Sister Nivedita University

Department of Mathematics

A Satyam Roychowdhury initiative

SNU SISTER NIVEDITA UNIVERSITY

Syllabus for Mathematics Undergraduate Programme

Framed according to the

National Education Policy (NEP 2020)

B.Sc. Mathematics (Honours)

VISION:

We, the Department of Mathematics envision our students as excellent Mathematicians who will be able to create high impact on the society through their scientific creativity; entrepreneurship and research as well as they can encourage the future generations to follow their path.

MISSION:

- To achieve the vision, we have diligent faculties who use effective teaching methodologies to impart updated technical education and knowledge.
- To groom our young students to become professionally and morally sound mathematicians to be a potential researcher or industry ready.
- To reach global standards in production and value-based living through an honest and scientific approach.

Programme Educational Objectives (PEOs):

The Programme Educational Objectives of the B.Sc. Mathematics (Honors) curriculum is to prepare graduates to:

PEO 1: Successfully secure admissions and thrive in advanced graduate programs (M.Sc., Ph.D.) in Mathematics, Statistics, Data Science, or related quantitative and theoretical disciplines, contributing to the corpus of scientific knowledge.

PEO 2: Establish themselves as effective professionals in high-demand quantitative fields, such as financial modelling, actuarial science, computational science, data analytics, and IT, by utilizing their strong analytical and programming foundations.

PEO 3: Engage in continuous professional development and adapt to evolving technological and mathematical tools, while demonstrating ethical responsibility and effective communication skills in their professional and social endeavors.

Program Specific Outcomes (PSOs):

Upon successful completion of the B.Sc. Mathematics (Honors) program, graduates will be able to:

PSO 1: Demonstrate profound conceptual mastery of Abstract Algebra, Real analysis, Differential Equations, Topology and several branches of mathematics enabling them to comprehend, analyze, and communicate the foundational logic and rigorous proof techniques that underpin higher mathematics.

PSO 2: Apply numerical methods, optimization techniques, and Python programming to solve complex, large-scale problems efficiently, particularly those encountered in industry, operations research, and large data sets.

PSO 3: Construct and analyze mathematical models using tools from Differential Equations, Vector Analysis, and Probability Theory to interpret and predict the behaviour of dynamical systems in physics, engineering, biology, and finance.

Programme Outcomes (PO):

Programme Outcomes (POs):

Upon successful completion of the B.Sc. Mathematics (Honors) program, graduates will be able to:

PO1: Possess a deep and comprehensive understanding of core mathematical disciplines, including Algebra, Calculus, Geometry, Differential Equations, and several other branches of mathematics.

PO2: Apply rigorous analytical and logical reasoning to evaluate mathematical statements, construct formal proofs, and solve complex problems across diverse fields of mathematics.

PO3: Skilfully apply advanced programming languages and computational tools to develop, implement, and interpret mathematical models for data-intensive problems in fields like finance, engineering, and data science, thereby meeting industry demands.

PO4: Formulate, Analyze, and Solve application-oriented problems using techniques from Optimization, Differential Equations, Financial Mathematics, and Biomathematics.

PO5: Conduct independent research, define a problem, review literature, apply advanced techniques, and effectively present their findings through the mandatory Final Project or Research Design and Communication.

PO6: Proficient in the principles of Probability and Statistical inference and data analysis to interpret quantitative information, make reasoned conclusions, and handle uncertainty in various domains.

PO7: Exhibit effective written and oral communication skills and professional attributes, including teamwork and ethical responsibility, necessary for collaborative environments.

PO8: Appreciate the multidisciplinary nature of mathematics by integrating knowledge from elective subjects and applying mathematical principles to other fields, enhancing their flexibility for higher studies or diverse career paths.

Category definition with credit breakup

Semester	Credits										Credits/ semester
	MC/ME	ME		Non-Major		MDC	AEC	SEC	VAC	INT	
		Course	Project	NM	NV						
I	4+4			5	1+1		2	3	2		22
II	4+4				1+1+1	3	2	3	2		21
III	4+4			4	1+1	3	2				19
IV	4+4+4			4	1+1	3	2				23
V	4+4+4				1+1			3	2		19
VI	4+4+4			4	1+1					3	21
VII	4+4+4+4			4							20
VIII		8/20	12/0								20
Credits/ Course	99			33		9	8	9	6	3	
Total Credit											165

Category Definition

Definition of Category/Type	Abbreviation
Major Compulsory	**MC**
Major Elective	**ME**
Non-Major Specific Subject Course	**NM**
Non-major Vocational Education and Training	**NV**
Multidisciplinary Courses	**MDC**
Ability Enhancement Courses	**AEC**
Skill Enhancement Courses	**SEC**
Value Added Courses	**VAC**
Internship	**INT**
Project	**Project**

Course structure for B.Sc. in Mathematics

Category	Course name	Credit	Teaching Scheme		
			L	T	P
	Semester I				
MC1	Classical and Abstract Algebra	4	4		
MC2	Real Analysis	4	4		
NM1	Basic Statistics	4	4		
NV1	Vocational – EAA I (Yoga/ Sports/ NCC/ NSS)	1			2
NV2	Vocational – Soft Skill Development I	1	1		
AEC 1	Communicative English I	2	2		
SEC 1	Computer Application	3	3		
VAC 1	Environmental Science I	2	2		
Total Credit = 21			Teaching Hour = 23		
	Semester II				
MC3	Linear Algebra and Field Extension	4	4		

MC4	Discrete Mathematics and Riemann Integration and Series of Functions	4	4		
NV3	Vocational – Mentored Seminar I	1	1		
NV4	Vocational – EAA II (Yoga/ Sports/ NCC/ NSS)	1			2
NV5	Vocational – Soft Skill Development II	1	1		
MDC 1	Selected by the candidate (Elective)	3	3		
AEC 2	Communicative English II	2	2		
SEC 2	Basic Management Skill	3	3		
VAC 2	Environmental Science II	2	2		
Total Credit = 21			Teaching Hour = 22		
Semester III					
MC5	Analytical Geometry and Vector Analysis	4	4		
MC6	Probability and Statistics	4	4		
NM2	Probability and Probability Distributions	4	4		
NV6	Vocational – Mentored Seminar II	1	1		
NV7	Vocational – Soft Skill Development III	1	1		
MDC 2	Selected by the candidate (Elective)	3	3		
AEC3	Logical Ability I / Foreign Language I	2	2		
Total Credit = 19			Teaching Hour = 19		
Semester IV					
MC7	Numerical Analysis	3	3		
	Numerical Analysis Lab	1			2
MC8	Optimization techniques	4	4		
MC9	Python Programming	3	3		
	Python Programming Lab	1			2
NM3	Selected by the candidate	4	4		
NV8	Vocational - Mentored Seminar III	1	1		
NV9	Vocational – Soft Skill Development IV	1	1		
MDC3	Selected by the candidate (Elective)	3	3		
AEC4	Logical Ability II / Foreign Language II	2	2		

Total Credit = 23			Teaching Hour = 25		
Semester V					
MC10	Complex Analysis and Applications of Calculus	4	4		
MC11	Metric Space and Topology	4	4		
MC12	Ordinary differential equation and Multivariate Calculus	4	4		
NV10	Vocational- Mentored Seminar IV	1	1		
NV11	Vocational – Soft Skill Development V	1	1		
SEC3	Data Analysis	3	3		
VAC3	Ethics Study and IPR	2	2		
Total Credit = 19			Teaching Hour = 19		
Semester VI					
MC13	Analytical Dynamics and Statics	4	4		
MC14	Financial Mathematics and Bio Mathematics	4	4		
MC15	Partial Differential equation	4	4		
NM4	Selected by the candidate	4	4		
NV12	Vocational	1	1		
NV13	Vocational – Soft Skill Development VI	1	1		
INT1	Internship	3			6
Total Credit = 21			Teaching Hour = 24		
Semester VII					
MC16	Continuum Mechanics	4	4		
MC17	Introduction to Fuzzy Sets and Stochastic Process	4	4		
MC18	Integral Transforms	4	4		
MC19	Advanced ODE and dynamical system	4	4		
NM5	Selected by the candidate	4	4		
Total Credit = 20			Teaching Hour = 20		

Semester VIII					
MC20	Generalized functions and special functions	4	4		
MC21	Calculus of variations and integral equations	4	4		
ME- Project/ Courses	Project/ Research Design and Communication (Mandatory), [Advanced Computational Method/ Differential Geometry/ Measure theory and Topology/Theory of Relativity /Classical Electromagnetism/ Foundations of Cryptography and Machine Learning]	12/ (4+4+4)	0/12		24/0
Total Credit = 24			Teaching Hour = 36		

COURSE CO-PO-PSO MAPPING

SEMESTER I

Course MC1: Classical and Abstract Algebra
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: Present concept and properties of various algebraic structures and discuss the importance of algebraic properties relative to working within various number systems and develop the ability to solve simple and complex problems of algebra.*

Prerequisite: *Before learning the course learners should have a basic knowledge about polynomial, number systems and sets, relations, mapping.*

SYLLABUS OUTLINE:

Module I: Number Theory and Classical Algebra: [12L]

Euclid’s algorithm, Coprimes, Congruences, Chinese remainder theorem, Fermat’s Theorem, Euler's phi function, Euler's theorem, Diophantine equation.
Relation between roots and coefficients, Newton’s formula, Descartes’ rules of signs, Cubic solution using Cardan’s method, Biquadratic solution using Ferrari’s method.

Module II: Set Theory: [6L]
Set partition, Partial order relation and Poset, Permutations of set, Binary operations

Module III: Fundamentals of Group Theory [10L]

Semigroup, Groupoid, Group, Abelian group, Cardinality, Order of an element, Subgroup, Lagrange's theorem, Generating element, Cyclic group, Permutation group.

Module IV: Advanced Group Theory : [8L]
Homomorphism. Isomorphism (concept only)**,** Coset. Normal subgroup**,** Proof of Fermat, Chinese remainder theorem.

Module V: Ring and Field Theory : [12L]
Ring. Subring. Ring isomorphism**,** Ideal. Primary ideal. Principal ideal. Maximum ideal**,** Zero divisor, Integral domain**,** Euclidean domain. Principal ideal domain. Field.

Text & Reference books:

Text Books:

1. S. K. Mapa , Higher Algebra.
2. S. K. Mapa, Classical Algebra.
3. Ghosh and Chakraborty, Higher Algebra.
4. Fraleigh , First Course in Abstract Algebra.

Reference Books:

1. Burnside and Panton, The Theory of Equations (Vol. I).
2. Barnard and Child, Higher Algebra .
3. Surjeet Singh & Zameruddin ,Modern Algebra .
4. N. P. Chaudhuri, Abstract Algebra (Tata Mc. Graw Hill).

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*: NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

After attending this course the students will be able to

CO1. **Describe** the foundational concepts of classical algebra.
CO2. **Implement** algebraic techniques to solve cubic and biquadratic equations.
CO3. **Examine** the structure of algebraic systems to determine their properties and interrelations.
CO4. **Verify** the properties of number-theoretic functions and theorems in various algebraic contexts.
CO5. **Construct** logical and abstract mathematical arguments to construct proofs to solve complex algebraic and number-theoretic problems.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	2	3	-	3	1	1	3	1	1
CO2	2	3	1	2	-	1	2	1	3	2	1
CO3	3	3	1	2	1	-	2	2	3	1	2
CO4	2	3	1	1	2	1	1	1	3	1	2
CO5	3	3	1	1	1	1	2	2	3	2	2

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC2: Real Analysis

Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, students will be able to: understand the fundamental properties of the real numbers including their algebraic and order properties. Understand how to construct rigorous Mathematical proofs and apply them to solve problems in Real Analysis.*

Prerequisite: *Before learning the course, learners should have a basic knowledge about number systems and sets, relations, mapping, differentiation, integration.*

SYLLABUS OUTLINE:

Module I: Sets in R: [8L]

Intuitive idea of numbers. Mathematical operations revisited with their Properties (closure, commutative, associative, identity, inverse, distributive). Sets and Functions - definition and properties. Field Axioms. Well ordering principle, Bounded set, L.U.B. (supremum) and G.L.B. (infimum) of a set. Properties of L.U.B. and G.L.B. Definition of an Archimedean ordered field. Archimedean property of IR. Open and closed Intervals, Neighbourhood of a point. Interior point. Open set. Union, intersection of open sets. Limit point and isolated point of a set. Criteria for L.U.B. and G.L.B. of a bounded set to be limit point of the set. Bolzano-Weierstrass theorem on limit point. Definition of derived set. Closed set. Complement of open set and closed set. Union and intersection of closed sets as a consequence. Countability (finite and infinite) and uncountability of a set. Subset of a countable set is countable. Cartesian product.

Module II: Sequences of real numbers: [10L]

Definition, bounded sequence, Limit of a sequence, examples. Algebra of limits. Monotone sequences and their convergence. Sandwich theorem. Nested interval theorem. Limit of some important sequences. Subsequence. Sub-sequential limits. Lim sup upper (limit) and lim inf (lower limit) of a sequence using inequalities. Alternative definitions of lim sup and lim inf of a sequence using L.U.B. and G.L.B. Cauchy Sequence and related theorems.

Module III: Infinite Series of real numbers: [10L]

Infinite Series and it's convergence. Cauchy's criterion of convergence. Tests of convergence – Cauchy's condensation test. Comparison test, Ratio Test, Root test, Raabe's test, Gauss's test. Series of non-negative real numbers: Absolute and conditional convergence Alternating series: Leibnitz test. Non-absolute convergence: Abel's and Dirichlet's test (statements and applications). Riemann's rearrangement.

Module IV: Limit and Continuity:[10L]

Continuity of real-valued functions of a real variable: Limit of a function. Sequential criteria. Algebra of limits. Algebra of continuous functions. Continuity of composite functions. Examples of continuous functions. Bounded functions. Neighbourhood properties of continuous functions regarding boundedness. Related Theorems.

Module V: Derivative: [10L]

Definition of differentiability. Leibnitz theorem. Theorems on derivatives : Darboux theorem, Rolle's theorem, Mean value theorems of Lagrange and Cauchy – as an application of Rolle's theorem. Taylor's theorem on closed and bounded interval with Lagrange's and Cauchy's form of remainder deduced from Lagrange's and Cauchy's mean value theorem respectively. Maclaurin's theorem as a consequence of Taylor's theorem. Statement of Maclaurin's theorem and the expansion of some standard functions.

Statement of L'Hospital's rule and its consequences. Point of local maximum/minimum of a function in an interval. Sufficient condition for the existence of a local maximum/minimum of a function at a point (statement only). Determination of local extremum using first order derivative.

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Application of the principle of maximum/minimum in geometrical problems.

Text & Reference books:

Text Books:

1. Introduction to Real Analysis- S. K. Mapa.

2. Introduction to Real Analysis–Bartle & Sherbert (John Wiley & Sons.)

3. Mathematical Analysis – Tom. M. Apostol.

4. Differential Calculus – R. K. Ghosh& K. C. Maity.

Reference Books:

1. Basic Real & Abstract Analysis–Randolph J.P. (Academic Press).
2. A First Course in Real Analysis–M. H. Protter & G. B. Morrey (Springer Verlag, NBHM).
3. A Course of Analysis –Phillips.
4. Problems in Mathematical Analysis– B. P. Demidovich (Mir).
5. Problems in Mathematical Analysis – Berman (Mir).
6. Differential & Integral Calculus (Vol.I&II)–Courant & John.
7. Calculus of One Variable – Maron (CBS Publication).

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcomes:

CO1: Discuss the foundational properties of real numbers, sets, and functions, boundedness, and the structure of $\mathbb{R}$.

CO2: Demonstrate the concepts of limits, continuity, and differentiability to analyze real-valued functions to solve related problems.

CO3: Examine the convergence behavior of sequences and infinite series using various mathematical tests and criteria.

CO4: Verify mathematical proofs involving the supremum and infimum of sets, limit points, and Cauchy sequences.

CO5: Construct problem-solving strategies involving real functions using Rolle's, Mean Value Theorem, and Taylor's Theorem.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	1	1	–	–	–	1	3	2	–
CO2	3	3	2	2	–	–	–	1	3	2	2
CO3	3	3	2	2	–	–	–	1	3	3	2
CO4	3	3	2	2	1	–	–	1	3	2	2
CO5	3	3	2	3	1	–	–	1	3	2	3

1. LOW 2.MODERATE 3. SUBSTANTIAL

SEMESTER II

Course MC3: Linear Algebra and Field Extension
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: apply the knowledge of matrix algebra, system of equations, vector space, linear transform as a tool in the field of Image Processing, Machine Learning and artificial intelligence etc. and the knowledge of vector calculus to solve complex problems.*

Prerequisite: *Before learning this course, the students should have a knowledge of basic abstract algebra.*

SYLLABUS OUTLINE:

Module I: Matrices: [8L]
Matrix. Determinant. Solving systems of linear equations. Uniqueness and existence criteria, Row and column spaces. LU Decomposition. LDU factorisation. Matrix transformations.

Module II: Vector spaces:[10L]
Definition, Subspaces, Basis. Dimension, Related Theorems. Linear Transformation, Examples of Linear Transformation, Matrix Representation, Rank-nullity theorem, Linear Operator, Eigenvalue, Eigenvector. Geometric significance. Duality. Dual mapping and space. Transposition, Characteristic polynomial. Diagonalization.

Module III: Inner product spaces [10L]
Definition. Orthogonality. Orthonormality, Gram schmidt orthogonalisation. QR decomposition, Adjoint of linear operator. Singular value decomposition, Principal component analysis.

Module IV: Application in machine learning [4L]
Ordinary least square. Linear regression, Principal Component Analysis. Dimension reduction, Gradient descent, Hyperplanes. Support vectors.

Module V: Field extension:[16L]
Centraliser. Class equation. Direct product, Simple group. Quotient group. Group Isomorphism theorems, Cayley' theorem. Sylow's theorem, Action of a group. Fixed point and Stabilizer. Ring Isomorphism theorems. Polynomial rings, Factorisation. Quotient rings. Irreducible polynomials, Module. Submodule. Extension of fields.

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Text & Reference books:

Text Books:

1. Linear Algebra: Stephen H. Freiedberg, Arnold J. Insel and Lorence E. Spence
2. Higher Algebra- S.K. Mapa
3. Contemporary Abstract Algebra: Joseph A Gallian

Reference Books:

4. Linear Algebra - Ghosh and Chakraborty
5. Linear Algebra – Hadley

COURSE OUTCOMES:

After attending this course, the students will be able to

CO1: Explain fundamental concepts of matrices, determinants, and vector spaces.

CO2: Identify linear transformations and matrix factorizations .

CO3: Inspect inner product spaces and orthogonality.

CO4: Determine abstract algebraic structures such as rings, and fields using isomorphism theorems and Sylow's theorems.

CO5: Develop mathematical models or algorithms using linear algebra and field theory concepts.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	2	2	3	2	1
CO2	2	3	3	3	2	2	2	2	3	3	2
CO3	2	3	3	3	3	3	2	2	3	3	3
CO4	3	2	3	3	3	2	3	2	3	3	3
CO5	2	3	3	3	3	3	3	3	3	3	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC4: Discrete Mathematics and Riemann Integration and Series of Functions
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: apply the knowledge of graph theory , Riemann integration and series of functions to solve complex problem.*

Prerequisite: *Before learning the concepts of Discrete Mathematics, the students should have a basic knowledge of set, relation, mapping, matrix, real number system, limit, continuity, differentiability of real functions etc.*

SYLLABUS OUTLINE:

Module I: Combinatorics and Basic Graph Theory [10 L]
Pigeonhole principle, Inclusion–Exclusion principle, Ball-bin problems, Graphs and Digraphs, Complements, Bipartite and complete graphs, Graph isomorphism, Connectedness, Reachability, Adjacency matrix.

Module II: Advanced Graph Theory and Applications [10 L]
Euler and Hamiltonian paths and circuits, Trees, Planar graphs, Euler's formula, Dual graphs, Cliques, Chromatic number, Generating functions, Recurrence relations.

Module III: Propositional Logic:[8 L]
Proposition and connectedness**,** Truth tables. Validity. Satisfiability**,** Equivalence and normal forms**,** Soundness and completeness.

Module IV: Riemann integration:[10 L]

Darboux sum. Integrability. Condition for Riemann's integrability, Negligible set. Condition on negligible discontinuity for Riemann integrability. MVT of integral calculus. Antiderivative, Area and volume integral in terms of double and triple integrals.

Module V: Series of functions:[10 L]

Power series. Uniqueness of power series. Abel's limit theorems, Uniform and absolute convergence, Fourier series. Trigonometric series, Dirichlet conditions.

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Text & Reference books:

Text Books:

1. Topics in Algebra, I. N. Herstein, John Wiley and Sons.
2. Digital Logic & Computer Design, M. Morris Mano, Pearson.
3. Elements of Discrete Mathematics, (Second Edition) C. L. LiuMcGraw Hill, New Delhi.
4. Graph Theory with Applications, J. A. Bondy and U. S. R. Murty, Macmillan Press, London.

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5. Mathematical Logic for Computer Science, L. Zhongwan, World Scientific, Singapore.

Reference Books:

6. Introduction to linear algebra. Gilbert Strang.
7. Introductory Combinatorics, R. A. Brualdi, North-Holland, New York.
8. Graph Theory with Applications to Engineering and Computer Science, N. Deo, Prentice Hall, Englewood Cliffs.
9. Introduction to Mathematical Logic, (Second Edition), E. Mendelsohn, Van-Nostrand, London.

Course learning outcome: (CO)

After attending this course, the students will be able to

CO1: **Define** the essential principles of combinatorics and graph theory.

CO2: **Apply** graph-theoretic and combinatorial techniques to solve mathematical and practical problems.

CO3: **Analyze** logical propositions using truth tables and validate arguments through logical equivalences.

CO4: **Evaluate** the properties of Riemann integrable functions and justify results of Riemann integration.

CO5: **Develop** the concepts of power series and Fourier series to construct representations of functions.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	2	2	2	3	2	2
CO2	3	3	3	3	2	1	2	1	3	3	3
CO3	3	3	2	3	2	2	2	2	3	3	2
CO4	3	3	2	3	3	3	1	2	3	3	2
CO5	3	3	2	2	3	2	2	3	3	3	3

1. LOW   2. MODERATE   3. SUBSTANTIAL

Course MC5: Analytical Geometry and Vector Analysis
Credit 4: (4L-0T-0P)

Learning objectives:
On completion of the course students will be able to apply the knowledge of analytical geometry and vector analysis in various mathematical and scientific disciplines.

Prerequisite: Before learning this course the students should have proficiency in algebra, trigonometry and calculus including knowledge of functions, equations, and derivatives. Familiarity with vectors, matrices, and linear algebra concepts is beneficial.

SYLLABUS OUTLINE:

Module I: Coordinate Geometry and Transformation (8 L)
Rotation of Axes: Derivation and geometrical interpretation, Elimination of Cross Product Term in second-degree equations, General Second-Degree Equation in Two Variables, Classification of Conic Sections based on discriminant, Reduction to Canonical Forms

Module II: Conic Sections (10 L)
Standard Forms of Parabola, Ellipse, Hyperbola, Tangent and Normal Equations for Conics, Parametric Equations of Conics, Polar Equations of Conics: Focus-directrix property, eccentricity, Applications in Geometry and Physics

Module III: Planes in 3D (5 L)
Equation of a Plane in different forms (general, intercept, normal), Angle Between Two Planes, Distance of a Point from a Plane, Line of Intersection of Two Planes. Parallelism and Perpendicularity: Plane with plane, plane with line, Identification of Sides of a Plane

Module IV: 3D Lines and Geometry (5 L)
Straight Lines in 3D: Vector and Cartesian form, Canonical/Symmetric Form of a Line. Angle Between Two Lines. Skew Lines: Shortest distance between them. Line-Plane Interactions: Intersection, angle, parallelism. Geometrical Interpretation and Problem Solving**.**

Module V: Vector Algebra (20 L)
Definition and Representation of Vectors. Free, Bound, Unit, and Position Vectors Vector Addition and Subtraction. Scalar Multiplication. Collinearity and Coplanarity of Vectors. Scalar (Dot) Product and Vector (Cross) Product. Geometric Interpretation and Properties. Scalar Triple Product: Volume of a parallelepiped. Vector Triple Product: Properties and identities. Work Done by a Force. Moment of a Force (Torque). Application Problems from physics and mechanics. Mixed Product Interpretation.

Text & Reference books:

Text Books:

1. Analytical Geometry – Ghosh and Chakravorty.

Avishek Adhikari   Anisha Dutta

2. Vector Analysis-Maity and Ghosh
2. Vector Analysis – Louis Brand.
3. Elementary Vector Analysis – C. E. Weatherburn (Vol. I & II).

Reference Books:

4. Vector Analysis – Barry Spain.
5. Vector & Tensor Analysis – Spiegel (Schaum).

Pedagogy for Course Delivery: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)

List of Professional Skill Development Activities (PSDA):NA
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

After attending this course, the students will be able to

CO1: Apply geometric methods to obtain the equations of standard conic sections.

CO2: Analyze second-degree equations in two variables to identify the corresponding conic sections.

CO3: Determine the angles, distances, and relative positions of planes in three-dimensional space.
CO4: Evaluate the shortest distance between skew lines and interpret geometric relationships among lines and planes.
CO5: Compute scalar and vector triple products to solve problems in Mechanics.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	-	-	1	3	2	-
CO2	3	3	1	2	-	-	-	1	3	3	-
CO3	3	2	2	2	-	-	-	1	3	3	2
CO4	3	3	2	3	-	-	-	1	3	3	2
CO5	3	3	2	3	1	-	-	1	3	3	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC6: Probability and Statistics

Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to:*

develop a solid understanding of key probability concepts such as sample spaces, random variables, and probability distributions. Additionally, students aim to gain proficiency in statistical analysis techniques, including hypothesis testing, regression analysis, and data interpretation, enabling them to make informed decisions and draw meaningful conclusions from data.

Prerequisite: *Before learning the course*

Prerequisites for probability and statistics include a strong foundation in algebra and basic mathematical operations, as well as an understanding of descriptive statistics and basic probability concepts such as sample spaces and probability rules.

SYLLABUS OUTLINE:

Module 1: Fundamentals of Probability (8L)

Concept of experiments, sample space, event, Definition of classical and combinatorial probability, Conditional probability, Independence of events, Bayes' theorem, and applications.

Module 2: Random Variable and Probability Distributions (12L)

Random variables (discrete and continuous), Mathematical expectation and its properties, Moments and variance, Moment generating function, Discrete distributions: Binomial, Poisson, Geometric, Continuous distributions: Uniform, Exponential, Normal, Special continuous distributions: Chi-square, t, F. Bivariate random variables.

Module 3: Introduction to Statistics and Data Collection (8L)

Definition of statistics, Basic objectives, Applications in various branches of science and social science with examples, Collection of Data: Internal and external data, Primary and secondary data, Population and sample, Representative sample, Classification, and tabulation of univariate data.

Module 4: Descriptive Statistics (12L)

Graphical representation of data, Frequency curves, Measures of central tendency, Measures of dispersion, Bivariate data, Summarization, Marginal, and conditional frequency distribution.

Module 5: Regression and Inferential Statistics (8L)

Correlation, Linear regression, Confidence intervals, Hypothesis testing, One-way ANOVA.

Text & Reference books:

1. Introduction to Probability - N. G. Das

2. Statistical Methods – N.G. Das
3. Fundamentals of Statistics (Vol. I) - Goon Gupta and Das Gupta
4. Groundwork of Mathematical Probability and Statistics - Amritava Gupta
5. Statistical Tools and Techniques- P. K. Giri and J. Banerjee

Course Outcome (CO):

On completion of the course, student will be able to:

CO1: Explain probability concepts and Bayes' theorem.

CO2: Implement probability distributions to solve mathematical problems.

CO3: Classify data types, sampling methods, and data collection techniques.

CO4: Judge suitability of graphs and descriptive measures for data summarization.

CO5: Construct regression models and perform hypothesis testing for conclusions.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	-	-	2	3	2	2
CO2	3	3	3	2	2	-	-	2	3	3	3
CO3	2	2	2	2	1	-	-	2	2	2	2
CO4	2	2	1	2	2	-	-	2	2	3	2
CO5	3	3	3	3	3	2	2	3	3	3	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC7: Numerical Analysis and Lab
Credit 4: (3L-0T-2P)

Learning objectives: On completion of the course, students will be able to solve complicated mathematical problems and real-life problems numerically. Also, they can apply MATLAB and other convenient numerical software such as Microsoft Excel to solve numerical problems with the help of simple programming.

Prerequisite: Before learning the course, the learner should have a basic knowledge about integration, differentiation, real number system, system of equations, linear algebra.

SYLLABUS OUTLINE:

Numerical Analysis Theory [36 L]

Module I. Error of numerical computations and Interpolation (12 L):
Errors in Numerical computation: Round off error, Truncation error. Approximate numbers. Significant figures. Absolute, relative and percentage error.
Operators: Δ, E, μ, δ (Definitions and simple relations among them).
Problems of interpolation, Weierstrass' approximation theorem only statement). Polynomial interpolation. Equi-spaced arguments. Difference table. Deduction of Newton's forward and backward interpolation formulae. Statements of Stirling's and Bessel's interpolation formulae. Error terms. Deduction of Lagrange's interpolation formula. Divided difference. Newton's General Interpolation formula (only statement).

Module II. Numerical Integration (6L):
Integration of Newton's interpolation formula. Newton-Cote's formula. Trapezoidal and Simpson's $1/3^{rd}$ formulae. Their composite forms. Weddle's rule (only statement). Statement of the error terms associated with these formulae. Degree of precision (only definition).

Module III. Numerical solution of non-linear equations (6L):
Location of a real root by tabular method. Bisection method. Secant/ Regula-Falsi and Newton-Raphson methods, their geometrical significance. Fixed point iteration method.

Module IV. Numerical solution of a system of linear equations (6L):
Gauss elimination method. Iterative method – Gauss-Seidal method. Matrix inversion by Gauss elimination method (only problems – up to 3×3 order), LU decomposition method.

Module V. Numerical solution or Ordinary Differential Equation (6L):
Basic ideas, nature of the problem. Picard, Euler and Runge-Kutta (4^{th} order) methods (emphasis on the problem only).

Numerical Analysis Lab [12L]

1. Evaluation of numerical integrations using

(a) Trapezoidal Rule
(b) Simpson's one-third rule

2. Solution of transcendental and algebraic equations by
   (a) Bisection Method
   (b) Regula-Falsi Method
   (c) Newton Raphson's method
3. Solution of system of linear equations by
   (a) Gauss-elimination method
   (b) Gauss-Seidel iteration method

4. Interpolation: Lagrange Interpolation
5. Solution of Initial value problems using
   (a) Euler's method
   (b) RK4 method

Text & Reference books:

Text Books:

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

2. Sahajahan Ali Mollah, Numerical Analysis and Computational Procedures, Books & Allied Ltd.

3. 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.

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

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

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

Reference Books:

1. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.

2. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978. Yashavant Kanetkar, Let Us C, BPB Publications.

3. P. S. Grover, Programming and Computing with FORTRAN 77/90 – (Allied Publishers).

Pedagogy for Course Delivery: *Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA):*NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

After attending this course, the students will be able to

CO1: **Explain** the fundamental principles of numerical computation, error analysis, and interpolation techniques

CO2: **Apply** numerical methods to solve nonlinear and linear systems.

CO3: **Examine** the accuracy and convergence of numerical techniques.

CO4: **Evaluate** the efficiency and stability of various numerical algorithms implemented through MATLAB or other computational tools.

CO5: Develop MATLAB/Excel programs to model and solve real-world mathematical and scientific problems numerically.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	1	1	3	2	1
CO2	3	3	3	3	2	2	1	1	3	3	2
CO3	2	3	3	3	2	2	2	2	3	3	3
CO4	2	2	3	3	3	3	2	2	3	3	3
CO5	2	3	3	3	3	3	3	3	3	3	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC8: Optimization techniques
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: apply the knowledge of linear programming problem, queuing theory, inventory control, Game Theory to solve complex problems.*

Prerequisite: *Before learning the concepts of Optimization Techniques, you should have a basic knowledge of set, vector space, probability theory.*

SYLLABUS OUTLINE:

Module I: Introduction to OR [2L]
Origin of OR and its definition. Types of OR problems, Deterministic vs. Stochastic optimization, Phases of OR problem approach – problem formulation, building mathematical model, deriving solutions, validating model, controlling and implementing solution.

Module II: Linear Programming [14L]

Linear programming – Examples from industrial cases, formulation & definitions, Matrix form. Implicit assumptions of LPP. Some basic concepts and results of linear algebra – Vectors, Matrices, Linear Independence /Dependence of vectors, Rank, Basis, System of linear eqns., Hyper plane, Convex set, Convex polyhedron, Extreme points, Basic feasible solutions. Geometric method: 2-variable case, Special cases – infeasibility, unboundedness, redundancy &degeneracy, Sensitivity analysis. Simplex Algorithm – slack, surplus & artificial variables, computational details, big-M method, identification and resolution of special cases through simplex iterations. Duality – formulation, results, fundamental theorem of duality, dual-simplex and primal-dual algorithms.

Module III: Transportation and Assignment problems [12L]

TP - Examples, Definitions – decision variables, supply & demand constraints, formulation, Balanced & unbalanced situations, Solution methods – NWCR, minimum cost and VAM, test for optimality (MODI method), degeneracy and its resolution. AP - Examples, Definitions – decision variables, constraints, formulation, Balanced & unbalanced situations, Solution method – Hungarian, test for optimality (MODI method), degeneracy & its resolution.

Module IV: PERT – CPM [6L]

Project definition, Project scheduling techniques – Gantt chart, PERT & CPM, Determination of critical paths, Estimation of Project time and its variance in PERT using statistical principles, Concept of project crashing/time-cost trade-off.

Module V: Inventory Control [4L]
Functions of inventory and its disadvantages, Concept of inventory costs, Basics of inventory policy (order, lead time, types), Fixed order-quantity models – EOQ model.

Module VI: Queuing Theory [6L]

Definitions – queue (waiting line), waiting costs, characteristics (arrival, queue, service discipline) of queuing system, queue types (channel vs. phase).Kendall's notation, Little's law, steady state behavior, Poisson's Process & queue, Models with examples - M/M/1 and its performance measures; M/M/m and its performance measures; brief description about some special models.

Module VII: Game Theory [4L]
Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method of solving rectangular games. Inter-relation between theory of games and L.P.P

Text Books:

1. Operations Research: An Introduction. H.A. Taha.
2. Linear Programming. G. Hadley.

Reference Books:

1. Linear Programming. K.G. Murthy.
2. Principles of OR with Application to Managerial Decisions. H.M. Wagner.
3. Introduction to Operations Research. F.S. Hiller and G.J. Lieberman.
4. Elements of Queuing Theory. Thomas L. Saaty.
5. Operations Research and Management Science, Hand Book: Edited By A. Ravi Ravindran.
6. Management Guide to PERT/CPM. Wiest& Levy.
7. Modern Inventory Management. J.W. Prichard and R.H. Eagle.

***Course learning outcome**: (CO)*

After attending this course, the students will be able to

CO1: Explain the basic concepts, scope, and phases of Operations Research and formulate Linear Programming Problems.

CO2: Apply optimization techniques to solve Transportation and Assignment problems.

CO3: Analyze project networks using PERT and CPM to determine critical paths and project durations.

CO4: Evaluate inventory and queuing models to optimize system performance under uncertainty.

CO5: Develop optimal strategies for decision-making problems using Game Theory and its relation to Linear Programming.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	1	2	1	1	2	2	3	2	3
CO2	3	3	2	2	2	2	3	2	3	3	3
CO3	3	3	2	3	2	3	3	2	3	3	2
CO4	3	3	2	3	2	2	2	2	3	3	2
CO5	3	3	2	2	3	2	2	3	3	3	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC9: Python Programming
Credit 4: (3L-0T-2P)

Learning objectives: *On completion of the course, students will be able to design and program Python applications by understanding the various components of the Python program.*

Prerequisite: *Before learning the course, students must have the basic understanding of data flow and control flow sequence as well as the knowledge of simple programming concepts .*

SYLLABUS OUTLINE:

Credit 3: (3L-0T-0P)

Module I (6L)

Introduction to Python: Python keywords and variables, Python basic Operators, Understanding python blocks. Python Data Types, Mutable and Immutable types, Declaring and using Numeric data types.

Module II (4L)

Conditional Blocks and Flow of control structure: Condition: if, else and nested if, Loops: For loops, while loops, Nested loops, Enumerate, Loop manipulation: Pass, Break, Continue Statement, Programming using conditional and loop blocks

Module III (6L)

Avishek Adhikari Anisha Dutta

Functions: def Statements with Parameters, Return Values, and return Statements, None and print, adding new function, parameters and argument, recursion, and its use, Local and Global Scope, The global Statement, Exception Handling.

Module IV (6L)

Complex data types: string data type and string operations, list and list slicing, Use of Tuple data type. String, List and Dictionary, string manipulation methods, List manipulation. Dictionary manipulation, Programming using string, list.

Module V (6L)

File Operations: Reading files, different read functions. Writing files in python using write functions. File handling and organization.

Text & Reference books:

Text Books:

1. Y. Daniel Liang," Introduction to Programming Using Python", Pearson Education.
2. Martin C Brown, "Python the Complete Reference", Tata McGraw Hill, India

Reference Books:

1. Wesley J. Chun, "Core Python Applications Programming", Pearson Education.
2. John V Guttag. "Introduction to Computation and Programming Using Python", Prentice Hall of India.

Pedagogy for Course Delivery: *Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA):*NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcome (CO):

CO1: Define the fundamental concepts of programming, including basic structures, variables, and data types.

CO2: Illustrate the use of control flow mechanisms such as decision-making structures and iterative loops to solve problems.

CO3: Implement functions with parameters, outputs, and error handling.

CO4: Analyze and manipulate data structures to organize and process information.

CO5: Demonstrate file handling techniques for data storage and retrieval.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	1	2	1
CO2	2	2	-	-	-	-	-	-	1	2	1
CO3	-	2	3	-	-	-	-	-	1	3	1
CO4	-	2	3	3	-	-	-	-	2	3	2
CO5	-	-	3	-	2	-	3	-	1	3	2

1. LOW 2.MODERATE 3. SUBSTANTIAL

SEMESTER V

Course MC10: Complex Analysis and Applications of Calculus
Credit 4: (4L-0T-0P)

Learning objectives: On completion of the course complex analysis, students will be able to understand complex numbers, analyze complex functions, evaluate integrals using contour integration, solve problems using the residue theorem, and apply complex analysis techniques in various scientific disciplines. Also, students will be able to the knowledge of calculus to find out the radius of curvatures, envelopes, asymptotes of different functions.

Prerequisite: Before learning the course, complex analysis includes a strong foundation in calculus, including knowledge of limits, derivatives, and integrals. A solid understanding of functions, including exponential, logarithmic, and trigonometric functions, is necessary. Knowledge of complex numbers and their algebraic operations will be beneficial to grasp the complex analysis aspects of Laplace transformation. Proficiency in solving equations and manipulating mathematical expressions is also recommended.

SYLLABUS OUTLINE:

Complex Analysis:

Module I: Complex Numbers and Complex Functions: [8L]
Complex numbers, Graphical Representation, Fundamental operations with complex numbers, topology of the complex plane, stereographic projection, complex-valued functions, Limit, Continuity, sequence and convergence of complex numbers, series of complex numbers, tests of convergence of complex series.

Module II: Analytic Function and Power Series: [10L]
Differentiability, Cauchy-Riemann equations, harmonic function, analytic functions and their zeros, multi-valued functions, branch cuts, Riemann sheets, Series and uniform convergence, properties of uniformly convergent series, power series, Taylor series, uniqueness theorem, analytic continuation, Laurent series.

Module III: Complex Integration and Classification of Singularities: [8L]
Curves in the complex plane, complex integration, Jordan's Lemma, Cauchy's theorem, Morera's theorem, Cauchy integral formula, singularity, Singularities, Classification of singularities, Cauchy's residue theorem. Evaluation of some integrals,

Module IV: Maximum Modulus Principle, Conformal Mapping [8L]

Argument principle. maximum modulus principle, open mapping theorem, Schwarz Lemma, Liouville's theorem, fundamental theorem of algebra, Conformal mapping, geometric interpretation, applications, Mobius transformations, and their properties.

Module V: Applications of Calculus [14L]

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$ $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, curvature, concavity and points of inflection, envelopes, rectilinear asymptotes (Cartesian & parametric form only), 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 $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \sec^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \sin mx dx$, $\int \sin^n x \cos^m x dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Text & Reference books:

Text Books:

1. 1. S. Ponnusamy, Foundation of Complex Analysis, Narosa Publishing House, ISBN: 9788173196294.
2. Differential & Integral Calculus (Vol.I&II)–Courant & John.
3. Calculus of One Variable – Maron (CBS Publication).

Reference Books:

4. R. V. Churchill and J. W. Brown , Complex Variables and Applications: Mcgraw-Hill; New York; 1996
5. R. V. Churchill and J. W. Brown: Complex Variables and Applications; Mcgraw-Hill; New York; 1996
6. N. W. Mclachlan, Laplace transform and their applications to differential equations.
7. 1. E.T. Copson, An introduction to theory of functions of a complex variable, Oxford, Clarendon Press, 1962.
8. 2. E.T. Whittaker and G.N. Watson, A course of modern analysis, Cambridge University Press, 1958.
9. 3. R.V. Churchill, J.W. Brown and R.E. Vermay, Complex variables and applications, McGraw Hill, 1984.
10. 4. T.M. MacRobert, Functions of a complex variable, MacMillan, 1962.
11. Problems in Mathematical Analysis– B. P. Demidovich (Mir).
12. Problems in Mathematical Analysis – Berman(Mir).

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES (CO):

After attending this course, the students will be able to

CO1 Describe the fundamental concepts of complex analysis in the complex plane.
CO2 Implement analytical techniques to solve problems involving complex functions and integration.
CO3 Examine the nature of singularities and conformal mappings to classify and transform complex functions.
CO4 Verify complex-valued series and the behavior of analytic functions in the context of uniqueness, continuation, and multi-valued functions through rigorous proofs.
CO5 Construct mathematical models using parametric curves to address real-world problems in sciences and economics.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	1	1	0	1	1	1	3	1	1
CO2	2	3	2	2	1	1	1	1	3	2	2
CO3	3	3	2	2	1	1	1	2	3	2	3
CO4	3	3	1	1	1	1	2	2	3	1	2
CO5	2	2	2	3	2	2	2	3	2	3	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC11: Metric space and Topology
Credit 4: (4L-0T-0P)

Learning objectives: On completion of this course, student will be able to understand the concepts of metric spaces and topological spaces and their properties.

Prerequisite: Before learning the course, learners should have a basic knowledge about real number, limit, continuity, and differentiability in real analysis.

SYLLABUS OUTLINE:

Module I: Foundations of $\mathbb{R}^n$ and Euclidean Topology [8L]
Topology of $\mathbb{R}^n$, Euclidean norms, Open and closed balls, Convergence of sequences in $\mathbb{R}^n$, Sequential compactness

Module II: Calculus of multi-variables[4L]
Chain rule of derivatives in $\mathbb{R}^n$,Basic differentiability in multivariable calculus

Module III: Metric Space[18L]
Metrics, Sets in metric spaces, Continuity, Connectedness, Compactness.

Module IV: Introduction to Topological Spaces [10L]
Topological spaces: definitions and examples, Open and closed sets, Bases and subbases, Subspace topology, Coverings

Avishek Adhikari Anisha Datta

Module V: Advanced Topology [8L]
Separation axioms (T_0–T_4), Compactness in topological spaces, Normal spaces, Separability

Text & Reference books:

Text Books:

1. Randolph J.P , Basic Real & Abstract Analysis. (Academic Press).
2. Tom M. Apostol, Mathematical Analysis (2nd Edition) (Addison-Wesley)
3. Maity and Ghosh, Differential Calculus
4. S. Kumaresan, Topology of Metric Spaces (Narosa)
5. James R. Munkres, Topology (2nd Edition), (Pearson)
6. Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill

Reference Books:

1. G. B. Folland, FOURIER ANALYSIS AND ITS APPLICATIONS (American Mathematical Society)

2. Sudhir R. Ghorpade and Balmohan V. Limaye, A Course in Calculus and Real Analysis, (Springer)

3. S K MAPA, Introduction to Real Analysis (LEVANT BOOKS)
4. E. T. Copson, Metric Spaces. Cambridge University Press.
5. Stephen Willard, General Topology, Dover Publications
6. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill
7. K.D. Joshi, Introduction to General Topology, New Age International

***Pedagogy for Course Delivery**: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

***List of Professional Skill Development Activities (PSDA)**:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcome (CO):

On completion of the course, student will be able to:

CO1: Explain key topological concepts in $\mathbb{R}^n$ based on their definitions, properties and significance.

CO2: Utilize various differentiability rules to solve multivariable problems in $\mathbb{R}^n$.

CO3: ***Design*** metric spaces to demonstrate properties of compactness, connectedness, and continuity.

CO4: ***Appraise*** *the application of subspace and covering concepts in solving topological problems.*

CO5: ***Distinguish*** separation axioms, compactness, normality, and separability in topological spaces.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	-	-	-	-	2	2	3	1	1
CO2	3	3	2	-	-	2	2	2	3	2	2
CO3	3	3	-	2	-	-	2	2	3	1	1
CO4	3	3	-	-	-	-	2	2	3	1	1
CO5	3	3	-	-	-	-	2	2	3	1	1

1. LOW 2.MODERATE 3. SUBSTANTIAL

Course MC12: Ordinary differential equations and Multivariate calculus
Credit 4: (4L-0T-0P)

Learning objectives: On completion of the course, student will be able to acquire the knowledge of the multivariate calculus and implement it to optimize a function with the help of the Lagrangian Multiplier method. Also, the knowledge of solving different types of ordinary differential equations enables someone to easily solve the initial and boundary value problems.

Prerequisite: Before learning the course, the learner should have a basic knowledge about calculus of one variable.

SYLLABUS OUTLINE:

Module I: Introduction to ODEs and First-Order Equations (8 Lectures)

Significance of ODEs: Geometric and physical interpretations, Formation of ODEs: Elimination of arbitrary constants. Meaning of solution of ODEs. Linear vs Non-linear equations. Existence theorem (statement only). Separable Equations. Homogeneous Equations. Exact Equations and condition for exactness.

Module II: Integrating Factor and First Order Non-Linear Equations (7 Lectures)

Integrating Factors: Rules and relevant results (statement only). First-order linear equations: Method using integrating factor. Equations reducible to linear form. Equations not of first degree. Clairaut's Equation. Singular Solutions. Applications: Orthogonal trajectories and geometric problems.

Module III: Higher-Order Linear ODEs with Constant Coefficients (7 Lectures)

Linear ODEs: Complementary function and particular integral. Symbolic Operator (D) method. Method of Undetermined Coefficients. Method of Variation of Parameters. Euler's Homogeneous Equation. Reduction to Equation with Constant Coefficients.

Module IV: Second-Order ODEs with Variable Coefficients (8 Lectures)

Reduction of order (when one solution is known). Complete solution construction. Variation of Parameters (revisited). Reduction to normal form, Change of independent variable. Operational Factors: Use in simplification

Module V: Foundations of Multivariate Calculus (18 Lectures)

Functions of Two and Three Variables: Limits, continuity, Sufficient condition for continuity. Partial Derivatives. Repeated & Double Limits, Differentiability, and its conditions. Differential as a Map, Chain Rule. Euler's Theorem and its converse. Young's & Schwarz's Theorem (Commutativity of mixed partials). Jacobian: Definition and simple properties (2 & 3 variables), Functional dependence. Implicit Function Theorem (statement and simple applications), Differentiation of implicit functions, Taylor's Theorem for functions of two variables, Lagrange's Method of Undetermined Multipliers (problems only).

Text & Reference books:

Text Books:

1. D.A. Murray, Introductory course in Differential Equations, Orient and Longman
2. H.T. H. Piaggio, Elementary Treaties on Differential Equations and their applications, C.B.S Publisher & Distributors, Delhi,1985.
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004
4. Real Analysis (Vol I)- Maity and Ghosh

Reference Books:

1. G. F. Simmons, Differential Equations, Tata McGraw Hill 14

Pedagogy for Course Delivery: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)

List of Professional Skill Development Activities (PSDA):NA
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

After attending this course, the students will be able to

CO1: Define the fundamental concepts and classifications of ordinary differential equations, including their formation and significance in physical contexts.

CO2: Explain the methods for solving first-order and first-degree differential equations using integrating factors and geometric interpretations.

CO3: Apply appropriate analytical techniques to obtain solutions of higher-order linear differential equations with constant coefficients.

CO4: Analyze the behaviour of second-order differential equations with variable coefficients using reduction of order and variation of parameters.

CO5: Evaluate optimization problems involving multivariate functions using Jacobians and the Lagrange Multiplier method.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	3	-	1
CO2	3	3	1	2	1	1	-	-	3	1	2
CO3	3	3	2	3	1	1	-	-	3	2	3
CO4	2	3	2	3	1	1	-	-	3	2	3
CO5	2	2	2	3	1	2	-	1	2	3	3

Course MC13: Analytical dynamics and Statics
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to acquire the basic knowledge of the dynamics and statics of a body and apply the knowledge to solve different problems in Mechanics.*

Prerequisite: *Before learning the course, students must have the undergraduate knowledge in definite integrals and calculus.*

SYLLABUS OUTLINE:

Module I (10L)

Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work

Module II (10L)

Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium.

Module III (16L)

Simple Harmonic Motion. Velocities and accelerations in Cartesian, polar, and intrinsic coordinates. Equations of motion referred to a set of rotating axes. Central forces. Stability of nearly circular orbits. Motion of a projectile in a resisting medium. Stability of nearly circular orbits. Motion under the inverse square law. Slightly disturbed orbits. Motion of artificial satellites. Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution.

Module IV (12L)

Degrees of freedom. Moments and products of inertia. Mometal Ellipsoid. Principal axes. D'Alembert's Principle. Motion about a fixed axis. Compound pendulum. Motion of a rigid body in two dimensions under finite and impulsive forces. Conservation of momentum and energy.

Text & Reference books:

Text Books:

1. F. Chorlton, Textbook of Dynamics.

2. S. L. Loney, An Elementary Treatise on the Dynamics of particle and of Rigid Bodies

Reference Books:

1. S. L. Loney, Elements of Statics and Dynamics I and II.

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

3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

After attending this course, the students will be able to

CO1: Define the fundamental laws and principles governing equilibrium, friction, and virtual work in statics.

CO2: Describe the conditions of equilibrium for systems of forces in two and three dimensions and locate the centres of gravity of different bodies.

CO3: Apply Newton's laws and kinematic relations to solve problems on the motion of particles in various coordinate systems.

CO4: Analyze particle motion under central forces, projectiles in resisting media, and the dynamics of satellites.

CO5: Evaluate the motion of rigid bodies using D'Alembert's principle and the conservation of momentum and energy.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	-	1	-	-	-	1	3	-	1
CO2	3	3	-	2	-	-	-	1	3	1	2
CO3	2	3	2	3	-	-	-	1	3	2	3
CO4	2	3	1	3	1	1	-	2	3	2	3
CO5	2	3	-	3	2	1	-	1	2	2	3

Course MC14: Financial Mathematics and Biomathematics
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to acquire the basic knowledge of the financial markets and ecology of pray predator models.*

Prerequisite: *Before learning the course, students must have the undergraduate knowledge in probability theory, differential calculus.*

SYLLABUS OUTLINE:

Module I: Introduction to Financial Mathematics [10 L]:

Brownian motion, geometric Brownian motion, interest rates, present value analysis, and rate of return. It covers the concepts of pricing via arbitrage, risk-neutral probabilities, and the multi-period binomial model, leading to the statement and application of the Arbitrage Theorem.

Module II: Option Pricing and Risk-neutral Valuation [8 L]:

Derivation and properties of the Black–Scholes formula, delta-hedging and arbitrage strategies, and pricing of American put options. The Capital Asset Pricing Model (CAPM) is discussed to explain the relationship between risk and return in financial markets.

Module III: Portfolio Theory and Risk Analysis [10 L]:

Valuation by expected utility and explores risk-averse, risk-neutral, and log utility functions. It introduces the portfolio selection problem, mean–variance analysis, and risk measures such as Value at Risk (VaR) and Conditional Value at Risk (CVaR), along with risk-neutral pricing of call options.

Module IV: Fundamentals of Biomathematics and Ecological Modelling [10 L]:

An introduction to the role of mathematics in biology and ecology, focusing on discrete-time and continuous-time dynamical models. It covers single-species population models without age structure, including exponential and logistic growth models and their analytical solutions.

Module V: Age-Structured and Epidemiological Models [10 L]:

Age-structured population models, the Lotka integral equation and its solution, and the formulation and solution of basic epidemiological models such as SI and SIS with constant coefficients, along with illustrative examples and biological interpretations.

Text & Reference books:

Text Books:

1. An Elementary Introduction to Mathematical Finance –S.M. Ross

2. An Introduction to Mathematics of Financial Derivatives –S.N. Neftchi

3. Mathematics of Financial Markets –R.J. Elliot and P.E. Kopp

Reference Books:

4. J.D. Murray (2001). Mathematical Biology, Vol.I& II, Springer-Verlag.

5. Mark Kot (2001). Elements of Mathematical Ecology, Cambridge University Press.
6. Bhupendra Singh and N. Agrawal (2008), Bio-Mathematics, Krishna Prakash Media (P) Ltd.

Pedagogy for Course Delivery: *Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA):*NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

CO1: Describe the concepts of Brownian motion, geometric Brownian motion, and their applications in modeling financial markets.

CO2: Apply arbitrage principles, risk-neutral valuation, and the Black–Scholes models.

CO3: Analyze portfolio selection problems using expected utility theory, mean-variance analysis, and risk measures such as Value at Risk (VaR) and Conditional Value at Risk (CVaR).

CO4: Develop mathematical models in ecology and epidemiology, including exponential, logistic, and Lotka–Volterra population models, as well as SI and SIS disease models.

CO5: Evaluate the effectiveness and limitations of discrete-time and continuous-time dynamical models in representing real-world biological and financial systems.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	2	3	1	2	1	2	3	2	3
CO2	2	3	3	3	2	3	1	2	2	3	3
CO3	2	3	3	3	2	3	1	2	2	3	3
CO4	3	2	2	3	2	2	1	3	3	2	3
CO5	2	3	2	3	3	3	1	2	3	2	3

1. LOW 2.MODERATE 3. SUBSTANTIAL

Course MC15: Partial differential equations
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to acquire the basic knowledge of the partial differential equation and differential geometry which will help the candidate to formulate and solve different problems of physics.*

Prerequisite: *Before learning the course, students must have the undergraduate knowledge in differential calculus of one and two variables and the fundamental concepts of differential equations.*

SYLLABUS OUTLINE:

Module I: First-Order PDEs [10 L]:

Order, degree, linear and nonlinear PDEs, Lagrange and Charpit methods.

Module II: Classification of Second-Order PDEs [8 L]:

Classification, and three fundamental equations: Laplace, Wave, Diffusion.

Module III: Solution Methods for Second-Order PDEs [10 L]:

Separation of variables and method of characteristics for second-order PDEs.

Module IV: Vector Calculus Basics [10 L]:

Derivatives of vector functions, velocity, acceleration, vector fields, divergence, and curl.

Module V: Integrals and Theorems in Vector Calculus [10 L]:

Line and surface integrals, applications, Green's theorem, Stokes' theorem, Divergence theorem with illustrative examples.

Text & Reference books:
Text Books:

1. Sneddon I.N. : Elements of Partial Differential Equations, McGraw Hill.
2. Rao, K. S.: Partial differential equations.
3. An Introduction to Differential Geometry (with the use of tensor Calculus), L. P. Eisenhart, Princeton University Press, 1940.
4. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
5. Vector Analysis- Maity and Ghosh
6. Vector Analysis – Louis Brand.
7. Elementary Vector Analysis – C. E. Weatherburn (Vol. I & II).

Reference Books:

1. Williams W.E. : Partial Differential Equations.
2. Miller F.H. : Partial Differential Equations.
3. Petrovsky. I.G : Lectures on Partial differential equations.
4. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
5. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.

Pedagogy for Course Delivery: *Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA):*NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcomes (COs):

CO1: Describe the basic concepts of order, degree, linearity, and nonlinearity in first-order partial differential equations.

CO2: Classify second-order partial differential equations.

CO3: Apply methods like separation of variables and characteristics second-order PDEs arising in physical and engineering contexts.

CO4: Demonstrate the principles of vector calculus including differentiation of vector functions, velocity, acceleration, divergence, and curl.

CO5: Evaluate line, surface, and volume integral to relate different forms of integrals.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	2	–	–	–	1	3	2	2
CO2	3	3	2	3	–	–	–	1	3	2	3
CO3	3	2	2	3	–	–	–	1	3	2	3
CO4	3	2	1	2	–	–	–	1	3	3	2
CO5	3	3	1	3	1	–	–	1	3	3	3

1. LOW 2.MODERATE 3. SUBSTANTIAL

Course MC16: Continuum Mechanics
Credit 4: (4L-0T-0P)

Learning objectives: On completion of the course, student will be able to understand and apply fundamental concepts, analyze stress and strain, formulate conservation laws, model material behaviour, solve boundary value problems, analyze fluid mechanics and waves, and apply these principles to real-world engineering problems.

Prerequisite: Before learning the course of continuum mechanics, it is recommended to have a strong foundation in calculus, differential equations, and solid mechanics. Familiarity with concepts such as stress, strain, equilibrium, Newton's laws of motion and basic principles of mechanics is essential. A background in physics and engineering mechanics will also be beneficial.

SYLLABUS OUTLINE:

Module I (8L):
Deformation of Continuum: Lagrangian and Eulerian methods of describing deformation, finite strain deformation, infinitesimal strain tensor, infinitesimal stretch, and rotation, change in volume.

Module II (8L):
Analysis of Strain: Relative displacement, strain quadratic, principal strains, strain invariants, compatibility conditions.

Module III (8L):
Analysis of Stress: Body forces, and surface forces, stress tensor, normal and shearing stresses, principal stress, stress invariants. Stress equations of equilibrium and motion, Symmetry of stress tensor.

Module IV (4L):
Generalized Hooke's Law: Strain energy, Generalized Hooke's Law, Isotropic elastic solid, Elastic moduli for isotropic media, Beltrami-Michel compatibility equations.

Module V (6L):
Fluid: Basic concept of fluid, classification of fluids, constitutive equations, equations of motion of fluid , stream lines, path line and vortex lines, circulation, and vorticity.

Module VI (14L):
Inviscid Incompressible Fluid: Equation of continuity, constitutive equation of perfect fluid and viscous fluid, Euler's equation of motion, integrals of Euler's equation of motion, Bernoulli's equation, Kelvin's minimum energy theorem, Sources and sinks and doublets. Viscous Incompressible Fluid: Governing equations, Navier Stroke's equations, flow between parallel plates.

Text & Reference books:

Text Books:

1. R. N. Chatterjee: Mathematical Theory of Continuum Mechanics, Narosa.
2. G. E. Mase: Theory and Problems of Continuum Mechanics, Schaum's Outline Series, McGraw-Hill Book Company.

Reference Books:

1. J. N. Reddy: Princilpes of Continuum Mechanics, Cambridge University Press.
2. Y. C. Fung : A first course in Continuum Mechanics, Prentice Hall.
3. R. C. Batra: Elements of Continuum Mechanics, AIAA.
4. W. M. Lai, D. Rubin, E. Krempl, Continuum Mechanics, Butterworth Heinemann,
5. S. Nair: Introduction to Continuum Mechanics, Cambridge University Press.
6. J. L. Wegner, J. B. Haddow: Elements of Continuum Mechanics and Thermodynamics, Cambridge University Press.
7. D. S. Chandrasekharaih and L. Debnath, Continuum Mechanics, Academic Press, 1994. Inc.
8. T. J. Chung: Applied Continuum Mechanics, Cambridge University Press.
9. A.C. Eringen: Mechanics of continua, Robert E. Krieger Publishing Company, INC.
10. L. E. Malvern: Introduction to the Mechanics of a continuous medium, Prentice-Hall,
11. L.I. Sedov :Introduction to the Mechanics of a Continuous Medium, Addison Wesley Publishing Company, INC.

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

COURSE OUTCOMES:

After attending this course, the students will be able to

CO1: Define the basic kinematic quantities of deformation, strain, and stress using Lagrangian and Eulerian formulations.

CO2: Describe the relationships among strain components, stress invariants, and compatibility conditions in a continuous medium.

CO3: Apply generalized Hooke's law and constitutive equations to determine stresses and strains in isotropic and anisotropic solids.

CO4: Analyze the motion of viscous and inviscid fluids using Euler's and Navier–Stokes equations to interpret flow characteristics such as vorticity and circulation.

CO5: Evaluate boundary value problems in solids and fluids using conservation laws, energy principles, and mathematical modelling techniques.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	2	-	1	-	-	-	1	1	2	2
CO2	3	3	-	2	-	-	-	1	1	2	2
CO3	2	3	2	3	-	-	-	1	2	3	3
CO4	2	3	1	3	1	1	-	2	2	3	3
CO5	2	3	-	3	2	1	-	1	3	3	3

1. LOW 2.MODERATE 3. SUBSTANTIAL

Course MC17: Introduction to Fuzzy sets and stochastic process
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: apply the concept of Fuzzy sets in various field and the concept of stochastic process in different fields in finance and industry.*

Prerequisite: *Before learning the course, the students must have the knowledge of set, relation, probability, differential equations.*

SYLLABUS OUTLINE:

Module I: Fuzzy Sets: [6L]

Basic concepts of fuzzy set, t-norm, Membership function, α -cuts, strong α -cuts, level set of a fuzzy set, support of a fuzzy set, the core and height of a fuzzy set, normal and subnormal fuzzy sets, convex fuzzy sets, cut worthy property, strong cut worthy property, standard fuzzy set operations, standard complement, equilibrium points, standard intersection, standard union, fuzzy set inclusion, scalar cardinality of a fuzzy set, the degree of sub set hood.

Module II: Properties of Fuzzy Sets: [8L]

Additional properties of α cuts involving the standard fuzzy set operators and the standard fuzzy set inclusion, Representation of fuzzy sets, three basic decomposition theorems of fuzzy sets Extension principle for fuzzy sets: the Zedah's extension principle

Module III: Operations on fuzzy sets: [10L]

Types of operations, fuzzy complements, equilibrium of a fuzzy complement, equilibrium of a continuous fuzzy complement, first and second characterization theorems of fuzzy complements.

Module IV: Stochastic Process: [10L]

Review of Probability: Sigma field; Probability measure. Random variables; Probability generating functions; Characteristic functions; Probability inequalities; Convergence concepts; random vectors; Bivariate and multivariate distributions, Conditional Expectation: Conditioning on an event, conditioning on a discrete random variable, conditioning on an arbitrary random variable, conditioning on a sigma-field.

Module V: Markov chains: [8L]

Definitions, Chapman-Kolmogorov equation, Equilibrium distributions, Classification of states, Long-time behaviour. Stochastic process in continuous time: Poisson process and Brownian motion

Module VI: Stochastic Differential Equations: **[6L]**

Stochastic Calculus; Brownian motion, Wiener Process and white noise, Properties of Brownian paths and Langevin equation, Mean square Calculus, Definition and properties of Ito integral, Indefinite Ito integrals, Ito’s formula, Ito integral in n-dimensions, Simple examples, Concept of Stratonovich integral. Stochastic differential equations; Definitions and examples; Existence and uniqueness of solutions, Properties of Solutions; Linear stochastic differential equations and its solutions.

References:

1. W. Feller, An introduction to probability theory and its applications, John Wiley, New York , 1968. 2. J.L. Doob, Stochastic processes, John Wiley, New York, 1953.

3. M.S. Bartlett, An introduction to Stochastic Process, Cambridge University Press, 1955.

4. Z. Brzezniak and T. Zastawniak, Basic Stochastic Processes, Springer, Indian Reprint, 2005.

5. R. Coleman, Stochastic Processes, George Allen & Unwin Ltd., London , 1974.

6. L. Takacs, Science paperbacks and Methuen and Co. Ltd., London, 1966.

7. P.G. Hoel, S.C. Port and C.J. Stone, Introduction to Stochastic Processes, Universal Book Stall, New Delhi, 1993.

8. J. Medhi, Stochastic Processes, Wiley Eastern Ltd., New Delhi, 1983.

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9. L. Arnold, Stochastic Differential Equations: Theory and Applications, Wiley, 1974.

10. L. Breiman, Probability, Addison-Wesley, 1968.

11. P. Bremaud, An Introduction to Probabilistic Modeling, Springer, 1988.

12. K.L. Chung, Elementary Probability Theory with Stochastic Processes, Springer, 1975.

13. A. Friedman, Stochastic Differential Equations and Applications, Vol. 1 & 2, Academic Press.

14.C.W. Gradiner, Handbook of Stochastic Methods for Physics, Chemistry and the Natural Sciences, Springer, 1983.

15.I.I. Gihman and A.V. Skorohod, Stochastic Differential Equations, Springer, 1972.

16. H. McKean, Stochastic Integrals, Academic Press, 1969.

17. E. Nelson, Dynamical Theories of Brownian Motion, Princeton University Press, 1967.

18. B.K. Oksendal, Stochastic Differential Equations: An Introduction with Applications, 4th ed., Springer, 1995.

19. D. Stroock, Probability Theory: An Analytic View, Cambridge University Press, 1993.

Pedagogy for Course Delivery: *Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA):*NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcome (CO):

After attending this course, the students will be able to

CO1: Explain fundamentals of the fuzzy sets and its properties.

CO2: Apply operations on of fuzzy set on appropriate fields.

CO3: Analyze conditional probability distributions and conditional expectations.

CO4: Determine the long-term behaviour of Markov chains.

CO5: Create problem centric stochastic differential equations.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	2	2	2	2
CO2	3	3	2	2	2	1	1	2	2	2	2
CO3	3	3	2	2	2	3	1	2	2	2	3
CO4	3	3	2	3	2	3	1	3	3	3	3
CO5	3	3	3	3	3	3	1	3	3	3	3

1. LOW   2. MODERATE   3. SUBSTANTIAL

Course MC18: Integral transforms
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: develop the knowledge of different integral transforms to solve complex differential equations and solve real life problems.*

Prerequisite: *Before learning the course, learners should have a basic knowledge about integration, differentiation, differential calculus, convergency and ordinary and partial differential equations.*

SYLLABUS OUTLINE:

Integral transform:

Module I The Fourier Transform (10L):

Fourier series, Algebraic properties of Fourier transform, Convolution, Translation, Modulation. Analytical properties of Fourier transforms, transform of derivatives and derivatives of transform, Perseval formula, Inversion theorem, Plancherel's theorem, Application to solving ordinary and partial differential equation.

Module II The Laplace transform (8L):

Algebraic properties of Laplace transform, Transform of derivatives and derivatives of transform. The inversion theorem, Evaluation of inverse transforms by residue. Asymptotic expansion of inverse transform, Application to solving P.D.E., Integral equation, etc.

Module III The Z-Transform (8L):

Z- Transform, Properties of the region convergence of the Z-transform. Inverse Z-transform for discrete-time systems and signals, Applications.

Module IV The Hankel transform (8L):

Elementary properties; Inversion theorem; transform of derivatives of functions; Perseval relation; Relation between Fourier and Hankel transform; use of Hankel transform in the solution of PDE.

Module V The Mellin transform (6L):

Definition; properties and evaluation of transforms; Convolution theorem for Mellin transforms; applications to integral equations.

Module VI Wavelet Transform: (8L)
Definition of wavelet, Examples, Window function, Windowed Fourier transform, Continuous wavelet transform, Discrete wavelet transform, Multiresolution analysis, Application to signal and image processing

Text & Reference books:

Text Books:

1. L. Debnath, Integral transforms and their applications, CRC press, New York-London-Tokyo, 1995.

2. I.N. Sneddon, Fourier Transform, McGraw Hill, 1951.

3. D. Porter and D.S.G. Stirling, Integral Equations, Cambridge University Press, 2004.
4. H. Hochstadt, Integral equations, Wiley-Interscience, 1989.
5. A. Wazwaz, A first course in integral equations, World Scientific, 1997.
6. F.G. Tricomi, Integral Equations, Dover, 1985.

Reference Books:

1. F.C. Titchmash, Introduction to the theory of Fourier Integrals, Oxford Press, 1937.
2. Peter, K.F. Kahfitting, Introduction to the Laplace Transform, Plenum Press, N.Y., 1980.
3. E.J. Watson, Laplace Transforms and Application, Van Nostland Reinhold Co. Ltd., 1981.
4. E.I. Jury, Theory and Application of Z-Transform, John Wiley and Sons, N.Y.
5. R.V. Churchill, Operational Mathematics, McGraw Hill, 1958.
6. D. Loknath, Integral Transforms and their Application, C.R.C. Press, 1995.
7. Introduction to Wavelet Transforms – Narasimhan, Basumallik and Veena
8. Ram P. Kanwal, Linear Integral Equation – Theory and Technique, Academic Press, Inc.
9. W.V. Lovitt, Linear Integral Equations, Dover, New York.
10. S.G. Mikhlin, Integral Equations, Pergamon Press, Oxford.
11. N.I. Mushkhelishvili, Noordhoff, Singular Integral Equations, Gronignen, Holland.

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcomes:

After attending this course, the students will be able to

CO1: Apply Laplace and Fourier transform to solve real-life problems.

CO2: Formulate complex engineering boundary value problems.

CO3: Discuss the properties of Z transform and Wavelet transform and its applications.

CO4: Identify the Fredholm and Volterra integral equations with different kind for different kernels.

CO5: Solve the problems of mechanics with the help of integral equations with different methods.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1	1	2	3	2	2
CO2	3	3	2	3	2	-	1	3	3	2	3
CO3	3	3	3	2	2	2	1	2	3	3	2
CO4	3	3	2	3	2	1	1	2	3	2	3
CO5	3	3	2	3	2	1	1	3	3	2	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Avishek Adhikari Anisha Datta

Course MC19: Advanced ODE and dynamical system
Credit 4: (4L-0T-0P)

Module I: Existence and Uniqueness; Singular Solutions [8 L]

Study of existence and uniqueness of solutions for first-order ODEs, including singular solutions.

Module II: Linear Homogeneous Differential Equations [10 L]

Linear homogeneous ODEs: ordinary and singular points, series solution, Method of Frobenius, Fuchs' theorem, and Fuchsian type equations.

Module III: Linear Non-Homogeneous Equations and Sturm-Liouville Problems [10 L]

Linear non-homogeneous ODEs: variation of parameters, Sturm-Liouville equations, eigenvalue problems, variational method, completeness of eigenfunctions, integral representation, and Green's function.

Module IV: Systems of ODEs and Stability [10 L]

Systems of ODEs: flow diagrams, phase portraits, isoclines, fixed points, nature and stability, asymptotic stability, Lyapunov function, and linearization at critical points.

Module V: Linear Dynamical Systems [10 L]

Linear dynamical systems: solutions, phase portraits, fixed points, plane autonomous systems, Poincaré phase plane, damped oscillator, simple pendulum, two-variable linear systems, characteristic polynomial, and classification of focal, nodal, and saddle points.

Text & Reference books:

Text Books:

1.G.F.Simmons, Differential Equations, Tata McGraw Hill 14
2.S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004
3. H Strogatz- Nonlinear Dynamics.

Reference Books:

1.D.A. Murray, Introductory course in Differential Equations, Orient and Longman
2.H.T. H.Piaggio, Elementary Treaties on Differential Equations and their applications, C.B.S Publisher & Distributors, Delhi,1985.

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcomes (COs)

CO1: *Describe* existence, uniqueness, and singular solutions of first-order ODEs.

CO2: *Solve* linear homogeneous ODEs using series methods, Frobenius method.

CO3: *Apply* variation of parameters, Sturm-Liouville theory, and Green's function to solve linear non-homogeneous ODEs and eigenvalue problems.

CO4: *Explain* systems of ODEs, phase portraits, fixed points, and determine stability using Lyapunov functions and linearization.

CO5: *Evaluate* linear dynamical systems, plane autonomous systems, and understand focal, nodal, and saddle points in physical examples.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	**PROGRAMME OUTCOMES**								**PROGRAMME SPECIFIC OUTCOMES**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2	–	–	–	1	3	2	2
CO2	3	3	2	3	–	–	–	1	3	2	3
CO3	3	2	2	3	–	–	–	1	3	2	3
CO4	3	2	1	2	–	–	–	1	3	3	2
CO5	3	3	1	3	1	–	–	1	3	3	3

1. LOW 2.MODERATE 3. SUBSTANTIAL

SEMESTER VIII

Course MC20: Generalized functions and special functions
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to: develop the knowledge of different generalized functions and special function and solve real life problems.*

Prerequisite: *Before learning the course, learners should have a basic knowledge about integration, differentiation, differential calculus, and the convergence criteria.*

SYLLABUS OUTLINE:

Module I Generalized Functions (10 L):
The Dirac Delta function and Delta sequences. Test functions. Linear functionals. Regular and singular distributions. Sokhotski-Plemelj equation. Operations on distributions.

Module II Properties of the generalized derivatives (10 L):
Properties of the generalized derivatives. Some transformation properties of the delta function. Convergence of distributions.

Module III Special functions (10 L):

Legendre function. Rodrigues formula. Orthogonal property. Recurrence relations.
Bessel function. Orthogonal property. Recurrence relations. Gauss hypergeometric function and its properties

Module IV Differentiation formulae for special functions (10 L):

Integral representation. Linear transformation formulas, Contiguous function relations. Differentiation formulae, Linear relation between the solutions of Gauss hypergeometric equation, Kunlmer's confluent hyper geometric function and its properties';

Module V Integral representation of special functions (8 L):

Integral representation, Kummer's first transformation. Legendre polynomials and functions and; Bessel functions; Hermite polynomials; Laguerre polynomials.

Text & Reference books:

Text Books:

1. L. Debnath, Integral transforms and their applications, CRC press, New York-London-Tokyo, 1995.

2. I.N. Sneddon, Fourier Transform, McGraw Hill, 1951.

3. D. Porter and D.S.G. Stirling, Integral Equations, Cambridge University Press, 2004.
4. H. Hochstadt, Integral equations, Wiley-Interscience, 1989.
5. A. Wazwaz, A first course in integral equations, World Scientific, 1997.
6. F.G. Tricomi, Integral Equations, Dover, 1985.
7. V. Vladimirov, Equations of mathematical physics. Dekker, New York, 1971.
8. I. Stakgold, Green's functions and boundary value problems, Wiley, New York, 1979.

Reference Books:

1. R.V. Churchill, Operational Mathematics, McGraw Hill, 1958.
2. D. Loknath, Integral Transforms and their Application, C.R.C. Press, 1995.
3. Introduction to Wavelet Transforms – Narasimhan, Basumallik and Veena
4. Ram P. Kanwal, Linear Integral Equation – Theory and Technique, Academic Press, Inc.
5. W.V. Lovitt, Linear Integral Equations, Dover, New York.
6. S.G. Mikhlin, Integral Equations, Pergamon Press, Oxford.
7. N.I. Mushkhelishvili, Noordhoff, Singular Integral Equations, Gronignen, Holland.

Pedagogy for Course Delivery*: Hybrid Mode (Offline Class/Presentation/Video/MOODLE/NPTEL)*

List of Professional Skill Development Activities (PSDA)*:NA*

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course Outcomes:

After attending this course, the students will be able to

CO1: Analyze generalized functions to solve various real world complex problems.

CO2: Use the properties of generalized functions in practical problems.

CO3: Formulate complex engineering boundary value problems using generalized functions.

CO4: Discuss the orthogonal properties of Legendre polynomials and its applications.

CO5: Evaluate special functions via integral forms.

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	-	1	2	3	2	2
CO2	3	3	2	3	2	-	1	2	3	2	2
CO3	3	3	2	3	2	-	1	3	3	2	3
CO4	3	3	2	2	1	-	1	2	3	1	2
CO5	3	3	2	2	1	-	1	2	3	2	2

1. LOW 2. MODERATE 3. SUBSTANTIAL

Course MC21: Calculus of variations and integral equations
Credit 4: (4L-0T-0P)

Learning objectives: *On completion of the course, student will be able to acquire the basic knowledge of the variational calculus and dynamical system.*

Prerequisite: *Before learning the course, students must have the undergraduate knowledge in probability theory, differential calculus.*

Module I Calculus of variations (8L):
Basic Lemma. Fundamental problem and its solution. Case of several dependent variables. Applications to geodesics on a surface. Hamilton's variational principle, brachistochrone problem.

Module II Lagrange's Problem (8L):
Variable end-point conditions; Extended problem and its solution. Lagrange's problem – Holonomic and Non-holonomic constraints. Solutions of holonomic and Non-holonomic Lagrange's problems with generalizations to several dependent variables.

Module III Isoperimetric problem (8L):
Mixed Lagrange's problem and its solution. Application to the Principle of Least Action. Isoperimetric problem and its solution. Basic Lemma and fundamental problem in two and three dimensions.

Module IV Integral Equations (12L):
Reduction of boundary value problem of an ordinary differential equation to an integral equation. Fredholm equation: Solution by the method of successive approximation. Numann series. Existence and uniqueness of the solution of Fredholm equation. Equations with degenerate kernel. Eigen values and eigen solutions.

Module V Volterra Equations (12L):
Volterra equation: Solution by the method of iterated kernel, existence and uniqueness of solution. Solution of Abel equation. Solution of Volterra equation of convolution type by Laplace transform.

Text & Reference books:

Text Books:

1. D.N. Burghes and A.M. Downs, Modern Introduction to Classical Mechanics & Control, Ellis Horwood Publisher, Chichester, 1975.
2. J.C. Pant, Introduction to Optimization, New Delhi, Jain Brothers, 1983.

Reference Books:

1. A.S. Gupta, Calculus of Variations with Applications, Prentice Hall, 1997.
2. G.M. Ewing, Calculus of variations with Applications, Dover Publications, 1985.
3. R. Weinstock, Calculus of Variations, Dover Publications, 1974.
4. Peter, K.F. Kahfitting, Introduction to the Laplace Transform, Plenum Press, N.Y., 1980.
5. E.J. Watson, Laplace Transforms and Application, Van Nostland Reinhold Co. Ltd., 1981.
6. E.I. Jury, Theory and Application of Z-Transform, John Wiley and Sons, N.Y.

Course Outcome (CO):

After attending this course, the students will be able to

CO1: Determine optimal solutions to variational problems.

CO2: Compute solutions to Lagrange's problem

CO3: Construct solutions to isoperimetric problems.

CO4: Analyze integral equations and its properties.

CO5: Solve different kinds of Fredholm and Volterra differential equations.

Avishek Adhikari Anirbha Datta

MAPPING OF COs WITH POs AND PSOs

COURSE OUTCOMES	PROGRAMME OUTCOMES								PROGRAMME SPECIFIC OUTCOMES		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	-	1	2	3	2	2
CO2	3	3	2	3	2	-	1	2	3	2	2
CO3	3	3	1	3	2	-	1	1	3	1	2
CO4	3	3	2	2	3	-	1	2	3	2	2
CO5	3	3	2	3	2	-	1	3	3	2	3

1. LOW 2. MODERATE 3. SUBSTANTIAL

Avishek Adhikari Anisha Dutta