NETAJI SUBHAS UNIVERSITY

Estd. Under Jharkhand State Private University Act, 2018

Department of Mathamatics

B.Sc. MATH (Hons.)
Course Curriculum
(with CO, PO Structure)

w.e.f. 2023

ESTD NSU JAMSHEDPUR 2018

NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

NETAJI SUBHAS UNIVERSITY JAMSHEDPUR

Dean Academics
Netaji Subhas University
Jamshedpur, Jharkhand

NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

Proposed Syllabus and Scheme of Examination

for

B.Sc. (Hons.) Mathematics

under the

Choice Based Credit System

August 2023 onwards

PROGRAMME OUTCOME

The graduates will be able to:

PO 1: Science Knowledge: Apply the knowledge of Mathematical Sciences to become competent professionals at global level.

PO 2: Problem analysis: Identify, formulates and analyze scientific problems to reaching substantiated conclusions by using various areas of Mathematical Sciences.

PO 3: Design/development of solutions: Design of solutions for complex scientific problems and design of model that meet the specified needs with appropriate considerations of public health and safety and cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based methods including design of experiments, analysis and interpretation of data and synthesis of information leading to logical conclusions.

PO 5: Modern tool usage: Create, select and apply appropriate statistical and computation techniques, resources and modern tools to solve problems related to various domains like sciences, engineering etc.

PO 6: Science graduate and society: Apply reasoning within the contextual knowledge to access societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the science practices.

PO 7: Environment and sustainability: Understand the impact of the scientific solutions in the societal and environmental contexts and demonstrate the knowledge and the need for sustainable developments.

PO 8: Ethics: Apply ethical principles and responsibilities of a graduate to serve the society.

PO9: Individual and team work: Function effectively as an individual independently and as a member or leader in diverse teams and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on scientific activities with the science community and with society at large such give and receive clear instructio

PROGRAMME SPECIFIC OUTCOME

PSO-1: Analytical Thinking and Problem Solving

Apply mathematical methods and reasoning to solve real-world problems in various fields like science, engineering, economics, and more.

Demonstrate the ability to analyze and break down complex problems using mathematical concepts and techniques.

PSO-2: Mathematical Modeling and Applications

Use mathematical models to understand, interpret, and solve practical problems in different domains such as physics, biology, and finance.

Interpret and construct mathematical models in both deterministic and stochastic systems.

PSO-3: Communication Skills in Mathematics

Communicate mathematical ideas and concepts clearly, both verbally and in writing, to diverse audiences.

Present mathematical arguments, proofs, and solutions in a logical and coherent manner.

PSO-4: Computational Skills and Software Proficiency

Develop proficiency in using mathematical software and programming languages such as MATLAB, Python, R, or other mathematical tools for computation, simulation, and data analysis.

Apply algorithms and numerical methods to solve problems efficiently.

PSO-5: Advanced Knowledge of Core Mathematical Areas

Demonstrate understanding of fundamental mathematical areas such as algebra, calculus, differential equations, linear algebra, and probability.

Develop expertise in advanced topics in mathematics like abstract algebra, real analysis, complex analysis, and discrete mathematics.

PSO-6: Critical Thinking and Theoretical Insights

Analyze and critique mathematical proofs and logical structures.

Demonstrate a deep understanding of mathematical theory and its foundational principles.

PSO-7: Teamwork and Collaboration

Work effectively in teams on collaborative mathematical projects.

Engage in discussions and share ideas with peers to solve mathematical problems collaboratively.

PSO-8: Ethics and Professionalism in Mathematical Practice

Uphold ethical standards in mathematical research, analysis, and applications.

Recognize the social and ethical implications of mathematical solutions and their impact on society.

SEMESTER I							
PAPER CODE	**PAPER NAME**	**L-P-T**	**Credit**	**Internal**	**External**	**Practical**	**Total Marks**
C1	Calculus (P)	3-1-0	4	30	50	20	100
C2	Algebra	3-0-1	4	30	70		100
AECC-1		2-0-0	2	15	35		50
GE-1		3-1-0	4	15	35	50	100
			14	90	190	70	350

SEMESTER II							
PAPER CODE	**PAPER NAME**	**L-P-T**	**Credit**	**Internal**	**External**	**Practical**	**Total Marks**
C3	Real Analysis	3-0-1	4	30	70		100
C4	Differential Equation (P)	3-1-0	4	30	50	20	100
AECC-2		2-0-0	2	15	35		50
GE-2		3-0-1	4	30	70		100
	Total		14	105	225	20	350

SEMESTER III							
PAPER CODE	**PAPER NAME**	**L-P-T**	**Credit**	**Internal**	**External**	**Practical**	**Total Marks**
C5	Theory of Real Functions	3-0-1	4	30	70		100
C6	Group Theory I	3-0-1	4	30	70		100
C7	PDE and Systems of ODE (P)	3-1-0	4	30	50	20	100
SEC 1		2-0-0	2	15	35		50
GE 3		3-0-1	4	30	70		100
	Total		18	135	295		450

SEMESTER IV							
PAPER CODE	PAPER NAME	L-P-T	Credit	Internal	External	Practical	Total Marks
C8	Numerical Methods (P)	3-0-1	4	30	70		100
C9	Riemann Integration and Series of Functions	3-0-1	4	30	70		100
C10	Ring Theory and Linear Algebra I	3-0-1	4	30	70		100
SEC 2		2-0-0	2	15	35		50
GE 4		3-0-1	4	30	70		100
	Total		18	135	295		450

SEMESTER V							
PAPER CODE	PAPER NAME	L-P-T	Credit	Internal	External	Practical	Total Marks
C11	Multivariate Calculus	3-0-1	4	30	70		100
C12	Group Theory II	3-0-1	4	30	70		100
DSE - 1		3-0-1	4	30	70		100
DSE -2		3-0-1	4	30	70		100
	Total			120	280		400

SEMESTER VI							
PAPER CODE	PAPER NAME	L-P-T	Credit	Internal	External	Practical	Total Marks
C13	Metric Spaces and Complex Analysis	3-0-1	4	30	70		100
C14	Ring Theory and Linear Algebra II	3-0-1	4	30	70		100
DSE - 3		3-0-1	4	30	70		100
DSE - 4		3-0-1	4	30	70		100
	Total			120	280		400

(P) means course with practicals

Discipline Specific Electives (DSE)

Choices for DSE 1 (choose one)

1. Portfolio Optimization
2. Number Theory
3. Analytical Geometry

Choices for DSE 2 (choose one)

1. Industrial Mathematics
2. Boolean Algebra and Automata Theory
3. Probability and Statistics

Choices for DSE 3 (choose one)

1. Theory of Equations
2. Bio-Mathematics
3. Linear Programming

Choices for DSE 4 (choose one)

1. Mathematical Modeling
2. Mechanics
3. Differential Geometry

Skill Enhancement Course (SEC)

Choices for SEC 1 (choose one)

1. Logic and Sets
2. Computer Graphics

Choices for SEC 2 (choose one)

1. Graph Theory
2. Operating System: Linux

Generic Electives (GE)

Choices for GE 1 (choose one)

1. Object Oriented Programming in C++ (P)
2. Finite Element Methods

Choices for GE 2 (choose one)

1. Mathematical Finance
2. Econometrics

Choices for GE 3 (choose one)

1. Cryptography and Network Security
2. Information Security

Choices for GE 4 (choose one)

1. Applications of Algebra
2. Combinatorial Mathematics.

SEMESTER I

C1 Calculus

COURSE OBJECTIVE

The main concern of Calculus is to -

1) The goal of this course is for students to gain proficiency in calculus computations.

2) To learn three main tools for analyzing and describing the behavior of functions limits, derivatives and integral.

3) To demonstration Curvature, Asymptotes and Curve Tracing etc.

4) To lean deep knowledge geometrical interpretations.

5) To understand the tools to solve application problems in a variety of setting ranging from physics and biology to business and economics etc.

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx\, dx$, $\int \cos nx\, dx$, $\int \tan nx\, dx$, $\int \sec nx\, dx$, $\int (\log x)^n\, dx$, $\int \sin^n x \sin^m x\, dx$, volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

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, modeling ballistics and planetary motion, Kepler's second law.

List of Practicals (using any software)

(i) Plotting of graphs of function e^{ax+b}, $\log(ax + b)$, $1/(ax + b)$, $\sin(ax + b)$, $\cos(ax + b)$, $|ax + b|$ and to illustrate the effect of a and b on the graph.

(ii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.

(iii) Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).

(iv) Obtaining surface of revolution of curves.

(v) Tracing of conics in cartesian coordinates/ polar coordinates.

(vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.

(vii) Matrix operation (addition, multiplication, inverse, transpose).

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.

3. H. Anton, I. Bivens and S. Davis, *Calculus,* 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.

4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

COURSE OUTCOME

On completion of this course students are able to

i. Solve different types of problems from different calculus
ii. Differentiate partially along with its applications.
iii. Familiarize with the techniques of finding n th derivatives of standard functions.
iv. Identify and apply the Leibniz rule and L'hospital's rule.
v. plot of graphs of function e^{ax+b}, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), |ax + b| and to illustrate the effect of a and b on the graph.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	1	2	3	3	3	1	1	-	2
CO-2	2	2	1	2	2	3	2	2	3	3
CO-3	3	2	3	-	3	2	1	2	2	2
CO-4	3	3	3	3	2	2	3	3	2	3
CO-5	3	2	2	1	2	-3	3	3	2	1
AVERAGE CO	2.6	2	2.2	1.8	2.4	1.4	2	2.2	1.8	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

NETAJI SUBHAS UNIVERSITY ★ JAMSHEDPUR

C2 Algebra

Course Objective :

The main concern of algebra is to -

1) The goal of this course is for students to gain proficiency in complex and n^{th} roots of unity.

2) To learn about the basic set theory and the properties of integer.

3) To demonstrate the matrix.

4) To learn system of linear equation and their application of linear system.

5) To learn about the linear transformation.

Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications.

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.

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.

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.

COURSE OUTCOME

After completions of this course, students will be able -

1) To solve the polynomial equations and to apply De Moivre's theorems.

2) To distinguish between relations, function and Tell about properties of positive integers, arithmetic and Principles of Mathematical Induction.

3) To find various type of problems related with system of linear equations, vector space, eigen values and eigen vectors.

4) To understand polar representation of complex number.

5) Student can apply linear algebra to solved real world problems in areas like computer graphics, physics and economics.

Books Recommended

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

2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 3rd

Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

3. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson EducationAsia,IndianReprint, 2007.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	1	2	3	3	3	1	1	-	2
CO-2	2	2	1	3	2	3	2	2	3	0
CO-3	3	1	3	1	1	2	1	2	2	2
CO-4	1	2	3	3	0	2	3	3	2	1
CO-5	3	2	2	1	2	-3	3	3	2	1
AVERAGE CO	2.4	1.6	2.2	2.2	1.6	1.4	2	2.2	2	1.2

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GE 1.1 Object Oriented Programming in C++

COURSE OBJECTIVE

The main concern of algebra is to –

i) Understand the fundamentals of Object-Oriented Programming (OOP) principles.
ii) Learn how to define and implement classes and objects.
iii) Work with dynamic memory allocation and pointers.
iv) Develop skills in operator overloading and function overloading.
v) Implement inheritance and polymorphism in C++.

OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.

Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value,Using Reference variables with Functions.

Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers – private, publicand protected. Implementing Class Functions within Class declaration or outside the Class declaration. instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members. Understanding Compile Time Polymorphism function overloading Rules of Operator Overloading (Unary and Binary) as member function/friend function, Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input,Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator , concepts of namespaces.

Books Recommended

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, *Mastering C++*, TMH, 1997.

2. S. B. Lippman and J. Lajoie, *C++ Primer,* 3rd Ed., Addison Wesley, 2000.

3. Bruce Eckel, *Thinking in C++*, 2nd Ed., President, Mindview Inc., Prentice Hall.

4. D. Parasons, *Object Oriented Programming with C++*, BPB Publication.

5. Bjarne Stroustrup , *The C++ Programming Language*, 3rd Ed., Addison Welsley.

Practical to be performed in lab.

COURSE OUTCOME

i) Proficiency in Object-Oriented Design and Programming.

ii) Effective Problem-Solving Using OOP Techniques.

iii) Understanding and Implementing Core C++ Features.

iv) Demonstrate Effective Use of Object-Oriented Programming in C++ Projects.

v) Optimization of Object-Oriented C++ Programs.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	1	2	3	1	3	1	1	1	2
CO-2	2	3	0	3	2	3	2	1	3	0
CO-3	3	1	3	3	1	2	1	2	2	2
CO-4	1	2	3	2	0	2	3	3	2	1
CO-5	3	2	2	1	2	-3	3	3	2	1
AVERAGE CO	2	1.8	2	2.4	1.2	1.4	2	2	2	1.2

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GE1.2 Finite Element Methods

COURSE OBJECTIVE :

The main concern of Finite Element Method is to –

i) Understand the theoretical foundation of FEM.
ii) Formulate and develop finite element models.
iii)Gain proficiency in discretization techniques.
iv) Apply boundary conditions and loads in FEM models.
v) Solve linear and nonlinear FEM equations.

Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin's method.Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.

Applications to solving simple problems of ordinary differential equations.

Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries

Interpolation functions, numerical integration, and modeling considerations.

Solution of two dimensional partial differential equations under different Geometric conditions.

Books Recommended

1. J.N. Reddy, *Introduction to the Finite Element Methods*, Tata McGraw-Hill, 2003.

2. K.J. Bathe, *Finite Element Procedures*, Prentice-Hall, 2001.

3. R.D. Cook, D.S. Malkus and M.E. Plesha, *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons, 2002.

4. Thomas J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publication, 2000.

5. George R. Buchanan, *Finite Element Analysis*, McGraw Hill, 1994.

COURSE OUTCOME

1. Understand the fundamental principles and concepts of the Finite Element Method.
2. Formulate and solve boundary value problems using the Finite Element Method.

3. Implement the Finite Element Method for simple one-dimensional problems, including the calculation of displacement, stress, and strain.
4. Apply the Finite Element Method to solve two-dimensional problems in structural mechanics.
5. Use computational tools and software (such as MATLAB, ANSYS, or ABAQUS) to solve Finite Element problems.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	2	2	1	3	1	1	1	2
CO-2	2	1	3	3	2	3	2	1	1	2
CO-3	3	1	3	3	1	2	1	2	2	2
CO-4	1	2	3	2	0	2	3	3	2	1
CO-5	3	2	2	1	2	-3	3	2	2	0
AVERAGE CO	2.2	1.8	2.6	2.2	1.2	1.4	2	1.8	1.6	1.4

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NETAJI SUBHAS UNIVERSITY JAMSHEDPUR

I. GENERIC ELECTIVE (GE 1):

COURSE OBJECTIVE

1. Understand the fundamental principles of mechanics, including motion, forces, and energy.
2. Develop the ability to solve problems involving the laws of motion and apply Newton's laws to real-world scenarios.
3. Analyze and model physical systems using ordinary differential equations (ODEs) to describe the behavior of systems over time.
4. Apply conservation principles, such as the conservation of momentum and energy, to solve complex mechanical problems.
5. Study the dynamics of rigid bodies, including translational and rotational motion, and understand the concept of inertia.

MECHANICS

Vectors:
Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

Ordinary Differential Equations:
1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. (6 Lectures)

Laws of Motion:
Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. (10 Lectures)

Momentum and Energy:
Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.
(6 Lectures)

Rotational Motion:
Angular velocity and angular momentum. Torque. Conservation of angular momentum.
(5 Lectures)

Gravitation:
Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts. (8 Lectures)

Oscillations:
Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

Elasticity:
Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire – Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method. (8 Lectures)

Speed Theory of Relativity:
Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. (7 Lectures)

Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.

Reference Books:

-University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison
-Wesley Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
-Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
-University Physics, Ronald Lane Reese, 2003, Thomson
-Brooks/Cole. A textbook of General Physics, Edser
-Oscillations and waves, Satya Prakash.
-A textbook of oscillation, waves and Acoustics, M. Ghosh and D. Bhattacharya

COURSE OUTCOME

1. Apply the laws of motion to analyze and solve problems related to the motion of objects under various force conditions.

2. Develop the ability to model physical systems using ordinary differential equations (ODEs) and solve them for dynamic behaviors.

3. Understand and apply the principles of momentum and energy conservation to solve complex mechanical systems.

4. Analyze translational and rotational motion of rigid bodies and solve related problems in mechanics.

5. Use work-energy theorems to solve problems related to work, energy, and power in mechanical systems.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	2	3	1	3	3	1	1	2
CO-2	2	1	1	1	2	3	2	0	1	2
CO-3	3	1	1	3	1	0	1	2	2	2
CO-4	1	2	3	2	2	2	3	3	2	1
CO-5	3	2	2	0	2	2	3	0	2	1
AVERAGE CO	2	1.8	1.8	1.8	1.6	2	2.4	1.2	1.6	1.6

1: Weakly related, 2: Moderately related and 3: strongly related

GE 1 LAB: MECHANICS

COURSE OBJECTIVE

1. **Understanding of Basic Mechanical Concepts**: To help students apply theoretical concepts from mechanics in real-world experiments, reinforcing the understanding of forces, motion, energy, and material properties.
2. **Practical Application of Theories**: To demonstrate the practical aspects of mechanics using laboratory experiments, such as the laws of motion, equilibrium, and friction, enhancing the conceptual clarity and application of mechanics.
3. **Development of Experimental Skills**: To develop essential laboratory skills, including the use of mechanical tools, measurement techniques, data collection, and analysis methods in mechanical experiments.
4. **Problem Solving and Analytical Thinking**: To foster problem-solving abilities and critical thinking in students as they analyze experimental data, perform error analysis, and evaluate results in comparison with theoretical predictions.
5. **Collaboration and Communication**: To enhance teamwork and communication skills by engaging students in collaborative experiments and report writing, encouraging them to present their findings and discuss experimental results.

LIST OF EXPERIMENTS

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Moment of Inertia of a Flywheel.
3. To determine the Young's Modulus of a bar by method of bending.
4. To determine the Elastic Constants of a Wire by Searle's method.
5. To determine g by Bar Pendulum.
6. To determine g by Kater's Pendulum.
7. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

Reference Books:

Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New
Delhi.

COURSE OUTCOME

1. **Apply Fundamental Mechanical Principles**: Demonstrate the ability to apply fundamental concepts of mechanics (e.g., Newton's Laws, equilibrium, work, and energy) in laboratory settings through practical experiments.
2. **Use Laboratory Instruments and Equipment**: Effectively use laboratory equipment such as force meters, accelerometers, motion sensors, and other mechanical instruments to conduct experiments and measure various physical quantities.
3. **Conduct Experiments and Analyze Data**: Perform mechanical experiments, accurately measure physical quantities, and analyze the data obtained to draw meaningful conclusions about the mechanics principles being studied.
4. **Understand and Identify Sources of Error**: Recognize and evaluate potential sources of error in experiments, including instrument calibration, measurement precision, and environmental factors, and develop strategies to minimize them.
5. **Collaborate and Communicate Scientific Findings**: Work effectively in teams to conduct experiments, and present results clearly through written reports and oral presentations, adhering to scientific methodologies.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	2	2	1	3	1	1	1	2
CO-2	2	1	3	3	2	3	2	1	1	2
CO-3	3	1	3	3	1	2	1	2	2	2
CO-4	1	2	3	2	0	2	3	3	2	1
CO-5	3	2	2	1	2	-3	3	2	2	0
AVERAGE CO	2.2	1.8	2.6	2.2	1.2	1.4	2	1.8	1.6	1.4

1: Weakly related, 2: Moderately related and 3: strongly related

SEMESTER –II

C3 Real Analysis

COURSE OBJECTIVE

The main concern of algebra is to -

1. Understand the Fundamental Properties of R\mathbb{R}R:
2. Analyze Convergence of Sequences:
3. Explore Continuity and Limits:
4. Study Series and Convergence Tests:
5. Investigate Uniform Convergence and Series of Functions:

Review of Algebraic and Order Properties of *R*, ð-neighborhood of a point in *R*, Idea of countable sets, uncountable sets and uncountability of *R*. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R*, The Archimedean Property, Density of Rational (and Irrational) numbers in *R*, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

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.

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

Books Recommended

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.

COURSE OUTCOME

This course will enable the students to –

1. 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 $\mathbb{R}$.

2. Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and To calculate their limit superior, limit inferior, and the limit of a bounded sequence.

3. Apply the ratio, root, and alternating series and limit comparison tests for Convergence and absolute convergence of an infinite series of real numbers.
4. To understand the basic concept of real number system and to identify the open and closed sets.
5. Understand the concept of sequence and series of functions.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	0	3	1	2	3	1	1	2
CO-2	3	1	2	1	2	3	2	0	1	2
CO-3	3	1	1	3	0	0	1	1	3	3
CO-4	0	1	3	2	2	2	3	3	2	1
CO-5	1	2	2	2	2	2	3	0	2	3
AVERAGE CO	1.8	1.6	1.6	2.2	1.4	1.8	2.4	1	1.8	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

C4 Differential Equations

COURSE OBJECTIVE :

The main concern of algebra is to -

1. Understand the Basics of Ordinary Differential Equations (ODEs):
2. Analyze Equilibrium Points and Stability:
3. Interpret the Phase Plane:
4. Apply Mathematical Models to Real-World Problems:
5. Understand the Role of the Wronskian in Solution Uniqueness:

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

Books Recommended

1. Belinda Barnes and Glenn R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab,* 2nd Ed., Taylor and Francis group, London and New York, 2009.

2. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling,* Pearson Education India, 2005.

3. S.L. Ross, *Differential Equations,* 3rd Ed., John Wiley and Sons, India, 2004.

4. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press, 2004.

List of Practicals (using any software)

1. Plotting of second order solution family of differential equation.

2. Plotting of third order solution family of differential equation.

3. Growth model (exponential case only).

4. Decay model (exponential case only).

5. Lake pollution model (with constant/seasonal flow and pollution concentration).

6. Case of single cold pill and a course of cold pills.

7. Limited growth of population (with and without harvesting).

8. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).

9. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).

10. Battle model (basic battle model, jungle warfare, long range weapons).

11. Plotting of recursive sequences.

12. Study the convergence of sequences through plotting.

13. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.

14. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.

15. Cauchy's root test by plotting n^{th} roots.

16. Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

COURSE OUTCOME

This course will enable the students to –

1) To understand the Plotting of recursive sequences, Plotting of second order solution family of differential equation.
2) To learn Growth model (exponential case only) , Decay model (exponential case only).
3) To Study the convergence of sequences, the convergence/divergence of infinite series by plotting their sequences of partial sum.
4) To understand the Wronskian - its properties and applications.
5) To understand the linear equation and Bernoulli equations, special integrating factors and transformations

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	0	2	2
CO-3	2	1	1	2	1	2	1	1	3	3
CO-4	1	1	3	2	2	2	3	3	2	1
CO-5	1	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.8	1.8	1.2	2.2	2.4	1.6	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

GE2.1 Mathematical Finance

COURSE OBJECTIVE

1. **Understand the fundamental concepts of financial mathematics**, including time value of money, interest rates, and financial instruments.

2. **Learn to apply mathematical tools** and techniques, such as calculus, probability theory, and optimization, to solve financial problems.

3. **Analyze various financial models** for pricing and hedging options, bonds, and other financial derivatives.

4. **Study risk management techniques** and understand how mathematical models are used to assess and mitigate financial risks.

5. **Develop proficiency in financial modeling** using mathematical methods to forecast and evaluate the performance of financial portfolios.

Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds.

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.

Books Recommended

1. David G. Luenberger, *Investment Science,* Oxford University Press, Delhi, 1998.

2. John C. Hull, *Options, Futures and Other Derivatives*, 6th Ed., Prentice-Hall India, Indian reprint, 2006.

3. Sheldon Ross, *An Elementary Introduction to Mathematical Finance*, 2nd Ed., Cambridge University Press, USA, 2003.

COURSE OUTCOME

1. **Apply mathematical techniques** to solve real-world financial problems, including the time value of money, compound interest, and loan amortization.
2. **Understand and implement financial models** for pricing derivatives, options, and bonds, using tools like the Black-Scholes model.
3. **Analyze financial instruments** and assess risk using mathematical methods such as stochastic processes and probability theory.
4. **Utilize optimization techniques** in portfolio management to balance risk and return and optimize investment strategies.
5. **Develop proficiency in financial modeling** for valuing assets, assessing market trends, and forecasting financial outcomes.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	1	2	2
CO-3	2	2	1	2	1	2	1	1	3	3
CO-4	1	1	2	1	2	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.6	1.6	1.2	2.2	2.4	1.4	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

GE2.2 Econometrics

COURSE OBJECTIVE

1. **Understand the fundamental concepts of econometrics**, including statistical techniques and their applications in economic data analysis.
2. **Develop skills in applying econometric methods** to estimate economic models and interpret their results.
3. **Learn to formulate and test hypotheses** about economic relationships using regression analysis and other statistical tools.
4. **Understand and apply the classical linear regression model (CLRM)**, including assumptions, estimation techniques, and hypothesis testing.
5. Examine the application of econometric methods in real-world data analysis, particularly in areas such as macroeconomics, microeconomics, and finance.

Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.

Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.

Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R2 and adjusted R2 ; partial regression coefficients; testing hypotheses – individual and joint; functional forms of regression models; qualitative (dummy) independent variables.

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation.

Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

Books Recommended

1. Jay L. Devore, *Probability and Statistics for Engineers*, Cengage Learning, 2010.

2. John E. Freund, *Mathematical Statistics*, Prentice Hall, 1992.

3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications,* Prentice Hall, 2011.

4. D. N. Gujarati and D.C. Porter, *Essentials of Econometrics*, McGraw Hill, 4th Ed.,

International Edition, 2009.

5. Christopher Dougherty, *Introduction to Econometrics*, Oxford University Press, 3rd Ed., Indian edition, 2007.

COURSE OUTCOME

1. **Apply econometric techniques** to analyze and estimate economic models using real-world data.
2. **Understand and use the classical linear regression model (CLRM)**, including its assumptions, estimation, and hypothesis testing.
3. **Identify and address issues in econometric modeling**, such as multicollinearity, heteroscedasticity, and autocorrelation, and apply corrective measures.
4. **Utilize advanced econometric methods**, including time series analysis, panel data models, and instrumental variables, to address complex economic problems.
5. **Interpret and evaluate econometric results** in relation to economic theory and real-world applications, providing meaningful insights.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	2	1	3	1	2	3	1	2	1
CO-2	2	2	3	1	0	3	2	2	2	3
CO-3	2	2	1	3	1	2	1	2	3	3
CO-4	1	1	2	1	3	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.8	1.8	1.8	1.4	2.2	2.4	1.8	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

I. GENERIC ELECTIVE (GE 2)

COURSE OBJECTIVE

1. **Understand the fundamental principles** of electricity and magnetism, including Coulomb's law, Gauss's law, Ampère's law, and Faraday's law.
2. **Explore the concepts of electric fields, magnetic fields, and electromagnetic waves**, and learn how they interact in various physical scenarios.
3. **Apply Maxwell's equations** to analyze and describe electric and magnetic phenomena in different contexts, both in static and dynamic situations.
4. **Learn about electromagnetic induction** and its applications, such as in transformers, motors, and generators.
5. **Analyze the behavior of conductors, dielectrics, and magnetic materials** in electric and magnetic fields.

ELECTRICITY AND MAGNETISM Theory: 60 Lectures

Vector Analysis:
Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). (12 Lectures)

Electrostatics:
Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theoremElectric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. (22 Lectures)

Magnetism:
Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferromagnetic materials. (10 Lectures)

Electromagnetic Induction:

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. (6 Lectures)

Maxwell`s equations and Electromagnetic wave propagation:
Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy
density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. (10 Lectures)
56
Reference Books:

Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press
Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.
Electricity and Magnetism, Chattopadhyaya and Rakshit
Electricity and Magnetism, Mahajan and Rangwala
Electricity and Magnetism, K. K. Tewary.

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GE 2 LAB: ELECTRICITY AND MAGNETISM 60 Lectures
1. To use a Multimeter for measuring
(a) Resistances, (b) AC and DC Voltages,
(c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
(i) Measurement of charge and current sensitivity
(ii) Measurement of CDR
(iii) Determine a high resistance by Leakage Method
(iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. To study the Characteristics of a Series RC Circuit.
5. To study a series LCR circuit LCR circuit and determine its
(a) Resonant frequency, (b) Quality factor
6. To study a parallel LCR circuit and determine its
(a) Anti-resonant frequency and (b) Quality factor Q
7. To verify the Thevenin and Norton theorems
8. To verify the Superposition, and Maximum Power Transfer Theorems
Reference Books

Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Maha

COURSE OUTCOME

1. **Apply the principles of electric fields, magnetic fields, and electromagnetism** to solve problems in electricity and magnetism.

2. **Demonstrate the ability to use Maxwell's equations** in analyzing electric and magnetic fields in various contexts, including static and time-varying situations.
3. **Solve complex problems involving electric circuits** using Kirchhoff's laws and other circuit analysis methods.
4. **Analyze electromagnetic waves** and understand their properties, including their generation, propagation, and interaction with matter.
5. **Understand the behavior of materials** in electric and magnetic fields and apply this knowledge to real-world scenarios such as capacitors, inductors, and magnetic media.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	1	2	2
CO-3	2	2	1	2	1	2	1	1	3	3
CO-4	1	1	2	1	2	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.6	1.6	1.2	2.2	2.4	1.4	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

SEMESTER-III

C5 Theory of Real Functions

COURSE OBJECTIVE :

1. Understand the Concept of Limits of Functions:
2. Apply the Sequential Criterion for Limits:
3. Study the Differentiability of Functions:
4. Examine the Darboux Theorem:
5. Analyze the Relationship Between Continuity and Differentiability:

Limits of functions (ϵ — ð approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem, Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Taylor's theorem to inequalities.

Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, ln(1 + x), 1/ax+b and $(1 +x)^n$.

COURSE OUTCOME :

This course will enable the students to –

1. Learn about Limits of functions (ϵ — ð approach)
2. Proficiency in Sequence and Series Convergence:
3. Understanding Continuity, Differentiability
4. Students will be able to apply real analysis techniques to real-world problems in various fields such as physics, economics, biology, and engineering.
5. Find out different approach of Algebra of continuous functions.

Books Recommended

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 B.V. Limaye, *A Course in Calculus and Real Analysis,* Springer, 2006.

CO AND PO MAPPING

CO	*PO-1*	*PO-2*	*PO-3*	*PO-4*	*PO-5*	*PO-6*	*PO-7*	*PO-8*	*PO-9*	*PO-10*
CO-1	3	2	2	3	2	1	2	1	2	3
CO-2	2	2	1	1	2	1	2	3	1	2
CO-3	1	3	2	2	1	2	3	0	2	3
CO-4	3	2	3	1	3	2	1	3	2	0
CO-5	3	3	1	2	3	2	2	2	2	2
AVERAGE CO	2.4	2.4	1.8	1.8	2.2	1.6	2	1.8	1.8	2

1 .Weakly related, 2: Moderately related and 3: strongly related

C6 Group Theory I

COURSE OBJECTIVE :

1. Understand the Fundamental Concepts of Group Theory:
2. . Study the Properties and Structure of Cyclic Groups:
3. Explore Normal Subgroups and Quotient Groups:
4. Understand Group Homomorphisms and Isomorphisms:
5. Apply Group Theoretic Concepts to Solve Problems:

Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups.

Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

Books Recommended

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 A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, New Delhi, 1999.

4. Joseph J. Rotman, *An Introduction to the Theory of Groups,* 4th Ed., Springer Verlag, 1995.

5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.

COURSE OUTCOME

This course will enable the students to

1. Learn about properties of group e.g- permutation groups and quaternion groups

2. Gain knowledge of Group Homomorphism , properties of isomorphisms.

3. Proficiency in Analyzing Cyclic Groups:

4. Understanding Normal Subgroups and Quotient Groups:

5. Students will develop the ability to apply group-theoretic concepts to solve algebraic problems and prove results

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	2	3	1	3	3	1	2	1
CO-2	1	3	3	1	0	3	2	2	2	2
CO-3	1	2	2	3	1	3	1	1	3	2
CO-4	3	2	1	1	3	2	3	1	2	1
CO-5	2	2	2	1	2	2	3	3	1	3
AVERAGE CO	1.8	2.4	2	1.8	1.4	2.6	2.4	1.6	2	1.8

1: Weakly related, 2: Moderately related and 3: strongly related

C7 PDE and Systems of ODE

COURSE OBJECTIVE :

1. Understand and Solve First- and Second-Order Partial Differential Equations:

2. Analyze the Behavior and Stability of Solutions to Systems of Ordinary Differential Equations:

3 .Master Advanced Solution Techniques for Linear and Nonlinear Systems:

4 Apply Boundary and Initial Conditions in the Context of PDEs:

5. Develop Computational Skills for Solving PDEs and ODEs:

Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First-Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.

Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms.

The Cauchy problem, the Cauchy-Kowaleewskaya theorem, Cauchy problem of an infinite string. Initial Boundary Value Problems, Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end, Equations with non-homogeneous boundary conditions, Non-Homogeneous Wave Equation. Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions, The method of successive approximations, the Euler method, the modified Euler method, The Runge-Kutta method.

Books Recommended

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

2. S.L. Ross, *Differential equations,* 3rd Ed., John Wiley and Sons, India, 2004.

3. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press, 2004.

List of Practicals (using any software)

(i) Solution of Cauchy problem for first order PDE.

(ii) Finding the characteristics for the first order PDE.

(iii) Plot the integral surfaces of a given first order PDE with initial data.

(iv) Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c_2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions

(a) $u(x,0) = \phi(x), \quad u_t(x,0) = \psi(x), \quad x \in R, \ t > 0$

(b) $u(x,0) = \phi(x), \quad u_t(x,0) = \psi(x), \quad u(0,t) = 0, \ x \in (0,\infty), \ t > 0$

(c) $u(x,0) = \phi(x), \quad u_t(x,0) = \psi(x), \quad u_x(0,t) = 0, \ x \in (0,\infty), \ t > 0$

(d) $u(x,0) = \phi(x), \quad u_t(x,0) = \psi(x), \quad u(0,t) = 0, \quad u(1,t) = 0, \quad 0 < x < l, \ t > 0$

(v) Solution of wave equation $\frac{\partial u}{\partial t} - k_2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions

(a) $u(x,0) = \phi(x), \ u(0,t) = a, \ u(l,t) = b, \ 0 < x < l, \ t > 0$

(b) $u(x,0) = \phi(x), \ x \in R, \ 0 < t < T$

(c) $u(x,0) = \phi(x), \ u(0,t) = a, \ x \in (0,\infty), \ t \geq 0$

COURSE OUTCOME

This course will enable the students to

1. Ability to Solve and Interpret Common PDEs and ODEs:
2. Mastery of Analytical and Numerical Methods for PDEs and ODEs:
3. Competence in Analyzing Stability and Behavior of Solutions:
4. Ability to Apply Boundary and Initial Conditions in Practical Contexts:
5. Effective Use of Computational Tools for Differential Equations:

1: Weakly related, 2: Moderately related and 3: strongly related

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	1	2	2
CO-3	2	2	1	2	1	2	1	1	3	3
CO-4	1	1	2	1	2	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.6	1.6	1.2	2.2	2.4	1.4	2.2	2.2

1 .Weakly related, 2: Moderately related and 3: strongly related

NETAJI SUBHAS UNIVERSITY ★ JAMSHEDPUR

GE3.1 Cryptography and Network Security

COURSE OBJECTIVE

1. **Understand the fundamental principles of cryptography** and network security, including encryption, decryption, hashing, and authentication mechanisms.
2. **Learn about classical and modern encryption algorithms**, including symmetric key cryptography (e.g., DES, AES) and asymmetric key cryptography (e.g., RSA, ECC).
3. **Study cryptographic protocols** for secure communication, including SSL/TLS, digital signatures, and key exchange protocols.
4. **Analyze network security threats and vulnerabilities**, and understand methods for securing networks against attacks, such as firewalls, intrusion detection systems, and VPNs.
5. **Understand and implement** authentication mechanisms, including password-based systems, biometrics, and multi-factor authentication.

Public Key Cryptography Principles & Applications, Algorithms: RSA, Message Authentication: One way Hash Functions: Message Digest, MD5, SHA1. Public Key Infrastructure: Digital Signatures, Digital Certificates, Certificate Authorities.

Network Attacks: Buffer Overflow, IP Spoofing, TCP Session Hijacking, Sequence Guessing, Network Scanning: ICMP, TCP sweeps, Basic Port Scans; Denial of Service Attacks: SYN Flood, Teardrop attacks, land, Smurf Attacks.IP security Architecture: Overview, Authentication header, Encapsulating Security Pay Load, combining Security Associations, Key Management. Virtual Private Network Technology: Tunneling using IPSEC.

Requirements, Secure Socket Layer, and Secure Electronic Transactions, Network Management Security: Overview of SNMP Architecture- SNMPV1, SNMPV3.Firewall Characteristics & Design Principles, Types of Firewalls: Packet Filtering Router, Application Level Gateway or Proxy, Content Filters, Bastion Host.

Books Recommended

1. W. Stallings, *Networks Security Essentials: Application & Standards,* Pearson Education, 2000.

2.TCP/IP Protocol Suite , Behrouz A. Forouzan, *Data Communication and Networking*, Tata McGraw Hill.

3. W. Stallings, *Cryptography and Network Security, Principles and Practice*, Pearson Education, 2000.

COURSE OUTCOME

1. **Apply cryptographic techniques** to secure data, ensuring confidentiality, integrity, and authenticity in digital communication systems.
2. **Implement and evaluate various encryption algorithms** (symmetric and asymmetric), such as AES, RSA, and ECC, for protecting data.
3. **Design and analyze secure communication protocols**, including SSL/TLS, IPsec, and key exchange protocols, for securing data transmission over networks.
4. **Understand and apply authentication methods**, including password-based systems, biometrics, digital signatures, and multi-factor authentication to verify the identity of users and systems.
5. **Analyze and mitigate network security vulnerabilities**, including attacks like man-in-the-middle, denial-of-service, and eavesdropping, and understand countermeasures like firewalls and intrusion detection systems (IDS).

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	1	3	1	3	3	1	2	1
CO-2	2	2	3	1	1	3	2	2	2	2
CO-3	1	2	2	3	1	0	1	1	2	2
CO-4	3	2	1	3	3	2	3	3	2	1
CO-5	2	2	2	1	2	1	3	3	1	3
AVERAGE CO	1.8	2.2	1.8	2.2	1.6	1.8	2.4	2	1.8	1.8

1: Weakly related, 2: Moderately related and 3: strongly related

GE 3.2 Information Security

COURSE OBJECTIVE

1. **Understand the foundational concepts of information security**, including confidentiality, integrity, availability, and authentication.
2. **Learn the principles of risk management** and apply them to identify, assess, and mitigate security risks in information systems.
3. **Study common security threats and vulnerabilities** in information systems and networks, including malware, phishing, and social engineering attacks.
4. **Develop the skills to implement and manage security measures** such as encryption, access control, firewalls, and intrusion detection systems.
5. Understand and apply security policies and frameworks, such as ISO 27001, NIST, and other standards, to safeguard organizational assets.

Overview of Security: Protection versus security; aspects of security–data integrity, data availability, privacy; security problems, user authentication, Orange Book.

Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy.

Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data EncryptionStandard, advanced encryption standards, public key encryption - RSA; Diffie-Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.

Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.

Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

Books Recommended

1. W. Stallings, *Cryptography and Network Security Principles and Practices,* 4th Ed., Prentice-Hall of India, 2006.

2. C. Pfleeger and S.L. Pfleeger, *Security in Computing*, 3rd Ed., Prentice-Hall of India, 2007.

3. D. Gollmann, *Computer Security*, John Wiley and Sons, NY, 2002.

4. J. Piwprzyk, T. Hardjono and J. Seberry, *Fundamentals of Computer Security,* Springer-Verlag Berlin, 2003.

5. J.M. Kizza, *Computer Network Security*, Springer, 2007.

6. M. Merkow and J. Breithaupt, *Information Security: Principles and Practices,* Pearson Education, 2006.

COURSE OUTCOME

1. **Apply information security principles** to design, implement, and manage secure systems that ensure confidentiality, integrity, and availability of data.
2. **Identify, assess, and mitigate security risks** in information systems using risk management frameworks and techniques.
3. **Analyze and defend against common security threats** such as malware, phishing, and social engineering, and implement appropriate countermeasures.
4. **Implement security measures** like encryption, firewalls, and access control mechanisms to protect data from unauthorized access and modification.
5. **Apply security policies and standards** (e.g., ISO 27001, NIST) to ensure the security of information systems within an organization.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	2	3	1	3	3	2	2	1
CO-2	3	1	3	1	1	3	2	2	3	2
CO-3	2	1	2	2	2	1	0	1	2	2
CO-4	3	2	3	3	3	2	3	3	3	2
CO-5	2	2	2	1	2	1	2	3	1	3
AVERAGE CO	2.4	1.8	2.4	2	1.8	2	2	2.2	2.2	2

1: Weakly related, 2: Moderately related and 3: strongly related

SEC1.1 Logic and Sets

COURSE OBJECTIVE :

1. Understand and Apply Fundamental Logical Operations:
2. Master Set Theory Concepts and Operations:
3. Prove and Analyze Logical Statements and Set Identities:
4. Apply Quantifiers and Logical Structures in Problem-Solving:
5. Explore the Foundations of Logic and Set Theory in Mathematics:

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

Books Recommended

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.

2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.

3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

COURSE OUTCOME

This course will enable the students to

1. Understanding of Logical Propositions:.
2. Mastery of Set Operations:

3. Application of Predicate Logic:

4. Understanding of Logical Proof Techniques:.

5. learn Set Theory and Relations

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	3	1	3	1	3	3	2	2	1
CO-2	1	2	3	1	1	3	2	2	3	2
CO-3	1	1	2	2	2	1	1	1	2	2
CO-4	3	1	1	3	1	2	3	3	0	1
CO-5	2	2	2	1	2	1	2	2	1	3
AVERAGE CO	2	1.8	1.8	2	1.4	2	2.2	2	1.6	1.8

1: Weakly related, 2: Moderately related and 3: strongly related

SEC1.2 Computer Graphics

COURSE OBJECTIVE :

1. Understand and Implement Raster Scan Graphics: n.
2. Develop and Analyze Random Scan (Vector) Graphics:.
3. Apply Storage Techniques in Graphics Systems:.
4. Generate and Manipulate Conic Sections:.
5. Evaluate and Compare Graphics Techniques:

Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices. Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

Books Recommended

1. D. Hearn and M.P. Baker, *Computer Graphics,* 2nd Ed., Prentice–Hall of India, 2004.

2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, *Computer Graphics: Principals and Practices,* 2nd Ed., Addison-Wesley, MA, 1990.

3. D.F. Rogers, *Procedural Elements in Computer Graphics,* 2nd Ed., McGraw Hill Book Company, 2001.

4. D.F. Rogers and A.J. Admas, *Mathematical Elements in Computer Graphics,* 2nd Ed., McGraw Hill Book Company, 1990.

COURSE OUTCOME

1. **Understand the fundamental concepts of computer graphics**, including graphics systems, image representation, and basic rendering techniques.
2. **Apply geometric transformations** such as translation, rotation, scaling, and reflection to manipulate and modify objects in a 2D or 3D space.
3. Implement **and work with algorithms for line, circle, and polygon drawing** (e.g., Bresenham's algorithm) to create graphical objects.
4. **Understand and apply the principles of 3D graphics**, including 3D transformations, projection, and rendering techniques to create 3D objects and scenes.
5. **Apply lighting and shading techniques** in 3D computer graphics to enhance

realism, using models such as Phong and Gouraud shading.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	1	2	2
CO-3	2	2	1	2	1	2	1	1	3	3
CO-4	1	1	2	1	2	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.6	1.6	1.2	2.2	2.4	1.4	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

SEMESTER-IV

C8 Numerical Methods

COURSE OBJECTIVE

Use of Scientific Calculator is allowed.

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation.

Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.

List of Practicals (using any software)

(i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 +-----------+ 1/ N.
(ii) To find the absolute value of an integer.
(iii) Enter 100 integers into an array and sort them in an ascending order.
(iv) Bisection Method.
(v) Newton Raphson Method.
(vi) Secant Method.
(vii) Regulai Falsi Method.
(viii) LU decomposition Method.
(ix) Gauss-Jacobi Method.
(x) SOR Method or Gauss-Siedel Method.
(xi) Lagrange Interpolation or Newton Interpolation.
(xii) 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.

Books Recommended

1. Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.

2. 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.

3. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008.

4. Uri M. Ascher and Chen Greif, *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited, 2013.

5. John H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited, 2012

COURSE OUTCOME

1. **Understand and apply numerical methods** for solving algebraic and transcendental equations, such as the bisection method, Newton-Raphson method, and secant method.
2. **Develop and apply numerical techniques** for solving systems of linear and nonlinear equations using methods like Gaussian elimination, LU decomposition, and iterative methods (Jacobi, Gauss-Seidel).
3. **Understand and implement numerical differentiation** and integration methods, such as finite differences, Simpson's rule, and trapezoidal rule, to approximate derivatives and integrals.
4. **Apply numerical methods** to solve ordinary differential equations (ODEs) using techniques like Euler's method, Runge-Kutta methods, and predictor-corrector methods.
5. **Develop skills to solve partial differential equations (PDEs)** using finite difference methods for problems in heat transfer, fluid dynamics, and other engineering applications.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	3	3	3	3	2	2	2
CO-2	2	2	2	1	2	3	2	2	3	2
CO-3	1	1	2	2	2	1	1	1	2	3
CO-4	2	2	1	3	1	2	3	3	2	2
CO-5	2	2	2	1	2	1	2	2	1	1
AVERAGE CO	1.8	2	1.6	2	2	2	2.2	2	2	2

1: Weakly related, 2: Moderately related and 3: strongly related

C9 Riemann Integration and Series of Functions

COURSE OBJECTIVE

1. **Understand the foundational concepts** of Riemann integration, including the definition, properties, and conditions for a function to be Riemann integrable.
2. **Develop a deep understanding of the criteria for integrability** and learn to apply the concept of partitioning intervals and approximation to solve integrals.
3. **Learn to evaluate the Riemann integrals** for continuous and discontinuous functions, and understand the significance of integrability in different scenarios.
4. **Analyze and apply concepts of convergence** and limit theorems to the study of improper integrals and integrals of functions defined on unbounded intervals.
5. Study the properties of series of functions**, including uniform convergence, pointwise convergence, and their implications for integration and differentiation.**

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.

Improper integrals; Convergence of Beta and Gamma functions.

Pointwise 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.

Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.

Books Recommended

1. K.A. 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

COURSE OUTCOME

1. **Define and compute the Riemann integrals** of continuous and piecewise continuous functions over closed intervals.
2. **Determine the conditions for a function to be Riemann integrable**, applying the concepts of boundedness, partitions, and upper and lower sums.
3. **Solve problems involving improper integrals**, including those with infinite limits and unbounded functions, using limit processes.
4. **Apply convergence tests** (e.g., Weierstrass M-test) to series of functions and determine their uniform and pointwise convergence.
5. **Analyze the effects of uniform convergence** on the interchange of limits and integration in series of functions.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	1	3	3	3	3	2	2	2
CO-2	2	2	2	1	2	2	2	2	3	2
CO-3	1	1	2	2	3	1	1	1	2	2
CO-4	0	2	1	2	1	2	3	3	2	2
CO-5	2	2	1	2	2	1	2	1	1	0
AVERAGE CO	1.2	2	1.4	2	2.2	1.8	2.2	1.8	2	1.6

1: Weakly related, 2: Moderately related and 3: strongly related

C10 Ring Theory and Linear Algebra I

COURSE OBJECTIVE

1. **Understand the basic concepts of ring theory**, including the definition of rings, subrings, ideals, and homomorphisms.
2. **Explore different types of rings**, such as commutative rings, integral domains, and fields, and understand their properties.
3. **Develop a deep understanding of polynomial rings**, and learn to factor polynomials and solve problems in polynomial rings.
4. **Study the structure of vector spaces**, including their axioms, subspaces, linear independence, and basis.
5. **Understand and apply the concepts of linear transformations** between vector spaces and learn how to represent these transformations using matrices.

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.

Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.

2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.

3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

4. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.

5. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer, 2005.

6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.

7. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India,1999.

8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

9. D.A.R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

COURSE OUTCOME

1. **Define and apply the basic properties of rings**, including operations on rings, ideals, and homomorphisms, and recognize different types of rings.
2. **Solve problems involving polynomial rings**, including factorization and finding roots of polynomials.
3. **Analyze vector spaces and their subspaces**, and use these concepts to determine linear independence, span, and dimension.
4. **Apply matrix representation** of linear transformations and calculate their effects on vector spaces.
5. **Solve systems of linear equations** using matrix methods like Gaussian elimination and matrix inverses, and **interpret the solutions geometrically.**

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	1	2	2
CO-3	2	2	1	2	1	2	1	1	3	3
CO-4	1	1	2	1	2	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.6	1.6	1.2	2.2	2.4	1.4	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

GE4.1 Applications of Algebra

COURSE OBJECTIVE

1. **Understanding Core Algebraic Concepts**: Gain a strong foundation in algebraic principles such as equations, inequalities, polynomials, and functions.
2. **Solving Real-World Problems**: Apply algebraic techniques to solve real-life problems in various fields, including physics, economics, engineering, and computer science.
3. **Modeling with Algebra**: Develop skills in using algebraic methods to create models that represent real-world situations, including optimization problems and data analysis.
4. **Advanced Algebraic Techniques**: Learn advanced topics such as matrices, determinants, and systems of linear equations and their applications in diverse domains.
5. **Mathematical Reasoning**: Cultivate logical reasoning and critical thinking through algebraic proofs and problem-solving strategies.

Balanced incomplete block designs (BIBD): definitions and results, incidence matrix of a BIBD, construction of BIBD from difference sets, construction of BIBD using quadratic residues, difference set families, construction of BIBD from finite fields.

Coding Theory: introduction to error correcting codes, linear cods, generator and parity check matrices, minimum distance, Hamming Codes, decoding and cyclic codes.

Symmetry groups and color patterns: review of permutation groups, groups of symmetry and action of a group on a set; colouring and colouring patterns, Polya theorem and pattern inventory, generating functions for non-isomorphic graphs.

Special types of matrices: idempotent, nilpotent, involution, and projection tri diagonal matrices, circulant matrices, Vandermonde matrices, Hadamard matrices, permutation and doubly stochastic matrices, Frobenius- König theorem, Birkhoff theorem. Positive Semi-definite matrices: positive semi-definite matrices, square root of apositive semi-definite matrix, a pair of positive semi-definite matrices, and their simultaneous diagonalization. Symmetric matrices and quadratic forms: diagonalization of symmetric matrices, quadratic forms, constrained optimization, singular value decomposition, and applications to image processing and statistics.

Applications of linear transformations: Fibonacci numbers, incidence models, and differential equations. Least squares methods: Approximate solutions of system of linear equations, approximate inverse of an $m \times n$ matrix, solving a matrix equation using its normal equation, finding functions that approximate data. Linear algorithms: LDU factorization, the row reduction algorithm and its inverse, backward and forward substitution, approximate inverse and projection algorithms.

Books Recommended

1. I. N. Herstein and D. J. Winter, *Primer on Linear Algebra*, Macmillan Publishing Company, New York, 1990.

2. S. R. Nagpaul and S. K. Jain, *Topics in Applied Abstract Algebra*, Thomson Brooks and Cole, Belmont, 2005.

3. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, *Applications of Abstract Algebra with Maple*, CRC Press LLC, Boca Raton, 2000.

4. David C. Lay, *Linear Algebra and its Applications.* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

5. Fuzhen Zhang, *Matrix theory*, Springer-Verlag New York, Inc., New York, 1999.

COURSE OUTCOME

1. **Understand the fundamental concepts of algebra** and their applications in real-world problems, including group theory, ring theory, and field theory.
2. **Learn how algebraic structures**, such as groups, rings, and fields, are used in various branches of mathematics and other fields like computer science, physics, and engineering.
3. **Apply algebraic techniques** to solve problems related to polynomial equations, vector spaces, and matrix theory.
4. **Develop an understanding of algebraic systems** and their role in cryptography, coding theory, and error correction.
5. **Explore the applications of algebra in solving linear and nonlinear equations**, using techniques like matrix operations, determinants, and systems of equations.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	3	3	3	3	2	2	2
CO-2	1	1	2	3	2	2	2	2	3	1
CO-3	1	2	2	2	3	2	2	1	2	1
CO-4	2	1	1	2	2	2	3	3	2	2
CO-5	2	2	2	2	2	1	1	1	1	1
AVERAGE CO	1.6	1.8	1.6	2.4	2.4	2	2.2	1.8	2	1.4

1: Weakly related, 2: Moderately related and 3: strongly related

GE4.2 Combinatorial Mathematics

COURSE OBJECTIVE

1. **Fundamentals of Combinatorics**: To introduce the foundational concepts of combinatorics such as counting principles (addition and multiplication rules), permutations, combinations, and the basic principle of inclusion-exclusion.
2. **Mathematical Reasoning**: To develop logical reasoning skills in students, enabling them to approach problems systematically and apply mathematical techniques in real-world scenarios.
3. **Advanced Counting Techniques**: To explore more advanced topics like generating functions, recurrence relations, and advanced counting strategies including combinatorial designs and partitions.
4. **Graph Theory**: To familiarize students with key ideas in graph theory, including the study of networks, trees, Eulerian and Hamiltonian paths, and their applications in solving combinatorial problems.
5. **Applications of Combinatorics**: To apply combinatorial techniques in solving problems in computer science, optimization, cryptography, and other fields, showcasing the real-world utility of combinatorial mathematics.

Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers

Principle of Inclusion and Exclusion, Derangements, Inversion formulae

Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.

Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.

Integer partitions, Systems of distinct representatives.

Polya theory of counting: Necklace problem and Burnside's lemma, Cyclic index of a permutation group, Polya's theorems and their immediate applications.

Latin squares, Hadamard matrices, Combinatorial designs: *t* designs, BIBDs, Symmetric designs.

Books Recommended

1. J.H. van Lint and R.M. Wilson, *A Course in Combinatorics*, 2nd Ed., Cambridge University Press, 2001.

2. V. Krishnamurthy, *Combinatorics, Theory and Application*, Affiliated East-West Press 1985.

3. P.J. Cameron, *Combinatorics, Topics, Techniques, Algorithms*, Cambridge University Press, 1995.

4. M. Jr. Hall, *Combinatorial Theory*, 2nd Ed., John Wiley & Sons, 1986.

5. S.S. Sane, *Combinatorial Techniques*, Hindustan Book Agency, 2013.

6. R.A. Brualdi, *Introductory Combinatorics*, 5th Ed., Pearson Education Inc., 2009.

COURSE OUTCOME

1. **Apply algebraic structures** such as groups, rings, and fields to solve problems in pure and applied mathematics.
2. **Solve real-world problems** using algebraic methods like solving systems of linear equations, matrix operations, and determinants.
3. **Understand the applications of algebraic methods** in areas like cryptography, coding theory, and error correction.
4. **Use abstract algebraic techniques** to solve problems in number theory, geometry, and combinatorics.
5. **Apply algebraic concepts to computational problems**, particularly in the development of algorithms, computer graphics, and cryptography.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	3	3	3	3	2	2	2
CO-2	1	2	2	3	1	2	2	2	3	1
CO-3	1	1	1	2	3	2	2	2	2	1
CO-4	2	1	1	2	2	2	3	3	2	2
CO-5	2	3	2	2	2	1	1	2	1	2
AVERAGE CO	1.6	2	1.4	2.4	2.2	2	2.2	2.2	2	1.6

1: Weakly related, 2: Moderately related and 3: strongly related

SEC 2.1 Graph Theory

COURSE OBJECTIVE

1. **Understand the basic concepts of graph theory**, including the definition of graphs, types of graphs, vertices, edges, and their properties.
2. **Explore different types of graphs** such as directed, undirected, weighted, bipartite, trees, and planar graphs, and understand their applications.
3. **Learn the algorithms used in graph theory** for tasks like searching (DFS, BFS), finding the shortest path (Dijkstra's algorithm), and finding spanning trees (Prim's and Kruskal's algorithms).
4. **Study connectivity concepts** in graph theory, including Eulerian and Hamiltonian paths and circuits, and learn how to identify them in graphs.
5. **Understand graph coloring problems**, including vertex coloring, edge coloring, and their applications in scheduling and optimization.

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Books Recommended

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) P. Ltd., Indian Reprint 2003.

3. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

COURSE OUTCOME

1. **Define and understand different types of graphs**, including directed, undirected, weighted, bipartite, trees, and planar graphs.
2. **Apply graph traversal algorithms** (DFS, BFS) to explore graphs and solve problems related to graph connectivity.
3. **Solve shortest path problems** using algorithms like Dijkstra's and Bellman-Ford, and apply them to practical applications.

4. **Identify and analyze Eulerian and Hamiltonian paths and circuits** and apply these concepts to real-world problems in optimization and scheduling.

5. **Solve graph coloring problems** by applying vertex and edge coloring algorithms, and use them in practical optimization tasks such as resource allocation.

CO AND MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	3	3	3	3	1	2	2
CO-2	2	2	2	1	2	2	2	2	1	1
CO-3	2	3	1	2	3	2	2	1	2	1
CO-4	3	1	1	3	2	2	3	3	2	2
CO-5	3	3	2	2	2	3	1	3	1	2
AVERAGE CO	2.4	2.4	1.4	2.2	2.4	2.4	2.2	2	1.6	1.6

1: Weakly related, 2: Moderately related and 3: strongly related

SEC 2.2 Operating System: Linux

COURSE OBJECTIVE

1. **Understand the fundamental concepts of operating systems**, with a particular focus on the Linux operating system, its architecture, and components.
2. **Learn the structure and functionality** of the Linux kernel, shell, and file systems.
3. **Gain proficiency in using Linux commands** and shell scripting to perform various system administration tasks, such as process management, file management, and user administration.
4. **Explore the Linux boot process**, including the stages of booting and initializing the operating system.
5. **Understand process management in Linux**, including process creation, scheduling, synchronization, and inter-process communication (IPC).

Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.

Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

Books Recommended

1. Arnold Robbins, *Linux Programming by Examples The Fundamentals*, 2nd Ed., Pearson Education, 2008.

2. Cox K, *Red Hat Linux Administrator's Guide*, PHI, 2009.

3. R. Stevens, *UNIX Network Programming*, 3rd Ed., PHI, 2008.

4. Sumitabha Das, *Unix Concepts and Applications*, 4th Ed., TMH, 2009.

5. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, *Linux in a Nutshell*, 6th Ed., O'Reilly Media, 2009.

6. Neil Matthew, Richard Stones, Alan Cox, *Beginning Linux Programming*, 3rd Ed., 2004.

COURSE OUTCOME

1. **Understand the core concepts** of Linux operating system architecture, including kernel, shell, and file system structures.
2. **Navigate and manage the Linux file system**, including tasks such as file creation, deletion, moving, and permission management.

3. **Utilize Linux commands and shell scripting** to automate system administration tasks and perform advanced file manipulation and text processing operations.
4. **Understand and manage processes** in Linux, including process creation, termination, scheduling, and synchronization, using commands like `ps`, `top`, and `kill`.

Apply memory management techniques in Linux, including memory allocation, paging, and virtual memory management

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	3	1	3	3	3	3	1	2	2
CO-2	2	2	3	1	2	2	2	2	1	2
CO-3	1	2	1	2	2	2	2	2	2	1
CO-4	2	1	2	3	2	1	3	3	3	2
CO-5	3	3	2	2	2	3	2	2	1	3
AVERAGE CO	2.2	2.2	1.8	2.2	2.2	2.2	2.4	2	1.8	2

1: Weakly related, 2: Moderately related and 3: strongly related

<u>**SEMESTER-V**</u>

C11 Multivariate Calculus

COURSE OBJECTIVE

1. **Understand the fundamental concepts** of multivariable functions and their applications in real-world scenarios, including functions of two or more variables.
2. **Learn partial differentiation** and how to compute derivatives of multivariable functions to analyze rates of change in various directions.
3. **Explore the geometric interpretation of multivariable functions**, such as surfaces, contour plots, and gradients, and their relationships to physical phenomena.
4. **Develop skills in optimization problems**, including finding local maxima, minima, and saddle points using techniques like Lagrange multipliers.
5. Study multiple integration techniques, including double and triple integrals, and their applications in computing volumes, areas, and physical quantities like mass and center of mass.

Use of Scientific calculator is allowed.

Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl

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 and triple integrals. 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. Stoke's theorem, The Divergence theorem.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

3. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE),

Indian reprint, 2005.

4. James Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

COURSE OUTCOME

1. **Understand the concepts of multivariable functions** and apply techniques of partial differentiation to compute derivatives and analyze multivariable functions.
2. **Use partial derivatives** to analyze the behavior of multivariable functions, including directional derivatives and gradients.
3. **Solve optimization problems** in multivariable settings, including using Lagrange multipliers to find constrained maxima and minima.
4. **Perform multiple integrations** (double and triple integrals) and apply these techniques to calculate areas, volumes, and physical quantities such as mass and center of mass.
5. **Interpret and apply the geometric concepts** of level curves, surfaces, and gradients in analyzing the behavior of multivariable functions.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	2	3	3	3	1	2	2
CO-2	2	1	3	1	2	2	2	2	1	2
CO-3	1	1	1	1	2	2	2	2	1	1
CO-4	2	1	2	0	2	1	3	1	3	2
CO-5	3	3	2	2	3	3	1	2	1	0
AVERAGE CO	2	1.8	1.8	1.2	2.4	2.2	2.2	1.6	1.6	1.4

1: Weakly related, 2: Moderately related and 3: strongly related

C12 Group Theory II

COURSE OBJECTIVE

1. **Understand the fundamental concepts of group theory**, including the definition of a group, its properties, and various types of groups such as abelian, cyclic, and permutation groups.
2. **Learn the basic group operations** and axioms such as closure, associativity, identity, and inverse, and their implications in the study of abstract algebra.
3. **Explore the structure and classification of groups**, including subgroups, cosets, normal subgroups, and quotient groups.
4. **Develop the ability to perform group homomorphisms and isomorphisms**, understanding their importance in establishing group equivalence and structure preservation.
5. Study group actions and their applications in various areas of mathematics, such as geometry and symmetry.

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.

Group actions, stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley's theorem, Index theorem.

Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, *p*-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.

Books Recommended

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 A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, 1999.

4. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.

5. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc., 2000.

6. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

COURSE OUTCOME

1. **Define and explain the basic concepts of groups**, such as group operations, identity elements, inverses, and group axioms.
2. **Classify and work with different types of groups**, including cyclic groups, abelian groups, permutation groups, and symmetric groups.
3. **Identify and work with subgroups**, cosets, normal subgroups, and quotient groups, and apply these concepts to solve problems.
4. **Apply group homomorphisms and isomorphisms** to establish equivalence between groups and understand how group structures are preserved under mappings.
5. **Understand and use group actions** to solve problems in symmetry, geometry, and other areas of mathematics.

CO AND PO MAPPING

CO	PO-1	PO-2	1	PO-4	2	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	3	1	2	3	1	2	2
CO-2	3	1	3	1	0	3	2	1	2	2
CO-3	2	2	1	2	1	2	1	1	3	3
CO-4	1	1	2	1	2	2	3	1	2	1
CO-5	0	2	2	1	2	2	3	3	2	3
AVERAGE CO	1.6	1.6	1.6	1.6	1.2	2.2	2.4	1.4	2.2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE1.1 Portfolio Optimization

COURSE OBJECTIVE

1. **Understand the fundamental principles of portfolio optimization**, including the concept of risk and return, diversification, and the trade-off between risk and expected return.

2. **Learn about different asset classes** and how to model and evaluate the risk and return of financial assets in the context of portfolio management.

3. **Explore the Markowitz mean-variance optimization model**, and understand how to apply it for selecting an optimal portfolio of assets.

4. **Study various methods of measuring portfolio performance**, including Sharpe ratio, alpha, and beta, and their importance in assessing portfolio efficiency.

5. **Learn about modern portfolio theory (MPT)**, and how it applies to asset allocation and the construction of diversified investment portfolios.

Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory.

Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

Books Recommended

1. F. K. Reilly, Keith C. Brown, *Investment Analysis and Portfolio Management*, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, *Mean-Variance Analysis in Portfolio Choice and Capital Markets*, Blackwell, New York, 1987.
3. M.J. Best, *Portfolio Optimization*, Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, *Investment Science*, 2nd Ed., Oxford University Press, 2013.

COURSE OUTCOME

1. **Understand and apply portfolio optimization concepts** by balancing risk and return, and constructing portfolios that align with investors' risk preferences and financial goals.

2. **Evaluate the risk and return characteristics** of different assets and understand how to use diversification to minimize portfolio risk.

3. **Apply the Markowitz mean-variance optimization model** to select the optimal portfolio based on expected returns, variances, and covariances of asset returns.

4. **Measure portfolio performance** using key metrics such as Sharpe ratio, alpha, and beta, and interpret these metrics to assess portfolio efficiency and risk-adjusted return.

5. • **Apply Modern Portfolio Theory (MPT)** in asset allocation to construct diversified portfolios that optimize return for a given level of risk.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	1	2	3	3	2	1	2	2
CO-2	2	1	3	1	2	2	2	2	1	2
CO-3	3	2	2	1	3	2	2	2	2	2
CO-4	2	1	2	1	2	1	3	1	3	2
CO-5	3	3	2	2	3	3	1	2	2	0
AVERAGE CO	2.2	2	2	1.4	2.6	2.2	2	1.6	2	1.6

1: Weakly related, 2: Moderately related and 3: strongly related

DSE1.2 Number Theory

COURSE OBJECTIVE

1. **Understand the basic concepts and definitions** in number theory, including prime numbers, divisibility, and the structure of integers.
2. **Learn fundamental theorems** such as the Fundamental Theorem of Arithmetic, and apply them to factorize integers and solve Diophantine equations.
3. **Study modular arithmetic**, including congruences, properties of congruences, and their applications in cryptography and computer science.
4. **Explore number-theoretic functions**, such as Euler's totient function, and understand their importance in solving problems related to primes and divisibility.
5. Learn about Diophantine equations and methods to solve linear and non-linear Diophantine problems, including solutions in integers.

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli. Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.

Books Recommended

1. David M. Burton, *Elementary Number Theory,* 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.

2. Neville Robinns, *Beginning Number Theory,* 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

COURSE OUTCOME

1. **Define and explain basic concepts of number theory**, including prime numbers, divisibility rules, and the Fundamental Theorem of Arithmetic.
2. **Apply modular arithmetic** techniques to solve problems involving congruences, and utilize these techniques in real-world applications like cryptography.

3. **Factorize integers** and solve Diophantine equations, both linear and non-linear, using techniques like the Euclidean algorithm and extended Euclidean algorithm.

4. **Understand and apply number-theoretic functions**, such as Euler's totient function, to compute properties of integers and solve related problems.

5. **Solve Diophantine equations** and analyze solutions, understanding when integer solutions exist and how to find them.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	2	3	3	2	1	2	2
CO-2	2	1	3	1	2	2	2	3	1	2
CO-3	3	2	2	2	2	1	1	2	2	2
CO-4	3	1	2	1	3	2	3	1	3	2
CO-5	2	3	1	2	3	3	1	2	2	2
AVERAGE CO	2.4	2	1.8	1.6	2.6	2.2	1.8	1.8	2	2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE1.3 Analytical Geometry

COURSE OBJECTIVE

1. **Understand the foundational concepts** of analytical geometry, including the Cartesian coordinate system, distance, and midpoint formula.
2. **Learn the geometric properties** of lines, curves, and surfaces in two and three dimensions, and understand how they can be represented algebraically.
3. **Explore the equations of conic sections**, including ellipses, hyperbolas, and parabolas, and analyze their properties and applications.
4. **Study the equations of lines and planes** in both two and three-dimensional spaces, including parametric and symmetric forms.
5. Learn about transformations in the coordinate plane, such as translations, rotations, scaling, and reflections, and understand their impact on geometric objects.

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola. Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.

Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd. 2002.

3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.

4. R.J.T. Bill, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

COURSE OUTCOME

1. **Understand and use the Cartesian coordinate system** to represent and analyze geometric figures in two and three dimensions.
2. **Solve problems involving lines, curves, and surfaces** by finding equations of lines and planes, and understanding their geometric properties.
3. **Analyze and represent conic sections**, such as circles, ellipses, parabolas, and hyperbolas, using their general equations and properties.

4. **Work with equations of lines and planes** in space, and apply various forms like parametric, symmetric, and vector forms to solve problems.

5. **Apply geometric transformations** (translations, rotations, reflections, and scaling) to analyze the movement and changes of geometric objects in the plane.

CO AND PIO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	1	2	3	3	2	1	2	2
CO-2	2	1	3	1	2	2	2	3	1	3
CO-3	2	2	2	2	2	1	1	2	2	3
CO-4	3	1	2	1	3	2	3	1	3	2
CO-5	2	3	1	2	3	3	1	2	2	2
AVERAGE CO	2	2	1.8	1.6	2.6	2.2	1.8	1.8	2	2.4

1: Weakly related, 2: Moderately related and 3: strongly related

DSE2.1 Industrial Mathematics

COURSE OBJECTIVE

1. **Understand the role of mathematics in industrial applications** and its relevance in solving real-world problems in industries such as manufacturing, logistics, and service operations.
2. **Study mathematical modeling techniques** used to represent industrial processes and optimize production systems, resource allocation, and supply chains.
3. **Learn about optimization methods**, including linear programming, integer programming, and non-linear optimization, to solve industrial problems related to cost minimization and profit maximization.
4. **Understand the application of statistical and probability theory** in quality control, reliability analysis, and decision-making in industrial contexts.
5. Explore the use of differential equations in modeling dynamic industrial systems such as chemical processes, machinery, and transportation networks.

Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

X-ray: Introduction, X-ray behavior and Beers Law (The fundament question of image construction) Lines in the place.

Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms).

Back Projection: Definition, properties and examples.

CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

Books Recommended

1. Timothy G. Feeman, *The Mathematics of Medical Imaging, A Beginners Guide*, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.

2. C.W. Groetsch, *Inverse Problems*, Activities for Undergraduates, The Mathematical Association of America, 1999.

3. Andreas Kirsch, *An Introduction to the Mathematical Theory of Inverse Problems*, 2nd Ed., Springer, 2011.

COURSE OUTCOME

1. **Understand and apply mathematical modeling** techniques to solve problems related to manufacturing, logistics, and industrial processes.
2. **Use optimization methods** such as linear programming, integer programming, and non-linear optimization to address real-world industrial issues like cost reduction and process improvement.
3. **Apply probability and statistics** in quality control, production planning, and reliability analysis to enhance decision-making and ensure optimal outcomes in industrial operations.
4. **Model dynamic industrial systems** using differential equations and analyze their behavior in various industries such as chemical processing, machinery, and supply chains.
5. **Solve complex industrial problems** using numerical methods and computational tools when analytical solutions are not feasible.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	2	3	3	2	1	2	2
CO-2	2	1	3	1	2	3	2	3	1	3
CO-3	2	1	1	2	1	1	1	2	2	3
CO-4	3	1	2	1	3	1	3	1	3	1
CO-5	2	3	1	2	1	3	1	2	2	2
AVERAGE CO	2.2	1.8	1.6	1.6	2	2.2	1.8	1.8	2	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE 2.2 Boolean Algebra and Automata Theory

COURSE OBJECTIVE

1. **Understand the fundamental concepts of Boolean algebra** and its application to digital logic design, including Boolean operations, truth tables, and simplification techniques.
2. **Learn the properties of Boolean functions** and how to represent and simplify them using Boolean identities and theorems.
3. **Study combinational logic circuits** and learn how to design and optimize them using Boolean expressions and logic gates.
4. **Understand the principles of automata theory**, including finite automata, deterministic and non-deterministic models, and their role in formal language theory.
5. Learn about regular expressions and regular languages, and understand how to use them in the context of pattern matching and string recognition.

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties.

Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem, Post Correspondence Problem, and undecidability problems About CFGs.

Books Recommended

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 Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.

3. Rudolf Lidl and Günter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

4. J. E. Hopcroft, R. Motwani and J. D. Ullman, *Introduction to Automata Theory, Languages, and Computation,* 2nd Ed., Addison-Wesley, 2001.

5. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, *Elements of the Theory of Computation*, 2nd Ed., Prentice-Hall, NJ, 1997.

6. J.A. Anderson, *Automata Theory with Modern Applications*, Cambridge University Press, 2006.

COURSE OUTCOME

1. **Understand and apply Boolean algebra principles** to simplify and design digital circuits using Boolean operations, truth tables, and identities.
2. **Simplify complex Boolean expressions** using Boolean theorems and laws to design efficient digital logic circuits.
3. **Design and analyze combinational logic circuits**, including adders, multiplexers, and encoders, by using Boolean expressions and logic gates.
4. **Understand and implement finite automata**, both deterministic (DFA) and non-deterministic (NFA), and apply them to model regular languages.
5. **Use regular expressions** to describe regular languages and apply them in applications such as pattern matching and text processing.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	2	3	3	2	1	2	2
CO-2	2	2	3	1	2	3	2	3	1	3
CO-3	2	1	1	2	1	3	1	2	2	3
CO-4	3	2	3	3	3	1	3	2	2	1
CO-5	2	3	1	2	1	2	1	2	2	2
AVERAGE CO	2.2	2.2	1.8	2	2	2.4	1.8	2	1.8	2.2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE2.3 Probability and Statistics

COURSE OBJECTIVE

1. **Understand the fundamental concepts of probability theory**, including sample spaces, events, and probability rules, and their applications in real-world situations.
2. **Learn about various probability distributions**, such as discrete and continuous distributions, and understand their properties and applications in modeling real-life phenomena.
3. **Explore the concept of random variables** and their expectations, variances, and distributions, and apply them in statistical analysis.
4. **Study the law of large numbers** and the central limit theorem, and understand their significance in statistical inference and data analysis.
5. Understand the methods of statistical inference, including estimation, hypothesis testing, and confidence intervals, and their applications in drawing conclusions from data.

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states.

Books Recommended

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.

2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia, 2006.

3. Sheldon Ross, *Introduction to Probability Models,* 9th Ed., Academic Press, Indian Reprint, 2007.

4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw- Hill, Reprint 2007

COURSE OUTCOME

1. **Understand and apply the basic principles of probability theory**, including conditional probability, Bayes' theorem, and probability distributions, to solve real-world problems.
2. **Analyze and apply various probability distributions** (e.g., Binomial, Poisson, Normal) to model real-world situations and make predictions.
3. **Understand and work with random variables**, calculating their expectation, variance, and applying them in problem-solving.
4. **Apply the law of large numbers and central limit theorem** to interpret large datasets and draw conclusions about population parameters.
5. **Use statistical methods for estimation and hypothesis testing**, including calculating and interpreting confidence intervals, conducting hypothesis tests, and determining p-values.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-
CO-1	2	3	1	2	3	3	2	1	2	
CO-2	1	2	3	1	2	3	2	3	1	
CO-3	2	1	2	3	1	3	1	2	2	
CO-4	3	2	3	3	3	3	2	2	2	
CO-5	2	1	1	2	1	2	2	2	2	
AVERAGE CO	2	1.8	2	2.2	2	2.8	1.8	2	1.8	

1: Weakly related, 2: Moderately related and 3: strongly related

SEMESTER-VI

C13 Metric Spaces and Complex Analysis

COURSE OBJECTIVE

1. **Understand the concepts of metric spaces**, including definitions, examples, and properties, and explore how distance functions are used to define these spaces.
2. **Learn the fundamental theorems of metric space theory**, such as completeness, compactness, and connectedness, and their applications in analysis.
3. **Study the convergence of sequences and series** in metric spaces and understand the importance of limits in the context of analysis.
4. **Understand the concept of continuity, open and closed sets** in metric spaces, and their relationship to the topological properties of spaces.
5. Develop a strong foundation in complex analysis, beginning with complex numbers and their properties, and then progressing to functions of a complex variable.

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces.

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem. Connectedness, connected subsets of R.

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

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.

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. 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. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 2004.

4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw – Hill International Edition, 2009.

5. Joseph Bak and Donald J. Newman, *Complex Analysis,* 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

COURSE OUTCOME

1. **Understand and apply the concept of a metric space**, including working with distance functions and exploring the properties of different types of metric spaces.
2. **Analyze the concepts of completeness, compactness, and connectedness** in metric spaces and apply them to solve problems in real analysis.
3. **Understand the convergence of sequences and series** in metric spaces and determine their limits, using tools like the Bolzano-Weierstrass theorem.
4. **Demonstrate the concept of continuity in metric spaces** and solve problems related to open and closed sets, limits, and continuity in general topology.
5. **Apply the concepts of complex numbers and complex functions**, and analyze them using the basic principles of complex analysis.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	1	2	3	3	2	1	2	2
CO-2	2	2	3	1	2	3	2	3	1	3
CO-3	3	2	3	3	1	2	1	2	2	2
CO-4	3	2	3	3	3	2	2	3	3	1
CO-5	2	1	1	2	1	2	2	3	2	2
AVERAGE CO	2.2	2	2.2	2.2	2	2.4	1.8	2.4	2	2

1: Weakly related, 2: Moderately related and 3: strongly related

C14 Ring Theory and Linear Algebra II

COURSE OBJECTIVE

1. **Understand the fundamental concepts of ring theory**, including definitions, properties, and types of rings such as commutative rings, integral domains, and fields.
2. **Study the structure of ring homomorphisms** and isomorphisms, and understand how these mappings preserve algebraic structures in rings.
3. **Learn about ideals and quotient rings** and how they are used to study the structure of rings, including prime and maximal ideals.
4. **Explore the concept of factorization** in rings, including unique factorization domains (UFDs) and principal ideal domains (PIDs), and understand their applications in algebraic number theory.
5. Study the advanced properties of vector spaces, including inner product spaces, orthogonality, and the Gram-Schmidt process for orthonormalization.

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[x]. Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator.

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

Books Recommended

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 A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.

4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

5. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer, 2005.

6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.

6. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999.

7. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

8. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., 2004.

COURSE OUTCOME

1. **Understand and apply the basic concepts of ring theory**, including various types of rings (e.g., commutative rings, integral domains, fields) and their properties.
2. **Work with ring homomorphisms** and isomorphisms, and apply these concepts to solve problems in abstract algebra and understand the structure-preserving properties of rings.
3. **Analyze ideals and quotient rings** by understanding their structure, and apply this knowledge to simplify and factorize ring-related problems.
4. **Identify and work with prime and maximal ideals** in rings, and solve problems involving factorization in unique factorization domains (UFDs) and principal ideal domains (PIDs).
5. **Apply advanced concepts of linear algebra**, including eigenvalues, eigenvectors, and diagonalization, to understand the structure of vector spaces and linear transformations.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	1	2	1	3	3	1	2	2
CO-2	3	2	3	1	2	3	2	3	1	3
CO-3	3	3	3	3	1	2	1	2	2	2
CO-4	3	2	2	2	2	2	2	1	3	1
CO-5	2	1	1	2	1	2	2	3	2	2
AVERAGE CO	2.6	2.2	2	2	1.4	2.4	2	2	2	2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE3.1 Theory of Equations

COURSE OBJECTIVE

1. **Understand the fundamental concepts** related to algebraic equations, including polynomial equations, roots, and the relationship between the coefficients and the roots of the equation.
2. **Study the different types of equations**, such as linear, quadratic, cubic, and higher-degree polynomial equations, and understand their solutions.
3. **Learn about the fundamental theorem of algebra** and its significance in solving polynomial equations.
4. **Examine the nature of roots** of a polynomial equation, including real and complex roots, and explore the techniques to find the roots of polynomial equations.
5. Understand symmetric functions of roots and apply Vieta's formulas to find relationships between the coefficients and roots of a polynomial equation.

General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.

Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.

Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations.

Books Recommended

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.

2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

COURSE OUTCOME

1. **Understand the basic principles of algebraic equations**, including polynomial equations, and determine the nature and number of roots for various types of equations.
2. **Apply the fundamental theorem of algebra** to demonstrate that every non-constant polynomial equation has at least one complex root.

3. **Find the roots of polynomial equations** of various degrees and classify them as real or complex roots.

4. **Use Vieta's formulas** to express the relationships between the coefficients and the roots of a polynomial equation.

5. **Solve polynomial equations** using different methods, such as factorization, synthetic division, and numerical methods like Newton's method.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	1	2	1	3	3	1	2	2
CO-2	3	2	2	1	2	3	2	3	1	2
CO-3	2	3	3	3	1	2	1	2	2	2
CO-4	3	2	3	3	3	2	2	1	3	1
CO-5	2	1	1	2	1	2	1	3	1	1
AVERAGE CO	2.2	2.2	2	2.2	1.6	2.4	1.8	2	1.8	1.6

1: Weakly related, 2: Moderately related and 3: strongly related

DSE3.2 Bio-Mathematics

COURTSE OBJECTIVE

1. **Understand the application of mathematical techniques** to biological systems, including how mathematical models can be used to describe and analyze biological phenomena.
2. **Learn the mathematical foundations** of biomathematics, focusing on the use of differential equations, linear algebra, and probability theory in biological contexts.
3. **Study mathematical modeling** techniques for biological processes such as population dynamics, disease spread, and ecological interactions.
4. **Develop a deep understanding of the role of mathematical analysis** in studying biological systems, including stability analysis, equilibrium, and bifurcation.
5. Learn how to model biological growth and decay using differential equations, and understand

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population. Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Books Recommended

1. L.E. Keshet, *Mathematical Models in Biology*, SIAM, 1988.

2. J. D. Murray, *Mathematical Biology*, Springer, 1993.

3. Y.C. Fung, *Biomechanics*, Springer-Verlag, 1990.

4. F. Brauer, P.V.D. Driessche and J. Wu, *Mathematical Epidemiology*, Springer, 2008.

5. M. Kot, *Elements of Mathematical Ecology*, Cambridge University Press, 2001.

COURSE OUTCOME

1. **Develop mathematical models** for biological processes, including population dynamics, disease modeling, and ecological systems, using differential equations and systems of equations.
2. **Apply differential equations** to describe biological phenomena such as growth, decay, and oscillatory behavior in biological systems.
3. **Analyze and solve mathematical models** of biological systems using qualitative and quantitative methods, focusing on stability analysis and equilibrium points.
4. **Apply mathematical methods in epidemiology** to model the spread of diseases, including concepts such as the SIR model and control strategies.
5. **Understand the role of biomathematics in genetics** and use models to study inheritance patterns and population genetics, including Hardy-Weinberg equilibrium.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	3	2	3	2	2	2	1	2	2
CO-2	3	3	2	1	2	3	2	3	1	2
CO-3	1	2	2	3	1	2	1	2	2	2
CO-4	3	3	3	3	3	3	3	2	3	2
CO-5	2	2	1	3	1	2	1	3	2	2
AVERAGE CO	2	2.6	2	2.6	1.8	2.4	1.8	2.2	2	2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE3.3 Linear Programming

COURSE OBJECTIVE

1. **Understand the fundamentals of linear programming (LP)**, including its definition, formulation, and various types of problems that can be modeled using linear programming techniques.
2. **Learn the mathematical foundations** of linear programming, including concepts like decision variables, objective functions, constraints, and feasible regions.
3. **Study the Simplex method**, an algorithm for solving linear programming problems, and understand its step-by-step procedure for finding optimal solutions.
4. **Understand duality theory** in linear programming and learn how to formulate and solve the dual problem for a given primal problem.
5. Study sensitivity analysis to evaluate how changes in the coefficients of the objective function or constraints affect the optimal solution.

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 and their comparison.

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

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

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

Books Recommended

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.

2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata McGraw Hill, Singapore, 2009.

3. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice-Hall India, 2006.

4. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

COURSE OUTCOME

1. **Formulate linear programming problems** by translating real-world scenarios into mathematical models, identifying decision variables, constraints, and objectives.
2. **Solve linear programming problems** using the Simplex method and understand how to identify optimal solutions within feasible regions.
3. **Apply duality theory** to solve linear programming problems by formulating and solving their dual problems, and interpret the relationship between primal and dual solutions.
4. **Perform sensitivity analysis** to determine the impact of changes in the objective function coefficients or constraint parameters on the optimal solution.
5. **Solve large-scale linear programming problems** using the revised Simplex method

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	3	2	3	2	2	2	1	2	2
CO-2	2	2	2	1	2	1	2	3	1	2
CO-3	2	2	2	2	1	2	1	2	2	2
CO-4	3	2	3	3	3	3	3	2	3	2
CO-5	2	3	1	3	3	2	1	2	2	2
AVERAGE CO	2.4	2.4	2	2.4	2.2	2	1.8	2	2	2

1: Weakly related, 2: Moderately related and 3: strongly related

DSE4.1 Mathematical Modeling

COURSE OBJECTIVE

1. **Understand the fundamental concepts of mathematical modeling**, including the process of formulating and solving models to represent real-world phenomena.
2. **Learn different types of mathematical models**, such as deterministic, probabilistic, static, dynamic, continuous, and discrete models, and understand their applications in various fields.
3. **Study techniques for translating real-world problems** into mathematical equations or systems that can be analyzed and solved using mathematical methods.
4. **Learn to select appropriate mathematical tools** and methods (e.g., differential equations, linear algebra, optimization, and probability) to solve different types of models.
5. **Develop problem-solving skills** for constructing models of biological, economic, physical, and engineering systems, and use these models to analyze and make predictions about the systems.

Power series solution of a differential equation about an ordinary point, solution about a regular singular point, Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order.

Monte Carlo Simulation Modeling: simulating deterministic behavior (area under a curve, volume under a surface), Generating Random Numbers: middle square method, linear congruence, Queuing Models: harbor system, morning rush hour, Overview of optimization modeling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

List of Practicals (using any software)

(i) Plotting of Legendre polynomial for n = 1 to 5 in the interval [0,1]. Verifying graphically that all the roots of Pn (x) lie in the interval [0,1].
(ii) Automatic computation of coefficients in the series solution near ordinary points.
(iii) Plotting of the Bessel's function of first kind of order 0 to 3.
(iv) Automating the Frobenius Series Method.
(v) Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.
(vi) Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).
(vii) Programming of the Simplex method for 2/3 variables.

Books Recommended

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equation for Scientists and*

Engineers, Springer, Indian reprint, 2006.

2. Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.

COURSE OUTCOME

1. **Formulate mathematical models** to represent real-world problems in various domains, such as biology, economics, engineering, and physics.
2. **Apply appropriate mathematical techniques** to solve the models, using tools such as algebra, calculus, optimization, and differential equations.
3. **Understand and use both analytical and numerical methods** for solving mathematical models, recognizing when each method is appropriate based on the nature of the problem.
4. **Analyze and interpret the results of mathematical models**, and evaluate the relevance and accuracy of the model in relation to real-world systems.
5. **Validate models by comparing theoretical predictions with experimental or real-world data**, ensuring that the model provides reliable insights.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	3	2	3	1	1	2	1	2	3
CO-2	2	2	2	1	2	1	2	3	1	2
CO-3	1	2	2	2	1	2	3	3	2	3
CO-4	3	2	3	3	3	1	1	2	3	3
CO-5	3	3	1	2	3	2	2	2	2	2
AVERAGE CO	2.2	2.4	2	2.2	2	1.4	2	2.2	2	2.6

1: Weakly related, 2: Moderately related and 3: strongly related

DSE4.2 Mechanics

COURSE OBJECTIVE

1. **Understand the fundamental principles of mechanics**, including the concepts of force, motion, energy, and momentum.
2. **Study Newton's laws of motion** and apply them to analyze the behavior of objects under various forces.
3. **Learn about work, energy, and power**, and understand the work-energy theorem and the principle of conservation of energy.
4. **Understand the concepts of momentum and impulse** and apply the principle of conservation of momentum to solve problems in mechanics.
5. Study the motion of rigid bodies, including concepts of rotational motion, angular velocity, torque, and moment of inertia.

Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two point equivalent loading, problems arising from structures, static indeterminacy.

Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers, Theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorems, relation between second moments and products of area, polar moment of area, principal axes.

Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles, translation and rotation of rigid bodies, Chasles' theorem, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references.

Books Recommended

1. I.H. Shames and G. Krishna Mohan Rao, *Engineering Mechanics: Statics and Dynamics,* (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.

2. R.C. Hibbeler and Ashok Gupta, *Engineering Mechanics: Statics and Dynamics,* 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

COURSE OUTCOME

1. **Apply Newton's laws of motion** to solve problems involving the dynamics of particles and rigid bodies, and analyze forces and their effects on motion.

2. **Understand and apply the work-energy theorem** to solve problems involving energy transfer and conservation of energy in mechanical systems.

3. **Analyze and solve problems using the conservation of momentum**, applying this principle to both linear and angular motion scenarios.

4. **Apply the principles of rotational motion**, including calculating moment of inertia, angular momentum, and torque, and solving problems related to the motion of rotating bodies.

5. **Solve problems related to the dynamics of systems of particles**, using concepts such as center of mass, relative motion, and multiple degrees of freedom.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	1	2	2	3	1	1	2	1	2	3
CO-2	2	3	3	1	2	1	2	3	1	2
CO-3	1	2	2	2	1	2	3	2	2	3
CO-4	3	2	3	3	3	1	1	3	2	1
CO-5	3	3	1	2	3	1	2	2	2	1

1: Weakly related, 2: Moderately related and 3: strongly related

DSE 4.3 Differential Geometry

COURSE OBJECTIVE

1. **Understand the fundamental concepts of differential geometry**, including curves, surfaces, and manifolds, and their applications in various fields such as physics and engineering.
2. **Study the properties of curves** in space, including curvature, torsion, and Frenet-Serret formulas, and understand their geometrical significance.
3. **Learn about the geometry of surfaces**, including concepts like tangent planes, normal vectors, and the first and second fundamental forms.
4. **Explore the concept of geodesics**, and study their properties and significance in the context of differential geometry and general relativity.
5. Examine the curvature of surfaces **using tools such as Gaussian curvature, mean curvature, and the Gauss-Bonnet theorem.**

Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines.

Developables: Developable associated with space curves and curveson surfaces, Minimal surfaces.

Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem.

Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.

Books Recommended

1. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications, 2012.

2. B. O'Neill, *Elementary Differential Geometry*, 2nd Ed., Academic Press, 2006.

3. C.E. Weatherburn, *Differential Geometry of Three Dimensions*, Cambridge University Press 2003.

4. D.J. Struik, *Lectures on Classical Differential Geometry*, Dover Publications, 1988.

5. S. Lang, *Fundamentals of Differential Geometry*, Springer, 1999.

6. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications, 2003.

COURSE OUTCOME

1. **Understand and apply the fundamental concepts of differential geometry**, such as curves, surfaces, and manifolds, to solve geometric problems.
2. **Analyze and compute the properties of curves**, including curvature and torsion, using the Frenet-Serret formulas to describe the geometry of space curves.
3. **Study and solve problems related to surfaces**, including calculating the first and second fundamental forms, and understanding the role of tangent planes and normal vectors.
4. **Understand and solve problems related to geodesics**, including finding geodesic curves on surfaces and understanding their significance in differential geometry.
5. **Apply concepts of curvature** to study the intrinsic properties of surfaces, such as calculating Gaussian curvature and using the Gauss-Bonnet theorem.

CO AND PO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	2	2	3	2	1	2	1	2	3
CO-2	2	2	1	1	2	1	2	3	1	2
CO-3	1	3	2	2	1	2	3	0	2	3
CO-4	3	2	3	1	3	2	1	3	2	0
CO-5	3	3	1	2	3	2	2	2	2	2
AVERAGE CO	2.4	2.4	1.8	1.8	2.2	1.6	2	1.8	1.8	2

1: Weakly related, 2: Moderately related and 3: strongly related