing a thesis the suggested format should contain, author, the title of thesis, where thesis was submitted or awarded, year.

ANNEXURE-I
Department of Mathematics
Project Registration Form

Name of the college/university:

Name of the student:

Roll No. :

e-mail :

Name of the supervisor(s):

Department(s):

e-mail(s):

Title of the Project:

Signature of the Student:

Signature of supervisor(s): (i)

(ii)

Signature of HOD, Mathematics:

GENERIC ELECTIVES (TWO PAPER CHOICE)
Generic Electives/Interdisciplinary (04 Papers, 02 papers each from two
Allied disciplines)

(Credit: 06 each, Marks:100) GE-I to GE-IV

GE-I: Calculus and Ordinary Differential Equations

CO-1:

- ❖ Develop a basic knowledge in calculus by studying Derivative of Arcs, Curvature, Asymptotes, Curve Tracing, Volume and Surface area of solids of revolution.

CO-2:

- ❖ Learn Explicit and Implicit functions, Limit and Continuity of functions of several variables, Partial derivatives.

CO-3:

- ❖ Demonstrate Ordinary Differential Equations of 1st order and 1st degree or higher degree.

CO-4:

- ❖ Able to solve Second order linear equations with constant coefficients.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	2	3	3	3	2	3
CO2	2	2	3	3	3	3	3	3	3	3
CO3	3	3	2	3	3	2	2	3	2	3
CO4	3	2	3	2	3	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Derivative of Arcs, Curvature, Asymptotes, Curve Tracing, Rectification, Quadrature, Volume and Surface area of solids of revolution.

Unit-II

Explicit and Implicit functions, Limit and Continuity of functions of several variables, Partial derivatives. Partial derivatives of higher orders, Homogeneous functions, Change of variables, Mean value theorem, Taylors theorem and Maclaurin's theorem for functions of two variables.

Unit-III

Ordinary Differential Equations of 1st order and 1st degree (Variables separable, homogenous, exact and linear). Equations of 1st order but higher degree.

Unit-IV

Second order linear equations with constant coefficients, homogeneous forms. Non homogeneous linear Equations with constant coefficients, The operator Method to solving linear differential Equation with constant coefficients, The Method of undetermined coefficients, Method of variation of Parameter.

Books Recommended:

1. Shantinakaran-Text Book of Calculus, Part-II, S. Chand and Co., Chapter-6, 8 (Art. 24, 25, 26)
2. Shantinakaran-Text Book of Calculus, Part-III, S. Chand and Co., Chapter-1 (Art 1,2), 3, 4(Art. 10 to 12 omitting Simpsons Rule), 5(Art-13), 6 (15, 16)
3. S.C. Mallik and S. Arora-Mathematical Analysis, New Age International Publications.Ch-15 (1 - 9)
4. J. Sinharoy and S. Padhy-A Course of Ordinary and Partial Differential Equations, Kalyani Publishers. Chapters: 2(2.1 to 2.7),3,4(4.1 to 4.8)

Books for References:

1. Shanti Narayan and P.K. Mittal-Analytical Solid Geometry, S. Chand & Company Pvt. Ltd., New Delhi.
2. David V. Weider-Advanced Calculus, Dover Publications.
3. Martin Braun-Differential Equations and their Applications-Martin Braun, Springer International.
4. M.D. Raisinghanian-Advanced Differential Equations, S. Chand & Company Ltd., New Delhi.

Generic Elective Paper - II

GE-II: Linear Algebra and Advanced Algebra

This course will enable the students to:

CO-1:

- ❖ Develop basic knowledge in Vector space, Subspace and their properties.

CO-2:

- ❖ Analyze Matrices and linear maps by studying the basic properties and operations on matrices
- ❖ Learn about Eigen values and Eigen vectors.

CO-3:

- ❖ Recognize the Mathematical objects called groups.

CO-4:

- ❖ Learn about Special Types of Groups Such as Abelian Group, Cyclic Group Symmetry Group, Permutation Groups.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	2	2	2	2	3	2	3
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit - I

Vector space, Subspace, Span of a set, Linear dependence and Independence, Dimensions and Basis. Linear transformations.

Unit - II

Matrices and linear maps, Rank and Nullity of a matrix, Transpose of a matrix, Elementary row operations, System of linear equations, Matrix inversion using row operations, Determinant and Rank of matrices, Eigen values, Eigen vectors.

Unit - III

Group Theory: Definition and examples, Subgroups, Normal subgroups

Unit - IV

Cyclic Groups, Cosets, Quotient Groups, Permutation Groups, Homomorphism.

Books Recommended:

1. V. Krishnamurty, V. P. Mainra, J. L. Arora-An introduction to Linear Algebra, Affiliated East-West Press Pvt. Ltd., New Delhi, Chapters: 3, 5 (5.1, 5.2, 5.5 - 5.9), 6 (6.5 to 6.8)
2. I.N. Herstein-Topics in Algebra, Wiley Eastern Pvt. Ltd.Ch-2 (2.1 to 2.6,2.7(ex application))

Books for References:

1. S. Kumaresan-Linear Algebra: A Geometric Approach, Prentice Hall of India.
2. Rao and Bhimasankaran-Linear Algebra, Hindustan Publishing House.
3. S. Singh-Linear Algebra, Vikas Publishing House Pvt. Ltd., New Delhi.
4. Gilbert Strang-Linear Algebra & its Applications, Cengage Learning India Pvt. Ltd.
5. Gallian-Contemporary Abstract Algebra, Narosa publishing House.
6. Artin-Algebra, Prentice Hall of India.

OR

GENERIC ELECTIVES (FOR FOUR PAPERS CHOICE)

Generic Elective Paper III

Linear Programming

Total Marks : 100 Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

This course will enable the students to:

CO-1:

- ❖ Develop a basic knowledge in calculus by studying Derivative of Arcs, Curvature, Asymptotes, Curve Tracing, Volume and Surface area of solids of revolution.

CO-2:

- ❖ Learn Explicit and Implicit functions, Limit and Continuity of functions of several variables, Partial derivatives.

CO-3:

- ❖ Demonstrate Ordinary Differential Equations of 1st order and 1st degree or higher degree.

CO-4:

- ❖ Able to solve Second order linear equations with constant coefficients.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	2	2	2	2	3	2	3
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two phase method, Big M method.

Unit-II

Duality, formulation of the dual problem, primal-dual relationships.

Unit-III

Transportation problem and its mathematical formulation, northwest corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem,

Unit-IV

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

Recommended Books:

1. Kanti Swarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt. Ltd. Ch-4 (4.1-4.5), 5(5.1-5.4), 10(10.1-10.3, 10.5, 10.9) 11 (11.1-11.3)

Books for Reference:

1. F.S. HiHier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009. Chapter: 14
2. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice Hall India, 2006. Chapter:5(5.1, 5.3, 5A).
3. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

4. NVR. Naidu, G. Rajendra and T. Krishna Rao-Operations Research, I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.
5. R. Veerachamy and V. Ravi Kumar-Operations Research- I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.

GENERIC ELECTIVE PAPER IV

Numerical Methods

Total Marks : 100 Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week)

This course will enable the students to:

CO-1:

- ❖ Develop basic knowledge in Vector space, Subspace and their properties.

CO-2:

- ❖ Analyze Matrices and linear maps by studying the basic properties and operations on matrices
- ❖ Learn about Eigen values and Eigen vectors.

CO-3:

- ❖ Recognize the Mathematical objects called groups.

CO-4:

- ❖ Learn about Special Types of Groups Such as Abelian Group, Cyclic Group Symmetry Group, Permutation Groups.

Mapping of Pos with Cos

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	2	2	2	2	3	2	3
CO4	3	2	3	2	2	3	3	3	3	3
C05	3	3	2	3	2	2	3	2	3	2

Unit-I

Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newtons method, Secant method. Rate of convergence of these methods.

Unit-II

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan

methods.

Unit-III

Interpolation: Lagrange and Newtons methods. Error bounds. Finite difference operators.

Unit-IV

Numerical Integration: Trapezoidal rule, Simpsons rule, Simpsons 3/8th rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpsons rule. Or.dinary Differential Equations: Eulers method.

Book Recommended:

2. B.P. Acharya and R.N. Das, A Course on Numerical Analysis, Kalyani Publishers, New Delhi, Ludhiana. Chapters: 1, 2(2.1 to 2.4, 2.6, 2.8, 2.9), 3(3.1 to 3.4, 3.6 to 3.9), 6(6.1-6.5), 7(7.3, 7.4),8(8.1,8.2)

Books for References:

5. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
6. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
7. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
8. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited,2012 .

