NETAJI SUBHAS UNIVERSITY

Estd. Under Jharkhand State Private University Act, 2018

Department of Mathamatics

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

w.e.f. 2023

NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

DEPARTMENT OF MATHS.

PROGRAMME OUTCOMES: M.SC. MATHS

DEPARTMENT OF MATHS PROGRAMME OUTCOME	After successful completion of three year degree program in Math's a student should be able to.,
PROGRAMME OUTCOMES	**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.

PROGRAMME SPECIFIC OTCOMES	**POS 1. Problem-Solving and Analytical Skills** Graduates will develop strong analytical and problem-solving abilities, enabling them to break down complex problems into smaller, manageable parts and apply mathematical techniques to find solutions. **POS2 .Ability to Use Advanced Mathematical Tools** Students will be trained in advanced mathematical tools and techniques such as computer algebra systems, statistical software, and numerical methods to solve practical problems in science, engineering, and economics. **POS3 .Application of Mathematics to Real-World Problems** Graduates will be able to apply mathematical theories and techniques to real-world problems in fields such as finance, technology, engineering, and research, particularly in data analysis, optimization, and decision-making. **POS4 .Research and Independent Learning** Students will develop the ability to conduct mathematical research, think critically, and independently explore advanced topics. This outcome also includes the ability to present and communicate mathematical results clearly. **POS5 .Development of Logical and Quantitative Reasoning** The program will enhance students' logical reasoning, critical thinking, and quantitative reasoning skills, which are crucial in many areas of professional work, including research, industry, and finance. **POS6.Ability to Communicate Mathematical Ideas** Graduates will have the ability to effectively communicate complex mathematical ideas, both orally and in writing, to a range of audiences, including other professionals and students.

NETAJI SUBHAS UNIVERSITY Jamshedpur

FIRST YEAR –1ST SEMESTER

PAPER I: REAL ANALYSIS &MEASURE THEORY
CODE NO. : - 101

COURSE OBJECTIVE:-

- Understand the structure of real numbers, including concepts like supremum, infimum, and completeness.
- Study the concept of limits, continuity, and differentiability of functions on the real line and understand their importance in real analysis.

- Develop the theory of sequences and series of real numbers, including convergence tests such as the comparison test, ratio test, and root test.
- Investigate the convergence of series of functions, and distinguish between pointwise convergence and uniform convergence.
- Study power series and Taylor series representations, and their role in approximating real functions.

UNIT – I REAL ANALYSIS

Sequence and series of function: Uniform convergence of sequence and series of real function. Cauchy's General Principle of Uniform Convergence, Continuity of the sum of a series of function. Weiestrass'sM-test for Uniform Convergence.Term by term integration and differentiation.

Fourier series: Fourier series expansion of a function relative to an orthonormal system. Bessel's inequality, point wiseconvergence of trigonometric Fourier series, Dirichlet's integral, Perseval's theorem, Riemann-Lebesgue theorem, Problems on finding trigonometric Fourier series representation of periodic functions.

Rn and Function of several variables: Schwartz's theorem, Young's theorem, Taylor's theorem in R n , extreme value of a function, related problems, invertible function, implicit functions, Jacobian of a transformation, implicit function theorem, trigonometric Fourier series representation of periodic functions, De'Morgans Theorem.

Unit – II MEASURE THEORY

Measure theory: Outer measure, measurable sets through Caratheodory approach, arithmetical properties of measureable sets, two fundamental theorems and examples of uncountable sets of zero measure. Measurable Functions: Closure of class of measurable function under all algebraic and limit operations, Littlewood's third principle trigonometric Fourier series representation of periodic functions. Function bounded over a set of finite measure, condition of measurability, Lebesgue integral and its arithmetical properties, comparison with R-integral, bounded convergence theorem.

COURSE OUTCOME:-

1. rasp the idea of a measure as a systematic way of assigning a size or weight to sets, which generalizes the notion of length, area, and volume.
2. Learn how to define and apply the basic properties of measures, such as σ-additivity and non-negativity.
3. Study the Lebesgue measure on the real line and other common measures.
4. Learn the construction and properties of the Lebesgue integral, and understand how it extends the idea of integration beyond the Riemann integral.
5. Compare and contrast the Lebesgue and Riemann integrals in terms of convergence properties, handling of discontinuities, etc.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	3	3	1	0	3	2	2
CO-3	3	2	3	2	-	-	3
CO-4	2	2	-	3	3	2	2
CO-5	3	2	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.8	2	1.4	2	2.2	1.4	2.4

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

NETAJI SUBHAS UNIVERSITY Jamshedpur

Paper II: COMPLEX ANALYSIS
Code no. : - 102

COURSE OBJECTIVE:-

- Understand the fundamental properties of complex numbers and operations with complex numbers, including addition, subtraction, multiplication, division, and polar form.
- Study the geometrical interpretation of complex numbers on the complex plane and understand how complex numbers can be used to represent points, transformations, and rotations in the plane.

- Introduce complex functions and define key concepts such as domain, range, image, and pre-image of a function.
- Learn about holomorphic functions and their relationship with the real and imaginary parts of complex functions.

UNIT –I Spherical representation of extended complex plane, Analytic functions,Harmonicconjugates,Cauchy's integral theorem, Cauchy's integral formula, Morera's theorem, Liouvillies theorem, Taylor's theorem, Laurent's theorem, Rouche's theorem, fundamental theorem of algebra. Power series: formula for radius of convergence of power series, absolute & uniform convergence theorem of power series, uniqueness theorem of power series, term by term integration and differentiation theorem. zeros& poles, contour integration and problem, Schwartz lemma, Casorati-Weierstrass theorem and problems. Conformal mapping: Conformal and bilinear mapping, necessary & sufficient condition for conformal mapping, mapping from half plane to circle, mapping from unit circle to unit circle and related problems. Analytic continuation and application: Definition of analytic continuation and related problems, uniqueness theorem of analytic continuation, circle of convergence theorem, standard method analytic continuation and other theorems

COURSE OUTCOMES:-

1. Develop a deep understanding of complex functions, including their properties and behavior.
2. .Study the basic concepts such as analyticity, holomorphic functions, and the Cauchy-Riemann equations.
3. .Learn the techniques and theorems of complex integration, including Cauchy's integral theorem, Cauchy's integral formula, and applications like residue calculus.
4. .Study the power series expansions, including Taylor and Laurent series, and learn how to use them for solving complex problems.

5. . Understand the concept of residues and learn how to apply residue theory to evaluate integrals, particularly in situations where real integrals are difficult to solve directly.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	3	1	2	2	2	3
CO-2	3	3	1	3	3	2	-
CO-3	3	2	3	2	3	3	3
CO-4	2	3	-	2	3	2	3
CO-5	3	3	-	3	2	1	2
COURSE OUTCOME AVERAGE	2.8	2.8	1	2.4	2.6	2	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Paper III: PROBABILITY AND STATISTICS **Code no. : - 103**

COURSE OBJECTIVE:-

- Understand the basic concepts of probability, including sample spaces, events, and the probability function.
- Study the axioms of probability and apply them to solve simple probability problems.
- Understand and apply concepts of conditional probability and independence of events.
- Learn the concept of Bayes' Theorem and its applications in updating probabilities based on new information.Introduce random variables (both discrete and continuous) and understand their probability distributions.Explore continuous probability distributions such as the normal, exponential, and uniform distributions.

Unit – I Probability & Statistics Probability space, conditional probability, Bayes' theorem.Independence, Random variables, joint and conditional distributions, standard probability distributions and their properties (Discrete uniform, Binomial, Poisson, Normal).Expectation, conditional expectation, moments.Sampling distributions, Testing of hypotheses, standard parametric tests based on normal distributions; Correlation Coefficient, Rank Correlation coefficient, Simple linear regression.

Unit – II Statistical Quality control, Time series, Index Number, Analysis of Variance, Design of sample surveys, Vital Statistics.

COURSE OUTCOMES:-

1. Grasp the foundational principles of probability, including events, sample spaces, conditional probability, and Bayes' Theorem.
2. Learn about probability distributions, both discrete and continuous, such as binomial, Poisson, normal, and exponential distributions.
3. Master methods for summarizing and describing data, including measures of central tendency (mean, median, mode), variability (variance, standard deviation), and other descriptive metrics (percentiles, quartiles).
4. Learn estimation techniques, including point and interval estimates, and understand confidence intervals and their interpretation.
5. Conduct hypothesis testing using t-tests, chi-square tests, and other statistical tests to make inferences about populations based on sample data.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	2	2	3	3	3	2	-
CO-3	3	-	3	3	-	1	3
CO-4	2	3	-	3	3	2	3
CO-5	3	2	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.6	1.6	1.8	2.8	2.2	1.6	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Paper IV: GROUP THEORY & HIGHER ARITHMETIC
Code no. : - 104

COURSE OBJECTIVE:-

- Understand the fundamental definition of a group, including the group axioms (closure, associativity, identity element, and invertibility).
- Study examples of groups, including finite and infinite groups, cyclic groups, and symmetric groups, and understand their properties.
- Learn to classify groups based on their properties, including abelian (commutative) and non-abelian groups.
- Study the concept of subgroups, including the criteria for a subset of a group to be a subgroup.
- Understand cosets and Lagrange's Theorem, which relates the order of a subgroup to the order of the group.

Unit – I Group Theory Isomorphism and Homomorphism of Groups, IsomorphismTheorem. Permutation group & simple group, two square theorem and quadratic reciprocity law via permutation group. Conjugacy classes, normaliser, class equation of a finite group. Direct products: Direct product of a finite number of groups, necessary & sufficient condition for the isomorphism between the product and the direct product of groups. Group action orbit stabilizer theorem, Syllow theorem & application in proving non-simplicity for the isomorphism between the product and the direct product of groups. Normal series, composition series and solvable groupscommutator, normal series and derived series of a group, composition series, Jordan-Holder theorem, solvable group.

Unit – II Higher Arithmetic Linear, simultaneous linear and polynomial congruences, Chinese remainder theorem, arithmetical function, Euler's totient function, Mobius function, drvisor function, Mobius inversion formula, Dirichlet product, group structure. Some Diophantine equations, Fermet's& Wilson's Theorem.

COURSE OUTCOMES:-

1. Gain familiarity with the fundamental concepts of group theory, including groups, subgroups, cosets, homomorphisms, and isomorphisms.
2. Study examples of groups in various contexts, including symmetric groups, cyclic groups, and matrix groups.
3. Understand the structure of finite and infinite groups, including important theorems such as Lagrange's Theorem, the Sylow theorems, and the classification of simple groups.
4. Explore the concept of group actions and understand how they are used to study symmetries and related structures.
5. Learn the basics of representation theory, focusing on the ways in which groups can be represented as matrices or linear transformations.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	3	3	1	3	3	2	-
CO-3	3	2	3	2	-	-	3
CO-4	2	3	-	3	2	2	3
CO-5	3	3	-	3	3	1	-
COURSE OUTCOME AVERAGE	2.8	2.4	1.4	2.6	2	1.4	1.8

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

FIRST YEAR: SEMESTER-II

PAPER V: TOPOLOGY **Code no. : - 201**

COURSE OBJECTIVE:-

- Understand the definition and basic properties of **topological spaces**, including the concepts of **open sets**, **closed sets**, and **neighborhoods**.
- Learn how to define and work with topological spaces in both general and specific contexts.
- Develop the ability to understand the **topology of Euclidean spaces** and **metric spaces** as foundational examples.
- Study the concept of a **basis** for a topology and how a topology can be generated from a given basis.
- Understand the relationship between bases, open sets, and the generation of topological spaces from sets of open sets.

UNIT-I Compacness in metric space, Ascoli's theorem. C(X, R), WeierstrassApproximation theorem and Picard's theorem. Topological spaces: Definition, examples, base, sub-base, first axiom space, second axiom space, Lindeloff space, comparison of topologies. Compactness: Compact space, product space, Tychonoff's theorem, locally compactness. Separation: T1 – space, T2 – space, normal & completely regular space, Uryshon's lemma, Tietze extension theorem, Uryshon'smetrizationtheor. Connectedness: connectedness & its properties.

PROGRAMME OUTCOMES:-

1. Understand the concept of a topological space, including open sets, closed sets, and bases for a topology.
2. Learn about various types of topological spaces such as metric spaces, Hausdorff spaces, and compact spaces.
3. Explore continuous functions, homeomorphisms, and the various properties of topological spaces.
4. Study connectedness, compactness, and convergence in the context of topology.
5. Understand the separation axioms (T0, T1, T2, T3, T4, etc.) and their significance in classifying different types of topological spaces.
6. Learn about the product and quotient topologies.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	2	3	1	3	3	2	-
CO-3	3	2	3	2	-	-	3
CO-4	3	3	-	3	3	2	3
CO-5	3	3	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.8	2.4	1.4	2.6	2.2	1.4	2.2

3* Strongly Mapped   2* Moderately Mapped   1*Slightly Mapped   0* None

PAPER VI : JAVA (THEORY &PRACTICAL) CODE NO. : - 202

COURSE OBJECTIVE:-

- Understand the basic syntax and structure of Java programs, including variables, data types, and control structures (loops, conditionals).
- Learn how to write, compile, and run simple Java programs using the Java Development Kit (JDK) and Integrated Development Environments (IDEs) like Eclipse or IntelliJ IDEA.

- Understand and apply object-oriented programming (OOP) concepts such as encapsulation, inheritance, polymorphism, and abstraction in Java.
- Learn to design and implement classes and objects, and understand how to use constructors, methods, and fields effectively.
- Apply principles of object-oriented design to model real-world systems and solve programming problems.

UNIT I:-Computer Basics: Input output units; Description of computer input units, input methods, computer output units. Computer Memory; Memory cells, memory organization, read only memory, serial access memory, magnetic hard disks, floppy disks drives, CD drives. Processors; Structure of instructions, description of a processor, idea of cache memory. Java Evolution and Overview of Java Language: How Java differs from C and C++, Java and Internet, Java and World Wide Web, Introduction, Simple Java Program, More of Java, An Application with Two Classes, Java Program Structure, Java Tokens, Java Statements, Implementing a Java Program, Java Virtual Machine, Command Line Arguments, Programming Style. Constants, Variables, and Data Types: Introduction, Constants, Variables, Data Types, Declaration of Variables, Giving Values of Variables, Scope of Variables, Symbolic Constants, Type Casting, Getting Values of Variables, Standard Default Values. Operators and Expressions: Introduction, Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operators, Bitwise Operators, Special Operators, Arithmetic Expressions, Evolution of Expressions, Precedence of Arithmetic Operators, Type Conversion in Expressions, Operator Precedence and Associativity, Mathematical Functions. Decision Making and Branching: Introduction, Decision Making with if Statement, Simple If Statement, The if... else Statement, Nesting of if ... else Statements, The else if Ladder, The switch Statement, The? Operator.

Decision Making and Looping: Introduction, The while Statement, The do Statement, The for Statement, Jumps in Loops, Labelled Loops.

UNIT II:-Classes, Objects and Methods: Introduction, Defining a Class, Adding Variables, Adding Methods, Creating Objects, Accessing Class Members, Constructors, Methods Overloading, Static Members, Nesting of Methods, Inheritance: Extending a. Class, Overriding Methods, final Variables and Methods, Final Classes, Finalizer Methods, Abstract Methods and Classes, Visibility Control. Arrays, String and Vectors: Arrays, One-Dimensional Arrays, Creating an Array, Two- Dimensional Arrays, Strings, Vectors, Wrapper Classes. Interfaces: Multiple Inheritance: Introduction, Defining Interfaces, Extending Interfaces, implementing Interfaces, Accessing Interface Variables. Packages: Putting Classes Together: Introduction, Java API Packages, Using system Packages, Naming Conventions, Creating Packages, Accessing a Packages, Using a Package, Adding a Class to a Package, Hiding Classes. Multithreaded Programming: Introduction, Creating Threads, Extending the Thread Class, Stopping and Blocking a Thread, Life Cycle of a Thread, Using Thread Methods, Thread Exceptions, Thread Priority, and Synchronization. Managing Errors and Exceptions: Introduction, Types of Errors, Exceptions, Syntax of Exception Handling Code, Multiple Catch Statements, Using finally Statement, Throwing Our Own Exceptions, Using Exceptions for Debugging

COURSE OUTCOME:-

1. **Introduce Java as a programming language**: Gain an understanding of Java syntax, data types, variables, operators, and control structures (loops, conditionals).
2. **Master object-oriented programming (OOP)**: Learn core OOP concepts such as classes, objects, inheritance, polymorphism, abstraction, and encapsulation, with an emphasis on their applications in mathematical problem-solving.
3. **Study Java's standard libraries**: Understand the use of Java libraries like java.util for data structures, java.io for file handling, and java.math for mathematical computations.
4. **Apply Java in mathematical modeling**: Use Java to create models of mathematical problems and solutions, such as numerical methods, algorithms, and data analysis.
5. **Algorithm implementation**: Develop algorithms related to mathematical concepts such as sorting, searching, and optimization.
6. **Problem-solving using Java**: Apply Java to solve mathematical problems in areas such as linear algebra, calculus, statistics, and combinatorics.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	3	2	3
CO-2	2	3	1	3	3	2	-
CO-3	3	3	3	2	-	-	3
CO-4	3	2	2	3	1	-	3

CO-5	3	3	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.8	2.4	1.8	2.6	2	1	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Paper VII: Differential Geometry
Code no. : - 203

COURSE OBJECTIVE:-

- Understand geodesics, the "straight lines" in curved spaces, and how they generalize the concept of a straight line in Euclidean geometry.
- Explore the role of metrics in defining distances, angles, and volumes on manifolds.
- Apply the concepts of differential geometry to other areas of mathematics and physics, such as general relativity, differential topology, and mechanical systems.
- Study the use of differential geometry in the analysis of surfaces in engineering and computer science (e.g., computer graphics, robotics).
- Learn about differential forms and their applications in geometry, especially in integration on manifolds.

Unit – I Differential Geometry Space curve: Curvature and torsion, Serret-Frenet formulae, helix uniqueness theorem for space curve, the circle of curvature, osculating sphere, locus of centre of curvature, spherical curvature, locus of centre of spherical curvature, Bertrand curve.Envelopes and developable: Envelop, the edge of regression developable associated with space curve and their properties. Curvilinear coordinates on a surface, fundamental magnitudes, direction on a surface.Curve on a surface: Parametric curves, curvature of normal section, Meusier’s theorem, principal direction & principal curvature, line of curvature, theorem of Euler and Dupin, conjugate direction and asymptotic line.Equation of Gauss and Mainardi-Codazzi.Geodesics: Differential equation of geodesics via normal properties, geodesics on developable, curvature & torsion of a geodesics.

Unit – II Numerical Analysis Solution of linear equations: Direct methods - Gauss elimination, Gauss-Jordan elimination, LU decomposition. Iterative methods - Jacobi, Gauss-Siedel. The algebraic eigenvalue problem: Jacobi's method, Given's method, House-holder's method, Power method. Ordinary differential equations: Euler's method, Single-step methods, Runge-Kutta's method, multistep methods.Approximation: Different types of approximation, least square polynomial ap-proximation.

COURSE OUTCOME:-

- Explain key concepts of differential geometry such as curves, surfaces, and manifolds, and understand their properties in various settings.
- Define and compute geometric quantities like curvature, torsion, geodesics, and normal vectors for curves and surfaces in Euclidean space.

- Apply multivariable calculus (including derivatives and integrals) to solve geometric problems, particularly in the study of curves and surfaces.
- Compute derivatives of vector fields on manifolds and apply these computations to study the behavior of geometric objects.

- Classify curves based on their curvature and torsion and analyze their properties, such as the Frenet-Serret formulas.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	3	1	2	2	3	3
CO-2	2	3	1	3	3	2	-
CO-3	3	1	3	2	-	-	3
CO-4	2	3	-	3	3	2	3
CO-5	3	3	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.6	2.6	1	2.6	2.2	1.6	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

PaperVIII: DISCRETE MATHEMATICS & GRAPH THEORY
Code no. : - 204

COURSE OBJECTIVE:-

- Develop an understanding of basic discrete structures such as sets, relations, functions, and graphs.
- Study combinatorics, including counting principles, permutations, combinations, and the pigeonhole principle.
- Understand mathematical logic and its applications, including logical operations, predicates, quantifiers, proofs (direct, indirect, and induction), and proof techniques.

- Learn to define and work with functions, including properties like injectivity, surjectivity, and bijectivity.
- Understand relations, equivalence relations, partial orders, and how they are applied in mathematics and computer science.

Unit – I Discrete Mathematics Partially order sets, lattices, geometrical lattices, distributive lattices, modular lattice, complemented lattice.Algebric Structures, Matrix Algebra. Mathematical Logic, Boolean algebra, Boolean expression, application to switching circuits. Tree, Formal Language and Automata.

Unit – II Graph theory Degree sum theorem, Eulerian graph and its properties, Hamiltonian graph, trees, planarity of graphs, Euler's theorem on planar graph and application, chromatic number and five colour theorem, marriage theorem, transversal version of marriage theorem, directed graph, Kruskal's algorithm, Dijkastra's algorithm. Pigeon hole principle, principle of inclusion & exclusion, derangement.

COURSE OUTCOME:-

- Students will understand and apply logic, including propositional and predicate logic, logical connectives, truth tables, and logical equivalences.
- Students will be able to construct rigorous mathematical proofs, including proofs by induction, contradiction, and contrapositive, to demonstrate the correctness of statements and algorithms.

- Students will have a solid understanding of sets, relations, and functions, including their properties (injectivity, surjectivity, bijectivity) and how to apply them to mathematical problems.
- Students will be proficient in working with recurrence relations and recursive functions for modeling discrete processes, and will be able to solve common recurrence relations using different methods.

- Students will be able to apply combinatorics to solve counting problems, using methods like the pigeonhole principle, permutations, combinations, and the inclusion-exclusion principle.

•	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	3	2	2	3

CO-2	2	3	1	-	3	2	-
CO-3	3	2	3	3	-	-	3
CO-4	2	3	-	2	3	2	3
CO-5	3	3	-	3	3	2	2
COURSE OUTCOME AVERAGE	2.6	2.4	1.4	2.2	2.2	1.6	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Second Year: Semester -III

Paper IX: FUNCTIONAL ANALYSIS **Code no. : - 301**

COURSE OBJECTIVE:-

- Understand and work with various types of spaces, such as normed spaces, Banach spaces, and Hilbert spaces, including their properties and basic structures.
- Identify and study linear operators acting on these spaces, and understand the concepts of boundedness and continuity in the context of operators.
- Define and analyze normed vector spaces, and understand the concept of the norm and how it relates to the geometry of the space.
- Study Banach spaces (complete normed spaces), and develop the ability to identify important properties of Banach spaces such as convergence, completeness, and the Banach fixed-point theorem.
- Define Hilbert spaces and understand their inner product structure, including completeness in the sense of inner products.

Cauchy's, Minskowski's and Holder's inequalities, normed linear space, Banach space, definition and examples including classic Banach space, sub-space and Quotient space. Continuous linear maps, B(N,N1 Dual (conjugate) space of 'N', natural embedding theorem, dual of Rn and Ip operator and its conjugate Riesz lemma. Hahn-Banach theorem and consequences, open mapping theorem and projection on Banach space, closed graph theorem and uniform boundedness principle. Hilbert's Space: Definition and examples, Schwartz inequalities, orthogonal completeness characterization, Gram-Schmidt orthogonalization. Dual of H, Reisz representation theorem, reflexivity. Adjoint of an operator, self adjoint operator, unitary and normal operator. Perpendicular projection, invariance, reducibility, orthogonal projection theorem

COURSE OUTCOME:-

- Recognize and describe normed spaces, Banach spaces, and their properties.
- Apply the concepts of completeness and convergence in Banach spaces and use the Banach Fixed Point Theorem for solving functional equations and iterative methods.
- Understand the structure of Hilbert spaces and their inner product properties.
- Apply key results such as the Cauchy-Schwarz inequality, Pythagoras theorem, and orthogonality in the context of Hilbert spaces.
- Analyze linear operators on Banach and Hilbert spaces, understanding the concepts of boundedness, continuity, and compactness.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	3	2	1	-	3	3	-
CO-3	3	2	3	2	-	1	3
CO-4	2	2	-	3	3	2	3
CO-5	3	3	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.8	2	1.4	2	2.2	1.8	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Paper X: RING & FIELD THEORY **Code no. : - 302**

COURSE OBJECTIVE:-

- Understand the fundamental algebraic structures such as sets and binary operations and how these structures lead to the definition of rings, fields, and related concepts.
- Learn the basic definitions and properties of groups, rings, and fields, including concepts like closure, identity elements, inverses, and associativity.

- Define and explore the properties of rings, including commutative and non-commutative rings, and understand key concepts such as ring homomorphisms, ideal theory, and quotient rings.
- Study the classification of rings based on additional properties such as unitary rings, division rings, integral domains, and fields.
- Understand subrings, ideal operations, maximal ideals, prime ideals, and quotient structures.

Unit – I Ring Theory Factorization in integral domain: Concept of divisibility in integral domain, GCD & LCM of two non-zero elements in an integral domain, irreducible and prime elements in an integral domain, relation between prime and irreducible elements, definition and examples of Euclidean domain, principal ideal domain and unique factorization domain, relation between Euclidean domain, principal ideal domain and unique factorization domain, the integral domain Z[I] and K[X] K field properties of Euclidean domain, principal ideal domain and unique factorization domain, Einstein criteria of irreducibility, Gauss's lemma.Definition of field and extension of a field. Unit – II Field Theory Extension of a field, finite extension and infinite extension, algebraic extension and transcendental extension, properties of algebraic extension, relation between algebraic and finite extension, splitting field of a polynomial over a field, normal extension, characterization of finite normal extension, separable extension and properties of a separable extension, perfect field and characterization of perfect field, primitive element theorem, finite field and their existence.

COURSE OUTCOME:-

- Identify and understand the properties of algebraic structures such as rings and fields, including their operations, elements, and axioms.
- Distinguish between different types of rings, such as commutative rings, division rings, fields, and integral domains, and understand their significance.
- Define and apply basic operations in rings, including addition, multiplication, and the concept of zero divisors, units, and idempotents.
- Work with ideals in rings, including principal ideals, maximal ideals, and prime ideals, and understand their role in ring structure.
- Apply the concept of quotient rings and understand how factor rings help classify and simplify complex algebraic structures.

•	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	2	3	1	3	3	2	-

CO-3	2	3	3	2	3	3	3
CO-4	2	3	-	3	3	2	3
CO-5	3	2	-	3	-	1	2
COURSE OUTCOME AVERAGE	2.4	2.4	1.4	2.6	2.2	2	2.2

3* Strongly Mapped   2* Moderately Mapped   1*Slightly Mapped   0* None

Paper XI: Analytical Dynamics   **Code no. : - 303**

COURSE OBJECTIVE:-

- Review and understand the fundamental principles of classical mechanics, particularly Newton's laws of motion, and how these laws are applied in various dynamical systems.
- Introduce generalized coordinates and develop a comprehensive understanding of their role in describing mechanical systems, particularly when dealing with constrained motion.
- Develop the Lagrangian formulation of mechanics as an alternative to Newton's laws, using the principle of least action and generalized coordinates.
- Formulate and apply the Euler-Lagrange equations for a system of particles, and understand the conditions for the conservation of energy, momentum, and angular momentum.
- Analyze complex mechanical systems (such as multi-particle systems and systems with constraints) using the Lagrangian approach.

Motion in two dimensions: Motion of C. G. and motion about C. G., K. E. slipping of road, motion of sphere on inclined plane when rolling and sliding are combined, motion of circular disk on a plane and related problems. Moving axes: Velocity and acceleration in two dimensional motion when the axes are moving, velocity and acceleration in three dimensions when the axes are moving, velocity and acceleration in three dimensional motion in polar form, angular velocity referred to moving axes and Euler's geometrical equation. Equation of motion and its application in three dimensions: General equation of motion, Euler's equation of motion, momentum of rigid body, moments about instantaneous axes, K. E. of rigid body and related problems. Lagrange's equation of motion of small oscillation: Generalized co-ordinates, constraints classification of mechanical systems, Lagrange's equation of motion, principle of energy, small oscillation, normal co-ordinates Hamilton's canonical equation, Routh's equation: Canonical variables Hamiltonian, Hamilton's canonical equation, equation from Lagrange's equation of motion, cyclic co-ordinate, Routh's equation of motion.

COURSE OUTCOME:-

- Comprehend and apply the basic principles of classical mechanics, including Newton's laws, the principle of least action, and generalized coordinates, to describe the motion of physical systems.
- Distinguish between different formulations of mechanics (Newtonian, Lagrangian, and Hamiltonian) and apply the most appropriate formulation for a given problem.
- Formulate the equations of motion for a wide variety of systems using the Euler-Lagrange equations.
- Apply generalized coordinates and develop the Lagrangian of both constrained and unconstrained systems, including multi-particle systems.
- Solve mechanical problems using Lagrange's equations and analyze systems involving constraints through Lagrange multipliers.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	2	3	1	3	3	2	-
CO-3	3	2	3	2	-	-	3
CO-4	2	2	3	-	3	2	3
CO-5	3	3	-	3	3	1	2
COURSE OUTCOME AVERAGE	2.6	2.2	2	2	2.2	1.4	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Paper XII: DIFFERENTIAL EQUATION
Code no. : - 303

COURSE OBJECTIVE:-

- Understand the basic concepts of differential equations, including the differences between ordinary differential equations (ODEs) and partial differential equations (PDEs).
- Learn the methods to classify differential equations, including linear vs. nonlinear, homogeneous vs. non-homogeneous, and initial value problems vs. boundary value problems.
- Solve first-order differential equations using a variety of methods, including separation of variables, integrating factors, and exact equations.
- Apply the method of substitution to simplify first-order equations into solvable forms, such as Bernoulli's equation or Riccati's equation.
- Analyze real-world applications that can be modeled by first-order ODEs, such as growth models, decay, and population dynamics.

Laplace transform, transform of elementary function, transform of derivative, inverse transform, convolution theorem, application of ordinary and partial differential equation Fourier transform, sine and cosine transform, inverse Fourier transform, application to ordinary and partial differential equation.Series solution of general homogeneous linear second order equation, singular points, the method of Frobenius. Linear system, linear algebra applied to ordinary differential equation, Eigen value problem, fundamental matrix solution, introduction to stability problem. Green function, Strum-Liouville boundary value problem, Eigen value problem. Classification of second order partial differential equation, reduction to canonical forms. Wave equation, one dimensional solution by separation of variable, D' Alembert's solution of wave equation. Heat equation, one dimensional heat flow in infinity bar, solution by Fourier series, solution by Fourier integral and transform .

COURSE OUTCOME:-

- Solve first-order ordinary differential equations (ODEs) using methods such as separation of variables, integrating factors, and exact equations.
- Apply appropriate methods (e.g., Bernoulli's equation, Riccati equation) to solve more complex first-order ODEs.
- Model real-world problems using first-order differential equations in fields such as population dynamics, chemistry, and physics.
- Solve second-order and higher-order linear differential equations, including both homogeneous and non-homogeneous cases.
- Use methods like undetermined coefficients, variation of parameters, and Laplace transforms to find solutions to higher-order equations.
- Interpret solutions to second-order linear ODEs in terms of physical phenomena, such as vibrations, mechanical systems, and electrical circuits.

•	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	3	3	1	3	3	2	-
CO-3	3	2	3	2	-	3	3
CO-4	2	3	3	3	3	2	3
CO-5	3	3	-	3	3	2	2
COURSE OUTCOME AVERAGE	2.8	2.4	2	2.6	2.2	2.2	2.2

3* Strongly Mapped   2* Moderately Mapped   1*Slightly Mapped   0* None

Second Year: Semester-IV

Paper XIII: OPERATION RESEARCH   **Code no. : - 401**

COURSE OBJECTIVE:-

- Understand the principles and scope of Operations Research, including its importance in decision-making and problem-solving in real-world scenarios.
- Gain an understanding of how mathematical modeling and quantitative techniques are used to solve optimization problems.
- Learn to formulate real-world problems as mathematical models, particularly linear, nonlinear, integer, and dynamic programming models.
- Translate practical problems into mathematical terms and represent them using variables, constraints, and objective functions.

- Understand and apply the methods of linear programming to optimize objective functions subject to linear constraints.

Game theory: Two person zero-sum games, games with mixed strategies, graphical solution, solution by linear programming.Inventory Control.Queuing Theory.Known demand, probabilistic demand, deterministic model and probabilistic model without lead time. Project planning and control with PERT-CPM: Rules of network construction, time calculation in networks, critical path method, PERT, PERT calculations, advantages of network (PERT/CPM),. difference between CP and PERT Integer programming: Branch and bound technique, Gomory's cutting plane method. Models in operation research: Different models, their construction and general method of solution. Non-Linear programming: One and multivariable unconstrained optimization, Kuhn-Tucker conditions for constrained optimization, quadratic programming, Wolfe's and Beale's method.

COURSE OUTCOMES:-

- Formulate real-world problems as mathematical models, translating practical situations into decision variables, constraints, and objective functions.
- Apply problem-solving methodologies to represent and analyze both structured and unstructured decision-making scenarios.

- Solve linear programming (LP) problems using methods like the Simplex method, graphical techniques, and duality theory.
- Interpret the results of LP models and perform sensitivity analysis to assess the impact of changes in parameters on the optimal solution.

- Solve integer programming (IP) and mixed-integer programming (MIP) problems, particularly where decision variables must take integer values.
- Use techniques like branch and bound and cutting plane methods to solve complex integer programming models.

•	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	1	3	2	2	2	3
CO-2	3	3	1	3	3	2	-
CO-3	3	2	3	2	-	3	3
CO-4	2	3	3	3	3	2	3
CO-5	3	3	-	3	3	2	2

COURSE OUTCOME AVERAGE	2.8	2.4	2	2.6	2.2	2.2	2.2

3* Strongly Mapped 2* Moderately Mapped 1*Slightly Mapped 0* None

Dean Academics
Netaji Subhas University
Jamshedpur, Jharkhand

NETAJI SUBHAS UNIVERSITY Jamshedpur