Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE

Syllabus
for

T. Y. B. Sc. (Mathematics)

[NEP 1.0]

(B.Sc. Semester-V and VI)

With Effect From
2025-2026

Syllabi NEP 1.0 Implemented from Academic Year 2025-26
T. Y. B. Sc. Semester: V/VI

Program Specific Outcomes (PSOs)

PSO	Outcomes
PSO1	Bachelor's degree in mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.
PSO2	The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.
PSO3	Students undergoing this programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.
PSO4	Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.
PSO5	Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.
PSO6	This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

T. Y. B. Sc. NEP 1.0						
Semester	Paper	Paper Code	Title	Type	Credits	Exam Type
V	Major	MTS-301	Real Analysis-I	Theory	2	CE+ESE
		MTS-302	Groups and Rings	Theory	2	CE+ESE
		MTS-303	Metric Spaces	Theory	2	CE+ESE
	Elective	MTS-304 OR	Number Theory	Theory	2	CE+ESE
		MTS-305 OR	Operations Research	Theory	2	CE+ESE
		MTS-306	Combinatorics	Theory	2	CE+ESE
		MTS-307 OR	Differential Geometry	Theory	2	CE+ESE
		MTS-308 OR	Financial Mathematics-I	Theory	2	CE+ESE
		MTS-309	Integral Transforms	Theory	2	CE+ESE
	Major	MTS-311	Mathematics Practical-5	Practical	2	CE+ESE
		MTS-312	Mathematics Practical-6	Practical	2	CE+ESE
	VSC	MTS-331	AI and ML with Python	Theory	2	CE
		MTS-332	Mathematics Practical-7	Practical	2	CE
	Minor	MTS-321	Special Functions and Integral Transforms	Theory	2	CE+ESE
		MTS-322	Linear Algebra and Applications	Theory	2	CE+ESE
		MTS-323	Calculus (CS)	Theory	2	CE+ESE
	FP	MTS-345	Field Project	Theory / Practical	2	CE
VI	Major	MTS-351	Real Analysis-II	Theory	2	CE+ESE
		MTS-352	Advanced Linear Algebra	Theory	2	CE+ESE
		MTS-353	Complex Analysis	Theory	2	CE+ESE
	Elective	MTS-354 OR	Cryptography	Theory	2	CE+ESE
		MTS-355 OR	Optimization Techniques	Theory	2	CE+ESE
		MTS-356	Lebesgue Integration	Theory	2	CE+ESE
		MTS-357 OR	Dynamical Systems	Theory	2	CE+ESE
		MTS-358 OR	Financial Mathematics-II	Theory	2	CE+ESE
		MTS-359	Graph Theory	Theory	2	CE+ESE
	Major	MTS-361	Mathematics Practical-8	Practical	2	CE+ESE
		MTS-362	Mathematics Practical-9	Practical	2	CE+ESE
	VSC	MTS-382	Mathematics Practical-10	Practical	2	CE
	Minor	MTS-371	Numerical Linear Algebra	Theory	2	CE+ESE
		MTS-372	Integral Transforms	Theory	2	CE+ESE
		MTS-373	Operations Research (CS)	Theory	2	CE+ESE
	OJT	MTS-395	On Job Training	Theory / Practical	4	CE

MTS-301 - Real Analysis-I Major-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Retrieve the structure of system of real numbers. State lub axiom. Define countability of subsets of real numbers, convergence of sequences and series, integrability of functions	1
CO2	Classify countable and uncountable sets. Distinguish convergent and divergent sequences and series.	2
CO3	Examine the set for its countability, sequences and series for convergence, functions for integrability	3
CO4	Analyse the sequences and series to apply proper test/technique to discuss the convergence. Invent examples in support of statements and their converses, in counter to the statements.	4
CO5	Evaluate limit of sequences and sums of series, integrals. Criticize the statements by arguments and/or counter examples. Justify the statements by arguments and/or suitable examples.	5
CO6	Produce bijective maps between equivalent sets. Create counter examples to the statements about sequences, series and integrable functions. Modify/rewrite the statements in order to make it valid.	6

MTS-301 - Real Analysis-I
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Real Numbers:** Revision of Algebraic Structure of R, Ordered Field, Supremum and Infimum, LUB Axiom, Density of rational and irrational numbers, Countable sets	5
2	**Sequences of Real Numbers:** Convergence of sequences, Algebra of limits of sequences, Bounded sequences, Monotonic sequences, Monotone convergence Theorem, Nested interval property, Sandwich principle, Ratio test for a sequence of positive numbers. Subsequences: Monotone subsequence theorem, Bolzano-Weierstrass Theorem, Cauchy sequences, Cauchy criteria for convergent sequences, Contracting sequences.	8
3	**Series of Real Numbers:** Convergence of Infinite Series, Convergence criteria, Cauchy's Convergence criteria Tests for Convergence: Absolute and conditional convergence, Comparison test, Cauchy's n-th root test, D'Alembert's ratio test, Integral Test, Alternating Series Alternating Series, Leibnitz test, Abel's test and Dirichlet Test, rearrangement of terms	10
4	**Integration:** Riemann Integrable functions, Necessary and sufficient conditions for Riemann Integrability, Uniform Continuity, Integral as a limit of Riemann sum, Properties of Riemann integrable functions, Fundamental Theorem of Calculus, Mean value theorems for integrals and their applications.	7

Learning Resources- References

Sr. No.	References
1.	Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd., (1970).
2.	Ajitkumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2010.
3.	S. Ponnusamy, Foundations of Mathematical Analysis, Birkauser, (2010).
4.	W. Rudin, Principles of Mathematical Analysis, McGraw Hill International Edition
5.	R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 4 th Edition, John Wiley, 2012.

MTS-302 - Groups and Rings Major - Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define basic terms related to groups and rings, such as "group," "ring," "subgroup," "ideal," and "homomorphism." List the properties of group operations (closure, associativity, identity, inverses) and ring operations (additive and multiplicative structures).	1
CO2	Explain the distinction between different types of groups (e.g., cyclic, abelian, symmetric) and rings (e.g., commutative, integral domains, fields).	2
CO3	Solve problems involving group and ring properties, including verifying whether a set with a binary operation forms a group or ring.	3
CO4	Analyze the structure of a given group or ring to determine if it is cyclic, abelian, or satisfies other specific properties.	4
CO5	Evaluate the isomorphism between two groups or two rings based on their structural properties. Assess the validity of specific algebraic claims related to group or ring theory, providing rigorous justifications.	5
CO6	Design new examples of groups and rings that satisfy given properties (e.g., find a group that is not cyclic but is abelian).	6

MTS-302 - Groups and Rings
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Normal Subgroups and Factor Groups: Normal Subgroups, Factor Groups, Applications of Factor Groups, Group Homomorphisms Definition and Examples, Properties of Homomorphisms, The First Isomorphism Theorem	10
2	Introduction to Rings Motivation and Definition, Examples of Rings, Properties of Rings, Subrings, Integral Domains , Fields, Characteristic of a Ring	5
3	Ideals, Factor Rings, Prime Ideals and Maximal Ideals, Ring Homomorphisms Definition and Examples, Properties of Ring Homomorphisms , The Field of Quotients	7
4	Polynomial Rings Notation and Terminology, The Division Algorithm and Consequences, Factorization of Polynomials Reducibility Tests, Irreducibility Tests, Unique Factorization in $Z[x]$	8

Learning Resources - References

Sr. No.	References
1.	Joseph A. Gallian , Contemporary Abstract Algebra, Narosa
2.	I. N. Herstein, Topics in Algebra, Wiley
3.	J. B. Fraleigh, A First Course in Abstract Algebra, Pearson

MTS-303 - Metric Spaces **Major-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define basic concepts related to metric spaces, such as "metric," "distance function," "open set," "closed set," "convergence," and "continuity." List properties of metric spaces, such as the triangle inequality, non-negativity, and symmetry.	1
CO2	Explain the properties of a metric, including how it defines the structure of a metric space and how it induces the notion of convergence and continuity. Illustrate the difference between bounded, unbounded, complete, and incomplete metric spaces.	2
CO3	Apply the definition of a metric space to verify whether a given set with a distance function forms a metric space. Use the properties of convergence to determine the limit of a sequence in a metric space.	3
CO4	Analyze sequences and series in metric spaces to determine if they converge, using the definitions of convergence and limits.	4
CO5	Evaluate the continuity of a function between metric spaces using the epsilon-delta definition of continuity. Critically assess the properties of a metric space to determine if it is compact, connected, or satisfies other specific conditions.	5
CO6	Design new examples of metric spaces, such as creating non-standard metrics or spaces with particular properties (e.g., complete, compact, etc.).	6

MTS-303 - Metric Spaces
(Major - Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Metric Spaces, Definition and Examples, Young's Inequality, Holder's Inequality, Minkowski inequality, Open ball, open set, continuous functions on metric space, Closed set, closure of set, Interior of set, boundary of set, convergence in metric space, limit and cluster point, Bounded set, dense set, equivalent metrics, Hausdorff condition	9
2	Continuous functions on metric spaces, Connected Spaces, connectedness, connectedness and homeomorphism	6
3	Compact spaces, Definition and examples, compactness of closed and bounded interval, Properties of compact spaces, Continuous maps on compact spaces, Compact subsets of Euclidean spaces, Compactness and uniform continuity, sequential compact	10
4	Complete spaces, definitions and examples, product of complete spaces, Banach's fixed point theorem.	5

Learning Resources - References

Sr. No.	References
1.	Wilson S Sutherland, Introduction to Metric and Topological spaces, Oxford Press
2.	R. R. Goldberg, Methods of Real Analysis, Oxford and IBH publishing C. Pvt. Ltd.
3.	S. Kumaresan, Topology of Matric Spaces, Narosa Publishing House.
4.	Dhananjay Gopal, Aniruddha Deshmukh and Abhay Randive, Introduction to Metric Spaces, CRC Press
5.	Robert Magnus, Metrixc Spaces-a Companion to Analysis, Springer

MTS-304 - Number Theory Major-Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	List the properties of prime numbers, divisibility rules, and common theorems like the Fundamental Theorem of Arithmetic.	1
CO2	Explain the concept of divisibility, the Euclidean algorithm, and its application in finding the gcd and lcm of two integers. Describe the principle of mathematical induction and its use in proving statements related to divisibility, prime numbers, and congruences.	2
CO3	Apply the Euclidean algorithm to compute the gcd of two numbers and use it to find solutions to linear Diophantine equations. Apply number-theoretic algorithms like the Sieve of Eratosthenes to find prime numbers up to a given limit.	3
CO4	Analyze the structure of integers under modular arithmetic and identify properties of number systems, such as the properties of groups and rings in modular settings. Investigate the distribution of prime numbers using the concepts of prime density, the Prime Number Theorem, and the concept of prime factorization.	4
CO5	Evaluate the validity of number-theoretic conjectures or theorems using proofs (e.g., evaluating the truth of Fermat's Little Theorem or evaluating primality tests).	5
CO6	Design algorithms based on number-theoretic concepts, such as creating an algorithm for finding the multiplicative inverse modulo n or for solving linear congruences.	6

MTS-304 - Number Theory
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Divisibility** Divisibility in Integers, Division Algorithm, GCD, LCM, Fundamental Theorem of Arithmetic, Infinitude of Primes, Mersenne Numbers and Fermat Numbers	8
2	**Congruences** Definition, Properties of Congruences, Residue classes, complete and reduced residue system, their properties, Fermat's theorem. Euler's theorem, Wilsons theorem, $x^2 \equiv 1 \pmod p$ has a solution if and only if $p = 2$ or $1 \pmod 4$; where p is a prime. Linear congruences of degree 1 and Chinese remainder theorem.	8
3	**Diophantine Equations** $ax + by = c, x^2 + y^2 = z^2$	2
4	**Greatest integer function** Arithmetic functions Euler's function, the number of divisors d(n), sum of divisors σ(n); Ω(n), Multiplicative functions, Mobius function, Mobius inversion formula	6
5	**Quadratic Reciprocity** Quadratic residues, Legendre's symbol and its properties, Law of quadratic reciprocity	6

Learning Resources - References

Sr. No.	References
1.	Niven, H. Zuckerman and H. L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.
2.	David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991

MTS-305 - Operations Research Major-Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define basic terms and concepts in operations research such as "optimization," "linear programming," "simplex method," "transportation problem," "decision analysis," and "network flow."	1
CO2	Describe the key principles behind linear programming, such as the feasible region, objective function, and constraints. Explain the concepts of duality and sensitivity analysis in the context of linear programming.	2
CO3	Apply the simplex method to solve linear programming problems and interpret the results in real-world contexts. Solve transportation and assignment problems using appropriate algorithms.	3
CO4	Analyze optimization problems and formulate them into mathematical models, identifying the appropriate objective function and constraints. Evaluate different optimization techniques (e.g., linear vs. nonlinear programming, simplex vs. interior-point methods) to determine their effectiveness in solving specific real-world problems.	4
CO5	Evaluate the optimality of solutions obtained from linear programming models and assess the impact of changes in parameters through sensitivity analysis. Critically evaluate the applicability of operations research models	5
CO6	Develop optimization models for complex business or engineering problems, including formulating the objective function, constraints, and decision variables.	6

MTS-305 - Operations Research
(Major-Elective- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Modelling with Linear Programming** Two variable LP Model,, Graphical LP solution, Selected LP Applications, Graphical Sensitivity analysis	4
2	**The Simplex Method** LP Model in equation form, Transition from graphical to algebraic solutions, the simplex method, Artificial starting solutions	10
3	**Duality:** Definition of the dual problem, primal dual and their relationship.	4
4	**Transportation Model :** Definition of the Transportation model, the Transportation Algorithm	6
5	**The Assignment Model** The Hungarian method, Simplex explanation of the Hungarian method	6

Learning Resources- References

Sr. No.	References
1.	Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi
2.	Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition), Tata McGraw-Hill
3.	J. K. Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmillan India Ltd.
4.	Hira and Gupta, Operations Research.

MTS-306 - Combinatorics Major-Elective-Theory		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	List and describe fundamental counting principles like the addition rule, multiplication rule, and the pigeonhole principle.	1
CO2	Explain the difference between permutations and combinations, and when to apply each in counting problems. Illustrate how binomial coefficients arise in combinatorics, particularly in problems related to counting subsets and arrangements.	2
CO3	Apply counting principles (e.g., multiplication and addition rules) to solve basic combinatorial problems involving arrangements and selections. Solve problems involving permutations with repetitions, combinations with repetitions, and the use of the stars and bars method.	3
CO4	Analyze complex combinatorial problems by breaking them down into smaller sub-problems and applying appropriate counting techniques (e.g., inclusion-exclusion, recurrence relations). Investigate and analyze the relationships between different combinatorial objects, such as graphs, trees, and permutations, and their corresponding counting formulas.	4
CO5	Evaluate the correctness of a combinatorial solution by verifying it against different methods or checking consistency through alternate approaches. Assess the efficiency of combinatorial algorithms or counting strategies used to solve large-scale or complex problems.	5
CO6	Design new combinatorial models or approaches to solve real-world problems, such as scheduling, graph theory, or optimization, by applying combinatorial techniques. Create new algorithms for efficiently solving combinatorial problems, particularly for large datasets or complex structures	6

MTS-306 - Combinatorics
(Major-Elective- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Two basic Counting Principles, Addition Principle and Multiplication Principle, Simple Arrangements and Selections, Arrangements and Selections with repetition, Distributions, Number of distributions of r distinct objects into n distinct boxes, Number of distributions of r identical objects into n distinct boxes, Binomial identities and Multinomial theorem	10
2	Inclusion-Exclusion Principle, Counting with Venn diagrams, Inclusion Exclusion formula, Derangements, Simple Examples.	8
3	Pigeonhole principle	4
4	Recurrence Relations: Recurrence relation models, Solution of Linear Homogeneous and non-homogeneous recurrence relations (methods without proof)	8

Learning Resources- References

Sr. No.	References
1.	Alan Tucker, Applied Combinatorics, Wiley, 1995.
2.	Richard A. Brualdi, Introductory Combinatorics, Elsevier, North-Holland, New York, 1977.
3.	V. K. Balkrishnan, Combinatorics, Schuam Series, 1995.
4.	S. S. Sane, Combinatorial Thechniques, TRIM Series, Vol. 64.

MTS-307 - Differential Geometry Major-Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall key definitions and concepts in differential geometry, such as curves, surfaces, manifolds, tangent spaces, and metrics.	1
CO2	Explain the fundamental concepts of a differentiable manifold, including charts, atlases, and smooth maps between manifolds. Describe the significance of the first and second fundamental forms in the study of surfaces, and understand how curvature describes the geometry of surfaces.	2
CO3	Apply the notions of tangent vectors, differential forms, and the connection between vector fields to compute geodesics, curvature, and other geometric quantities on curves and surfaces.	3
CO4	Analyze the relationship between the geometry of curves and surfaces using tools such as the Frenet-Serret formulas, curvature.	4
CO5	Evaluate the application of the Gauss curvature and mean curvature in understanding the global properties of surfaces, such as classification of minimal surfaces and understanding theorems in surface theory.	5
CO6	Design geometric models and develop mathematical representations of physical systems using differential geometric tools, such as modeling the geometry of spacetime in general relativity or the shape of minimal surfaces in physical phenomena.	6

MTS-307 - Differential Geometry
(Major- Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Curves in the plane and in space** What is a curve? Arc-length, Reparameterization, Level curves vs. Parametrized curves	6
2	**How much does a curve curve?** Curvature, Plane curves, Space curves	6
3	**Global Properties of curves** Simple closed curves, The Isoperimetric Inequality, The Four Vertex Theorem	6
4	**Surfaces in three dimensions** What is a Surface? Smooth Surfaces, Tangents, Normals and Orientability, Examples of Surfaces	6
5	**The first and second fundamental form** Lengths of curves on surfaces, Isometries of Surfaces, Conformal mappings of surfaces, Surface area, Equiareal maps and a Theorem of Archimedes, The Second Fundamental Form	6

Learning Resources- References

Sr. No.	References
1.	Andrew Pressley: Elementary Differential Geometry, Springer International Edition, Indian Reprint 2004.
2.	Eberhald Malkowsky, Cemal Dolicanin and Vesna Velickovic, Differential Geometry and Its Visualization, CRC Press, Taylor and Francos
3.	Paulo Ventura Araújo, Differential Geometry, Springer
4.	Joel W. Robbin and Dietmar A. Salamon, Introduction to Differential Geometry, Springer
5.	John A. Thorpe: Differential Geometry, Springer International Edition, Indian Reprint 2004.

MTS-308 - Financial Mathematics-I Major-Elective-Theory		
	Number of Credits: 02 No. of Hours: 30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall and articulate basic concepts of simple Interest, , Calculate and illustrate interest with discrete and continuous compounding. Discuss, execute, explain, illustrate, use time value of money.	1
CO2	Construct deterministic cash flows, translate, formulate Internal rate of return, NPV.	2
CO3	Define, explain random cash flows.	3
CO4	Define, explain, solve Markowitz model. Use, execute various methods to solve it.	4
CO5	Define, explain, solve CAPM, Use of Portfolio diagrams	5
CO6	Formulate CAPM, Calculate and illustrate CAPM formula and Discuss, execute, explain, illustrate, use it.	6

MTS-308 - Financial Mathematics-I
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Basic Concepts** Arbitrage, return and interest, time value of money, bonds, shares and indices, Models and assumptions.	10
2	**Deterministic cash flows** Net present value, internal rate of return, a comparison of IRR and NPV, bonds: price and yield, clean and dirty price, price yield curves, duration, term structure of interest rates, immunization, convexity.	10
3	**Random cash flows** Random returns, Portfolio diagrams and efficiency, feasible set, Markowitz model, capital asset pricing model, diversification, CAMP as a pricing formula.	10

Learning Resources- References

Sr. No.	References
1.	Amber Habib, The Calculus of Finance, Universities Press.
2.	D. Lemberger, Investment Science, Cambridge University Press
3.	John Hull, Option Futures and other derivatives, Prentice Hall.

MTS-309 - Integral Transforms Major-Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Define key terms related to integral transforms such as "Laplace transform," "Fourier transform," "inverse transform," "region of convergence," and "initial and final value theorems."	1
CO2	Explain the concept of an integral transform and how it is used to convert a function from one domain (e.g., time) to another (e.g., frequency). Describe the conditions under which integral transforms are valid and how they are applied to solve differential and integral equations.	2
CO3	Apply the Laplace transform to solve ordinary differential equations (ODEs) and partial differential equations (PDEs), and interpret the results. Use the Fourier transform to analyze periodic functions, signal processing, and to solve problems involving heat conduction or wave propagation.	3
CO4	Analyze the properties of integral transforms, such as linearity, scaling, time shifting, and differentiation in the transformed domain, and apply them to simplify complex problems.	4
CO5	Evaluate the usefulness of different types of transforms (Laplace, Fourier) in solving specific types of problems in engineering, physics, and applied mathematics. Critically assess the accuracy and efficiency of using numerical methods for computing Laplace and Fourier transforms, particularly for non-standard or complex functions.	5
CO6	Design custom problems or scenarios where integral transforms can be used to solve real-world applications in areas such as electrical engineering, control theory, or communications.	6

MTS-309 - Integral Transforms
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Laplace Transform: Definition of Laplace Transform and examples, Properties of Laplace Transform, Differentiation and Integration properties of Laplace Transform, Inverse Laplace Transforms and its examples, Convolution theorem and related examples.	8
2	Applications of Laplace Transform: Solution of Ordinary Differential Equations, Solution of Integral equations, Solution of Boundary Value Problems, Solution of system of differential equations.	5
3	Fourier Series: Periodic function, Fourier series formula for periodic functions, Fourier series for Odd and Even functions, Fourier series for Discontinuous function, half range Fourier series, half range Cosine series, half range Sine series.	5

4	Fourier Integral: Fourier Integral of a function formula and examples, Fourier Cosine integral, Fourier Sine integral, Complex Fourier integral, Evaluation of integration using Fourier integral.	8
5	Fourier Sine and Cosine Transforms: Fourier sine and cosine transformation and its examples, Properties of Fourier sine and cosine transform and its examples, Application of Fourier sine and cosine transform on Partial differential equation.	4

Learning Resources- References

Sr. No.	References
1.	Erwin Kreyszig, Advanced Engineering Mathematics(8th Edition), Willey Publication, 2010
2.	L. Debnath, Integral transforms and their Applications, CRC Press, New YorkLondon-Tokyo, 1995.
3.	Wiley & Barrett: Advanced Engineering Mathematics, Mc Graw Hill publication
4.	H. K.Dass, Advanced Engineering Mathematics, S. Chand Publication.
5.	Ravish R. Singh and Mukul Bhatt, Advanced Engineering Mathematics (4^{th} Edition), McGrawHill publication, 2018

MTS-311 - Mathematics Practical-5 Major-Practical		
	Number of Credits: 02 No. of Hours:60	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Create examples of integrable functions, groups with given order.	1
CO2	Evaluate limits of sequences, obtain sum of series, integrate functions. Calculate orders of elements of groups.	2
CO3	Analyse the nature of sequences, groups from the observations.	3
CO4	Apply tests for convergence, properties of integrable functions. Apply various statements to determine the order of elements.	4
CO5	Understand the properties of sequences, series and functions from the definitions. Relate the properties of a group with isomorphic groups.	5
CO6	Remember the tests for convergence, properties of groups.	6

MTS-311 - Mathematics Practical-5
Major-Practical

Unit No.	Title of Unit and Contents
1	Properties of real numbers and LUB axiom
2	Normal subgroup and factor groups
3	Countablility, uncountable sets
4	Convergent sequences, monotone sequences
5	Examples of rings and subrings
6	Subsequences and Cauchy sequences
7	Characteristic of ring, Fields, Finite Fields
8	Convergence of series and examples
9	Ideals, Field of quotients
10	Tests for convergence of series
11	Polynomial rings, irreducibility, Unique factorization
12	Riemann integral of functions, Properties of integrable functions, mean value theorems

MTS-312 - Mathematics Practical-6 Major-Practical		
	Number of Credits: 02 No. of Hours:60	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Create numbers with specic gcd, lcm. Generate examples of specific counting properties, curves with given length, curvature, etc.	1
CO2	Evaluate gcd, lcm of given numbers. Find the solution of a system of congruences, solutions of financial problems.	2
CO3	Analyse the properties of numbers, LPP, nature of surfaces.	3
CO4	Apply the properties of numbers to solve the congruences. Apply the basic mathematical properties to solve the problems from the finance.	4
CO5	Understand the properties of congruences, nature of the curves and surfaces, LPP.	5
CO6	Remember techniques to solve the LPP, financial problems.	6

MTS-312 - Mathematics Practical-6
(Major-Practical)

Unit No.	**Title of Unit and Contents**	
1	Practical 1	Number Theory, Operations Research, Combinatorics
2	Practical 2	Number Theory, Operations Research, Combinatorics
3	Practical 3	Number Theory, Operations Research, Combinatorics
4	Practical 4	Number Theory, Operations Research, Combinatorics
5	Practical 5	Number Theory, Operations Research, Combinatorics
6	Practical 6	Number Theory, Operations Research, Combinatorics
7	Practical 7	Differential Geometry, Financial Mathematics-I, Integral Transforms
8	Practical 8	Differential Geometry, Financial Mathematics-I, Integral Transforms
9	Practical 9	Differential Geometry, Financial Mathematics-I, Integral Transforms
10	Practical 10	Differential Geometry, Financial Mathematics-I, Integral Transforms
11	Practical 11	Differential Geometry, Financial Mathematics-I, Integral Transforms
12	Practical 12	Differential Geometry, Financial Mathematics-I, Integral Transforms

MTS-331 - AI and ML with Python Major-VSC-Theory		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define key concepts in AI and ML such as "supervised learning," "unsupervised learning," "reinforcement learning," "neural networks," "classification," "regression," and "clustering."	1
CO2	Explain the difference between supervised, unsupervised, and reinforcement learning, and describe when to apply each approach in problem-solving. Understand the fundamentals of neural networks, including their architecture (e.g., layers, nodes, activation functions) and how they are used in deep learning.	2
CO3	Apply supervised learning algorithms such as linear regression, logistic regression, decision trees, and SVM to real-world datasets for classification and regression tasks. Implement unsupervised learning algorithms like k-means clustering and hierarchical clustering to find patterns and groupings in data.	3
CO4	Analyze the performance of machine learning models using metrics such as accuracy, precision, recall, and AUC, and determine the most suitable metric for a given task. Investigate the structure of complex datasets (e.g., high-dimensional data, imbalanced datasets) and evaluate how different algorithms perform on them.	4
CO5	Evaluate the performance of machine learning models based on various criteria, such as computational efficiency, scalability, and interpretability, and suggest improvements. Critically assess the suitability of different algorithms (e.g., decision trees, deep learning, clustering) based on the characteristics of the data and the problem at hand.	5
CO6	Design and implement machine learning pipelines that include data preprocessing, feature engineering, model selection, and evaluation for end-to-end problem-solving.	6

MTS-331 - AI and ML with Python
(Major- VSC-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Introduction to AI, ML, and Python for Data Science • Overview of Artificial Intelligence and Machine Learning. • Key concepts in AI and ML: Supervised vs. Unsupervised learning, training vs. testing, overfitting vs. underfitting. • Introduction to Python libraries for data science: NumPy, Pandas, Matplotlib, and Seaborn. • Setting up the development environment (Jupyter Notebooks, Anaconda). • Hands-on: Working with datasets in Python.	6

2	Data Preprocessing and Feature Engineering • Understanding data types and structures in Python. • Data cleaning and preprocessing (handling missing values, encoding categorical variables). • Feature scaling (Normalization vs. Standardization). • Feature selection and extraction techniques. • Hands-on: Preprocessing a real-world dataset for ML tasks.	7
3	Supervised Learning – Linear Regression • Overview of supervised learning: Regression vs. Classification. • Simple linear regression: Equation, assumptions, and interpretation. • Model fitting and evaluation (Loss functions, MSE, RMSE, R^2 score). • Multiple linear regression and feature selection. • Hands-on: Building and evaluating a linear regression model using Scikit-learn.	6
4	Supervised Learning – Classification Algorithms • Introduction to classification problems. • Logistic regression and decision boundaries. • k-Nearest Neighbors (k-NN) and decision trees. • Model evaluation for classification (accuracy, precision, recall, F1 score, ROC curve). • Hands-on: Building classification models using Scikit-learn (Logistic Regression, k-NN, Decision Trees).	5
	Model Evaluation and Hyperparameter Tuning • Cross-validation: k-fold and leave-one-out. • Overfitting vs. underfitting and the bias-variance tradeoff. • Hyperparameter tuning using Grid Search and Random Search. • Regularization techniques: L1 and L2 regularization. • Hands-on: Hyperparameter tuning and cross-validation on classification models.	6

Learning Resources- References

Sr. No.	**References**
1.	Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow
2.	Sebastian Raschka and Vahid Mirjalili , Python Machine Learning (3rd Edition)
3.	François Chollet, Deep Learning with Python
4.	Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach
5.	Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning
6.	Christopher Bishop, Pattern Recognition and Machine Learning
7.	Foster Provost and Tom Fawcett , Data Science for Business
8.	Kaggle – A platform for data science competitions with numerous datasets and ML challenges. https://www.kaggle.com/
9.	TensorFlow Documentation – Official documentation and tutorials for learning TensorFlow. https://www.tensorflow.org/
10.	Scikit-learn Documentation – Official documentation for the Scikit-learn machine learning library. https://scikit-learn.org/
11.	Fast.ai – Free deep learning courses and tutorials for practitioners. https://www.fast.ai/

MTS-332 - Mathematics Practical-7 Major-VSC-Practical		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Create examples of libraries	1
CO2	Evaluate models, numerical values using the programing	2
CO3	Analyse the mathematical objects through the programming	3
CO4	Apply program for stability of the	4
CO5	Understand the models, regression	5
CO6	Remember the techniques for modelling, regression.	6

MTS-332 - Mathematics Practical-7
Major-VSC -Practical

Practical No.	Title of Unit and Contents
1	Key concepts in Ai and ML
2	Introduction to libraries
3	Settind up development environment, workin with databese
4	Data types, data clearing
5	Feature scaling, selection, extraction techniques
6	Simple leiner regression
7	Model fitting
8	Multiple linear regression
9	Logistic regression, k-nearest neighbork
10	Model evaluation
11	Cross validation
12	Regularization techniques

MTS-321 - Special Functions and Integral Transforms Minor-Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define key terms related to integral transforms such as "Laplace transform," "Fourier transform," "inverse transform," "region of convergence," and "initial and final value theorems."	1
CO2	Explain the concept of an integral transform and how it is used to convert a function from one domain (e.g., time) to another (e.g., frequency). Describe the conditions under which integral transforms are valid and how they are applied to solve differential and integral equations.	2
CO3	Apply the Laplace transform to solve ordinary differential equations (ODEs) and partial differential equations (PDEs), and interpret the results. Use the Fourier transform to analyze periodic functions, signal processing, and to solve problems involving heat conduction or wave propagation.	3
CO4	Analyze the properties of integral transforms, such as linearity, scaling, time shifting, and differentiation in the transformed domain, and apply them to simplify complex problems.	4
CO5	Evaluate the usefulness of different types of transforms (Laplace, Fourier) in solving specific types of problems in engineering, physics, and applied mathematics. Critically assess the accuracy and efficiency of using numerical methods for computing Laplace and Fourier transforms, particularly for non-standard or complex functions.	5
CO6	Design custom problems or scenarios where integral transforms can be used to solve real-world applications in areas such as electrical engineering, control theory, or communications. Formulate original theoretical results or extensions of existing theorems related to integral transforms, such as the application of multi-dimensional transforms or the study of generalized transforms.	6

MTS-321 - Special Functions and Integral Transforms
(Minor-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Special Functions: Beta function, Gamma function, Error function, Orthogonal Polynomials, Bessel Functions, Legendre polynomials	4
2	Laplace Transform: Definition of Laplace Transform and examples, Properties of Laplace Transform, Differentiation and Integration properties of Laplace Transform, Inverse Laplace Transforms and its examples, Convolution theorem and related examples.	6
3	Applications of Laplace Transform: Solution of Ordinary Differential Equations, Solution of Integral equations, Solution of Boundary Value Problems, Solution of system of differential equations.	5

4	Fourier Series: Periodic function, Fourier series formula for periodic functions, Fourier series for Odd and Even functions, Fourier series for Discontinuous function, half range Fourier series, half range Cosine series, half range Sine series.	5
5	Fourier Integral: Fourier Integral of a function formula and examples, Fourier Cosine integral, Fourier Sine integral, Complex Fourier integral, Evaluation of integration using Fourier integral.	6
6	Fourier Sine and Cosine Transforms: Fourier sine and cosine transformation and its examples, Properties of Fourier sine and cosine transform and its examples, Application of Fourier sine and cosine transform on Partial differential equation.	4

Learning Resources- References

Sr. No.	References
1.	Erwin Kreyszig, Advanced Engineering Mathematics(8th Edition), Willey Publication, 2010
2.	Bipin Singh Koranga, Sanjay Kumar Padilya and Vivek Kumar Nautiyal, Special Functions and Their Applications, Routledge, Taylor And Francis
3.	L. Debnath, Integral transforms and their Applications, CRC Press, New YorkLondon- Tokyo, 1995.
4.	Larry C. Andrews, Field Guide to Special Functions for Engineers-SPIE Press (2011)
5.	Wiley & Barrett: Advanced Engineering Mathematics, Mc Graw Hill publication
6.	H. K.Dass, Advanced Engineering Mathematics, S. Chand Publication.
7.	Ravish R. Singh and Mukul Bhatt, Advanced Engineering Mathematics (4^{th} Edition), McGrawHill publication, 2018
8.	Carlo Viola, An Introduction to Special Functions-Springer International Publishing (2016)

MTS-322 - Linear Algebra and Applications **Minor-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall key concepts of linear algebra, including vectors, matrices, vector spaces, linear transformations, and eigenvalues/eigenvectors. Identify various types of matrices (e.g., diagonal, symmetric, orthogonal) and their properties.	1
CO2	Explain the concepts of linear dependence and independence, the rank of a matrix, and how these relate to the solution of linear systems. Describe the geometric interpretation of vector spaces, subspaces, and linear transformations, and how they apply to real-world problems.	2
CO3	Solve systems of linear equations using Gaussian elimination, matrix inverses, and Cramer's rule, and interpret the results in the context of applied problems. Apply the concepts of eigenvalues and eigenvectors to diagonalize matrices and solve real-world problems such as stability analysis or principal component analysis (PCA).	3
CO4	Analyze the solution sets of linear systems using the rank-nullity theorem, and determine the consistency of systems by evaluating the coefficient matrix and augmented matrix. Analyze the impact of different matrix operations (e.g., determinant, inverse, rank) on the properties of linear systems and vector spaces.	4
CO5	Evaluate the efficiency and suitability of various numerical methods (e.g., LU decomposition, iterative methods) for solving large-scale systems of linear equations. Critique the use of eigenvalue decomposition and singular value decomposition (SVD) in applications like data compression, image processing, and machine learning.	5
CO6	Design and implement algorithms to solve real-world applied problems involving linear systems, such as optimization problems, computer graphics, and network flow analysis. Create mathematical models using linear algebra techniques to represent real-world scenarios in diverse fields such as economics, engineering, or data science, and solve these models effectively.	6

MTS-322 - Linear Algebra and Applications
(Minor - Theory)

Unit No.	**Title of Unit and Contents**	**No. of hours**
1	Revision of Matrices, System of linear equations, Row echelon form, Elementary matrices, Determinant, Properties of determinant, applications	2
2	Vector space, subspace, linear independence, basis and dimension, change of basis, row space and column space	8
3	Linear transformation, Examples of linear transformation, Rank-Nullity Theorem, Matrix representation of linear transformation, similarity, Tensors	8
4	Scalar product, Orthogonal spaces, least square problems, inner product spaces, orthogonal sets, Gram-Schmidt orthogonalisation	8

	process, QR factorisation, Orthogonal polynomials, least square approximation	
5	Eigenvalues, Eigenvectors, Diagonalization, Applications, spectral decomposition, singular value decomposition	4

Learning Resources- References

Sr. No.	References
1.	Steven J. Leon, Linea Algebra with Applications, Pearson
2.	David C. Lay, Linear Algebra and Its Applications, Pearson
3.	Michael Stone, Mathematics for Physics II, Pimander-Casaubon
4.	Paul Bamberg, Shlomo Sternberg, A Course in Mathematics for Students of Physics 2, Cambridge University Press
5.	Sheldon Axler, Linear Algebra Done Right, Springer
6.	S. Kumaresan, Linear Algebra –A Geometric Approach, PHI Learning Private Limited
7.	Titu Andreescu, Essential Linear Algebra with Applications-A Problem Solving Approach, Birkhauser

MTS-323 - Calculus (CS) Minor-Theory		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Understanding Fundamental Calculus Concepts	1
CO2	**Explain key calculus concepts** such as limits, derivatives, integrals, and continuity.	2
CO3	**Compute derivatives** of elementary functions and apply these concepts in **real-world problems** such as optimization.	3
CO4	Explain concepts like Curl, Gradient and divergence.	4
CO5	Evaluate maxima and minima of multi variable functions.	5
CO6	Design examples of continuous and non-differentiable functions	6

MTS-323 - Calculus (CS)
(Minor -Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Differentiation and Applications** **1.1** Definition of a derivative (via limits) **1.2** Mean Value Theorem **1.3** Increasing and decreasing functions, concavity **1.4** First and second derivative tests for local extrema	**4**
2	**Functions of Several Variables** **2.1** Graphs and level curves **2.2** Partial derivatives **2.3** Total derivative **2.4** Jacobian **2.5** Euler's Theorem for Homogeneous functions	**10**
3	**Extreme Values** **1.1** Extrema of functions of two or more variables **1.2** Necessary conditions for Extreme values **1.3** Second derivative test (without proof) **1.4** Lagrange Multipliers with one constraint	**7**
4	**Vector calculus** **4.1** Vector Fields **4.2** Curl and Divergence **4.3** Gradient vector **4.4** Gradient Descent Method	**4**

Learning Resources- References

Sr. No.	References
1.	Gilbert Strang, *Calculus* (For multivariable Calculus and Linear Algebra.)
2.	Multivariable calculus (seventh edition) James Stewart MC master university and university of Toronto.
3.	Thomas Jr., G.B., Weir, M.D. and Hass, J. Thomas' Calculus (12th ed.). Pearson, Boston, New York, 2010

	MTS-345 – Field Project (FP) **Major** **Theory/Practical**	
	Number of Credits: 02 **No. of Hours: 60**	

SEMESTER VI		
MTS-351 - Real Analysis-II **Major-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall the convergence of sequences and series of functions, Riemann integrability of functions. Identify the function to which sequences and series of functions converge, the type of improper integrals, and the properties of elementary functions. State the convergence tests for sequences and series of functions, conditions for convergence of improper integrals, and conditions for DUIS.	1
CO2	Clarify the pointwise or uniform convergence of sequences and series of functions, properties/identities about elementary functions, convergence/divergence of improper integrals, and applicability of DUIS. Compare the sequences and series of functions, improper integrals for convergence, and elementary functions.	2
CO3	Apply tests of convergence for sequences and series for functions, improper integrals. Apply properties of elementary functions to prove identities. Apply DUIS to prove improper integrals, and identities such as Fubini's theorem, Schwarz theorem, Euler's formula etc.	3
CO4	Analyse the sequence and series of functions to test the pointwise or uniform convergence. Analyse properties of elementary functions to prove the identities. Compare functions to test the convergence of improper integrals.	4
CO5	Evaluate the limit of sequence/series of functions, combinations of elementary functions, and improper integrals and write the conclusion. Decide the suitable method/test to check the convergence of sequence and series of functions, as well as improper integrals.	5
CO6	Produce counter-examples for false statements, and non-validity of converse of the statement. Combine statements and predict the result. Design the statement from examples. State the hypothesis for the validity of the statement.	6

MTS-351 - Real Analysis-II
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Sequences of Functions:** Sequences of functions, Point-wise Convergence, Uniform Convergence, Cauchy criteria for uniform convergence Interchange of limit and integration, Interchange of limit and derivative.	8
2	**Series of functions:** Series of functions, Point-wise Convergence, Uniform Convergence, Weirestrass M-test,Term by term Integration, Term by term differentiation, Power series, radius of convergence.	8
3	**Improper Integrals:** Improper integrals of first and second kind, Comparison test, Integral test for series	8
4	**Differentiation under the integral sign:** Differentiation under the integral sign with constant limits, Differentiation under the integral sign with variable limits, Applications of DUIS.	6

Learning Resources- References

Sr. No.	References
1.	Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd., (1970).
2.	Ajitkumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2010.
3.	S. Ponnusamy, Foundations of Mathematical Analysis, Birkauser, (2010).
4.	W. Rudin, Principles of Mathematical Analysis, McGraw Hill International Edition
5.	R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 4 th Edition, John Wiley, 2012.

MTS-352 - Advanced Linear Algebra **Major-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall advanced concepts in linear algebra, including vector spaces, inner product spaces, eigenvalues/eigenvectors, diagonalization, and bilinear forms. Identify the key properties of matrix decompositions such as QR decomposition, singular value decomposition (SVD), and Jordan canonical form.	1
CO2	Explain the fundamental theorem of linear algebra, including the relationships between a matrix's rank, nullity, row space, and column space. Describe the significance and applications of orthogonal and orthonormal bases, and understand the geometrical interpretation of linear transformations in high-dimensional spaces.	2
CO3	Apply the concepts of eigenvalues and eigenvectors to diagonalize matrices and solve problems in stability analysis, differential equations, and systems theory. Use advanced matrix decompositions (e.g., LU, QR, SVD) to solve linear systems and find least-squares solutions to overdetermined systems in practical scenarios.	3
CO4	Analyze the structure of linear operators on finite-dimensional and infinite-dimensional vector spaces using their matrix representations and associated eigenstructures.	4
CO5	Evaluate the effectiveness of various solution methods for large-scale linear systems, including iterative methods and matrix factorizations, considering both computational complexity and accuracy.	5
CO6	Develop new algorithms or approaches to solve complex linear algebra problems, such as solving large eigenvalue problems, in real-world applications like data science, image processing, or computer graphics.	6

MTS-352 - Advanced Linear Algebra
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Elementary Matrix Operations And System of Linear Equations: Elementary matrix operations and elementary matrices, The Rank of matrix and matrix inverses, System of linear equations-theory and computations.	7
2	Determinants: Determinants of Order 2, Determinants of Order n, Properties of Determinants Characterization of determinant, Vandermonde matrix, Cramer’s Rule, Moore-Penrose pseudo inverse, Alternating forms	7
3	Diagonalisation: Eigenvalues and eigenvectors, Diagonalizability, Direct Sums, Invariant subspaces and the Cayley-Hamilton theorem	8
4	Canonical Forms: Generalized eigenvectors, generalised eigenspace T-cyclic subspace, Jordan basis, The Jordan Canonical forms, minimal polynomial.	8

Learning Resources- References

Sr. No.	References
1.	Stephen H. Friedberg, Arnold J. Insel, Lawrence G. Spence, Linear Algebra, Pearson, Fifth Edition
2.	Steven J. Leon, Linear Algebra with Applications, Pearson
3.	Titu Andreescu, Essential Linear Algebra with Applications-A Problem Solving Approach, Birkhauser.
4.	Howard Anton, Chris Rorres, Elementary Linear Algebra: Applications Version, Wiley (11^{th} Edition)
5.	Gene H. Golub, Charles F. Van Loan, Matrix Computations, The Johns Hopkins University Press, Baltimore (Fourth Edition)

	MTS-353 - Complex Analysis **Major-Theory**	
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define complex numbers, complex functions, limits, continuity, and differentiability in the complex plane. State Cauchy-Riemann equations and fundamental theorems in complex analysis.	1
CO2	Explain analytic and harmonic functions with examples. Illustrate contour integration and its significance in evaluating integrals. Interpret the geometric representation of complex functions.	2
CO3	Apply Cauchy-Riemann equations to check analyticity. Compute contour integrals using Cauchy's integral theorem and formula. Use Taylor and Laurent series to expand complex functions.	3
CO4	Classify singularities as removable, poles, or essential singularities. Determine residues and apply the residue theorem to evaluate real integrals. Examine the behavior of complex functions using series expansions.	4
CO5	Assess improper real integrals and contour integrals using the residue theorem. Justify the application of conformal mapping techniques to solve engineering problems.	5
CO6	Design conformal mappings between different domains. Develop applications of complex analysis in fluid dynamics, electrical engineering, and signal processing.	6

MTS-353 - Complex Analysis
(Major - Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Analytic functions of Complex Variables, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas, Cauchy - Riemann Equations, Sufficient Conditions for differentiability, Polar coordinates and Harmonic functions	8
2	Elementary Functions, The Exponential functions, The Logarithmic function, Branches and derivatives of logarithms, Some identities involving logarithms, Complex exponents, Trigonometric functions, Hyperbolic functions, Inverse trigonometric and hyperbolic functions	7
3	Definite integrals of functions, Contours, Contour integral, Examples, Upper bounds for moduli of contour integrals, Anti-derivatives, Examples, Cauchy-Goursat's Theorem (without proof), Simply and multiply Connected domains. Cauchy integral formula. Derivatives of analytic functions, Liouville's Theorem and Fundamental Theorem of Algebra, Maximum modulus principle	8
4	Series Convergence of sequences, Convergence of series, Taylor Series (without proof), examples, Laurent Series (without proof), region of convergence, examples, Residues and Poles Cauchy residue theorem, using a single residue, Three types of isolated singular points, Residues at poles, Zeros of analytic functions, Zeros and poles	7

Learning Resources- References

Sr. No.	References
1.	J. W. Brown and R. V. Churchill, Complex Variables and Applications, International Student Edition, 2009. (Eighth Edition). Chapter 1: Section 1 to 10 Chapter 2: Section 12, 15 to 26 Chapter 3: Section 29 to 36. Chapter 4: Section 37 to 46 and 48 to 53 Chapter 5: Section 55 to 57, 59 to 60, 62 Chapter 6: Section 68 to 76
2.	S. Ponnusamy, Complex Analysis, Second Edition (Narosa).
3.	J. M. Howie, Complex Analysis, (Springer, 2003).
4.	S. Lang, Complex Analysis, (Springer, Verlag).
5.	A. R. Shastri, An Introduction to Complex Analysis, (MacMillan).

MTS-354 - Cryptography Major- Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall the fundamental concepts of cryptography, including encryption, decryption, keys, ciphers, and cryptographic protocols. Identify different types of cryptographic algorithms, such as symmetric-key and asymmetric-key algorithms, and their uses in real-world applications.	1
CO2	Explain the principles behind classical ciphers (e.g., Caesar cipher, Vigenère cipher) and modern cryptographic algorithms (e.g., AES, RSA). Describe key cryptographic concepts such as confidentiality, integrity, authentication, and non-repudiation, and understand how cryptographic techniques ensure these properties.	2
CO3	Apply cryptographic algorithms to encrypt and decrypt messages, including both symmetric and asymmetric encryption methods. Implement basic cryptographic protocols, such as Diffie-Hellman key exchange, digital signatures, and message authentication codes (MACs), to secure communications.	3
CO4	Analyze the security of cryptographic systems and protocols, including evaluating their resistance to common attacks like brute force, man-in-the-middle, and side-channel attacks. Analyze and differentiate between various modes of operation (e.g., ECB, CBC) for block ciphers and understand their strengths and weaknesses in different cryptographic contexts.	4
CO5	Evaluate the effectiveness of cryptographic systems in various security contexts, considering factors like key length, algorithm efficiency, and computational complexity.	5
CO6	Design and implement secure cryptographic protocols tailored to specific use cases, such as secure email communication, digital currency transactions, or secure file storage. Create cryptographic algorithms or modifications to existing algorithms to improve their efficiency, security, or scalability in real-world applications.	6

MTS-354 - Cryptography
(Major-Elective- Theory)

Unit No.	**Title of Unit and Contents**	**No. of hours**
1	**Classical Cryptography** 1.1 Introduction to some simple cryptosystems 1.1.1. The shift Cipher 1.1.2. The Substitution Cipher 1.1.3. The Affine Cipher 1.1.4. The Vigenère Cipher 1.1.5. The Hill Cipher 1.1.6. The Permutation Cipher 1.1.7. Introduction to Stream cipher and LFSR 1.2. Cryptanalysis	9

	1.2.1. Cryptanalysis of Substitution cipher 1.2.2. Cryptanalysis of Affine Cipher	
2	**Public Key Cryptography** **2.1.** Introduction and Overview 2.2. The RSA cryptosystem and its implementation, factoring integers 2.3. Generation of keys, Diffie Hellman Key Agreement protocol 2.4. ElGamal Encryption Algorithm 2.5. Discrete Logarithm 2.6. Introduction to attacks against RSA, Discrete Logarithm	8
3	**Symmetric Key Cryptography** 3.1. Introduction and overview 3.2. Stream Cipher, Block ciphers 3.3. one-time Pad 3.4. Digital signature 3.5. Data Encryption Standard, 3.6. Advanced Encryption Standard	6
4	**Elliptic Curve Cryptography** 4.1. Introduction and Overview, 4.2. Elliptic Curves over Real Numbers, 4.3. Elliptic curves over finite fields, 4.4. Elliptic curve cryptography,	5
5	**Introduction to Block chain technology and Quantum Cryptography** 5.1. Overview of blockchain technology, quantum cryptography and its application	2

Learning Resources- References

Sr. No.	References
1.	Stinson, D. R. (2005). Cryptography: theory and practice. Chapman and Hall/CRC.
2.	Koblitz, N. (1994). A course in number theory and cryptography (Vol. 114). Springer Science & Business Media.
3.	Lewand, R. E. (2000). Cryptological Mathematics. Mathematical Association of America Washington
4.	Hoffstein, J., Pipher, J., Silverman, J. H., Hoffstein, J., Pipher, J., & Silverman, J. H. (2014). An Introduction to Cryptography (pp. 1-59). Springer New York.
5.	Elbirt, A. J. (2009). Understanding and applying cryptography and data security. Auerbach Publications.
6.	Schneier, B. (2007). Applied cryptography: protocols, algorithms, and source code in C. john Wiley & sons.
7.	Swan, M. (2015). Blockchain: Blueprint for a new economy. " O'Reilly Media, Inc.".

MTS-355 - Optimization Techniques **Major-Elective-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall the fundamental concepts of optimization, including objective functions, constraints, feasible regions, and optimal solutions. Identify different types of optimization problems, such as linear, nonlinear, integer, and convex optimization.	1
CO2	Explain key optimization concepts, such as optimality conditions (e.g., Karush-Kuhn-Tucker conditions) and the difference between constrained and unconstrained optimization. Describe the basic principles of optimization algorithms, including gradient descent, simplex method, and integer programming, and their relevance to solving various optimization problems.	2
CO3	Apply optimization techniques to solve linear programming problems using methods such as the simplex algorithm or interior-point methods. Use nonlinear optimization methods (e.g., steepest descent, Newton's method) to solve unconstrained and constrained optimization problems in engineering, economics, or machine learning applications.	3
CO4	Analyze the convergence behavior and efficiency of optimization algorithms, identifying conditions under which they may fail or perform poorly (e.g., local minima in nonlinear optimization). Examine the duality in optimization problems, exploring the relationship between primal and dual solutions in linear programming, and apply duality theory to derive bounds and solutions.	4
CO5	Evaluate the effectiveness of different optimization algorithms for specific problem types, considering computational complexity, accuracy, and convergence. Critique the appropriateness of using certain optimization methods (e.g., linear vs. nonlinear) for solving real-world problems.	5
CO6	Design and implement custom optimization algorithms for solving complex, real-world problems that do not have standard solution methods, such as multi-objective optimization or large-scale optimization. Develop mathematical models to represent real-world optimization problems in fields such as logistics, finance, engineering design, and machine learning.	6

MTS-355 - Optimization Techniques
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Decision Analysis and Game Theory** The decision under uncertainty, Game theory, some basic terminologies, optimal solution of two persons zero-sum game, Solution of mixed strategy games, graphical solution of games, linear programming solution of games	10
2	**Sequencing Problems** Introduction, Notation, terminology and assumptions, processing n jobs through two machines, processing jobs through three machines	4
3	**Replacement and Maintenance Models** Introduction, Types of failure, Replacement of items whose efficiency deteriorates with time	4
4	**Network Models** CPM and PERT, Network representation, Critical Path Computations, Construction of the schedule, Linear programming formulation of CPM, PERT calculations	6
5	**Classical Optimization Theory** Unconstrained problems, Necessary and sufficient conditions, Newton Raphson method, Constrained problems, Equality constraints (Lagrangian)	6

Learning Resources- References

Sr. No.	References
1.	Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd., New Delhi
2.	J. K. Sharma, Operations Research (Theory and Applications, Second Edition, 2006), Macmillan India Ltd.
3.	Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition), Tata McGraw-Hill.
4.	Hira and Gupta, Operations Research, S. Chand Publication

MTS-356 - Lebesgue Integration Major-Elective-Theory		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall the fundamental definitions and properties of Lebesgue integration, including measurable sets, measurable functions, Lebesgue integrability, and the Lebesgue integral itself. Identify the key differences between Riemann and Lebesgue integrals, including their respective definitions and the types of functions they apply to.	1
CO2	Explain the concept of Lebesgue measure and its role in defining the Lebesgue integral for real-valued functions. Describe the Dominated Convergence Theorem, Monotone Convergence Theorem, and Fatou's Lemma, and understand their significance in the context of Lebesgue integration.	2
CO3	Apply the definitions of Lebesgue integrability to determine whether a function is Lebesgue integrable and calculate the Lebesgue integral for simple functions. Use the Lebesgue integral to evaluate integrals of functions that are difficult to integrate using Riemann methods, such as unbounded or discontinuous functions.	3
CO4	Analyze the convergence of integrals using the Dominated Convergence Theorem and Monotone Convergence Theorem to exchange limits and integrals in practical problems. Investigate the properties of the Lebesgue integral, such as linearity, monotonicity, and the relationship between the integral of a function and its simple approximations.	4
CO5	Evaluate the effectiveness of the Lebesgue integral in solving problems in real analysis and probability theory, comparing its advantages over the Riemann integral. Critique the application of Lebesgue's Dominated Convergence Theorem and Monotone Convergence Theorem in various contexts, considering their implications for integrability and limit operations.	5
CO6	Design and implement methods to compute the Lebesgue integral for more complex measurable functions, leveraging approximation techniques such as simple functions or characteristic functions.	6

MTS-356 - Lebesgue Integration
(Major- Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Measurable Sets : Length of open sets and closed sets, Inner and outer measure, Measurable sets, Properties of measurable sets	4
2	Measurable Functions	8
3	The Lebesgue Integrals: Definition and example of the Lebesgue integrals for bounded functions, Properties of Lebesgue integrals for bounded measurable functions, The Lebesgue integral for unbounded functions, Some fundamental theorems; Fatou's lemma, dominated convergence theorem, L^2 space	10
4	Fourier Series- Definition and examples of Fourier Series, Formulation of convergence problems, Parseval's theorem	8

Learning Resources- References

Sr. No.	References
1.	Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd., (1970).
2.	Soo Bong Chae, Lebesgue Integration, Springer-Verlag.
3.	T. M. Apostol, Advanced Calculus, 2nd Edition, Prentice Hall of India, 1994.
4.	R. G. Bartle and D. R. Scherbert, Introduction to Real Analysis, 4th Edition, John Wiley, 2012
5.	D. Somasundaram and B. Choudhari, A first course in Mathematical Analysis, Narosa Publishing House, 1997.

MTS-357 - Dynamical Systems **Major-Elective-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall fundamental concepts in dynamical systems, including state variables, phase space, trajectories, fixed points, and stability. Identify different types of dynamical systems such as continuous vs. discrete, linear vs. nonlinear, and deterministic vs. stochastic.	1
CO2	Explain the basic properties of dynamical systems, such as equilibrium points, periodic orbits, and attractors, and understand how they influence system behavior.	2
CO3	Apply the methods of linearization to analyze the stability of equilibrium points in both continuous and discrete dynamical systems. Use phase portraits to visualize the behavior of dynamical systems and determine the qualitative behavior of solutions near fixed points or along periodic orbits.	3
CO4	Analyze the behavior of nonlinear dynamical systems using techniques such as perturbation methods, Poincaré maps, and bifurcation diagrams. Investigate the existence and stability of periodic orbits in systems and explore their implications for the long-term behavior of the system.	4
CO5	Critique the applicability of different methods for analyzing dynamical systems, such as numerical simulations, linear stability analysis, and the Poincaré-Bendixson theorem. Evaluate the impact of system parameters on the stability and behavior of solutions, such as how changes in parameter values lead to bifurcations or chaos in nonlinear systems.	5
CO6	Develop mathematical models using dynamical systems theory to represent real-world phenomena, such as population dynamics, chemical reactions, or mechanical systems.	6

MTS-357 - Dynamical Systems
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Continuous Dynamical Systems: 1.1 Definition of Dynamical Systems, Flow, Evolution 1.2 Fixed points, Linear Stability 1.3 Analysis of One dimensional Systems 1.4 Conservative and Dissipative Dynamical Systems	8
2	Linear Systems 2.1 Solution of linear system by eigenvalues and eigenvectors 2.2 Fundamental matrix method 2.3 Exponential of matrix 2.4 Solving linear systems using exponential of matrix 2.5 Nonhomogeneous linear systems	8

3	Phase Plane Analysis 3.1 Phase Plane Analysis, Phase portrait 3.2 Local Stability of two dimensional systems 3.3 Linearization 3.4 Nonlinear Simple pendulum, Linear Oscillators	5
4	Discrete Dynamical Systems 4.2 Maps and flows, composition of maps 4.2 Orbits, Phase portraits 4.3 Fixed points, Existence and uniqueness of fixed points, stable and unstable fixed points 4.4 Basin of attraction, 1.1 Linear stability, Cobweb diagram 1.2 Periodic points, periodic cycles, stability of periodic points and periodic cycles	9

Learning Resources- References

Sr. No.	References
6.	G. C. Layek, An Introduction to Dynamical Systems and Chaos, Springer, Second Edition (2024)
7.	R. C. Robinson, An Introduction to Dynamical Systems,- Continuous and Discrete, American Mathematics Society
8.	Morris W. Hirsch, Stephen Smale., Robert L. Devaney, Differential Equations, Dynamical Systems and an Introduction to Chaos (Third Edition), Academic Press, ELSEVIER.
9.	Lawrence Perko, Differential Equations and Dynamical Systems, Springer, Third Edition
10.	Stephen Lynch, Dynamical Systems with Applications using Python, Birkhauser.
11.	J D Meiss, Differential Dynamical Systems, SIAMS

MTS-358 - Financial Mathematics-II Major-Elective-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Recall and articulate basic concepts of forwards and futures.	1
CO2	Formulate currency future and stock index futures	2
CO3	Define, explain call and put options and their types, Evaluate them	3
CO4	Explain put-call parity and solve various problems model. Use, execute and explain various factors which affect the stock options	4
CO5	Apply Black Scholes model and use of the formula. Define, Explain and use Greeks.	5
CO6	Formulate BOPM, Calculate and illustrate BOPM formula and Discuss, execute, explain, illustrate, use it.	6

MTS-358 - Financial Mathematics-II
(Major-Elective- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Forward and futures, Forward and futures price, value of a future contract, method of replicating portfolios, hedging with futures, currency futures, stock index futures.	6
2	Call options, put options, put-call parity, binomial options pricing model, pricing American options, factor influencing option premiums, options on assets with dividends, dynamic hedging, risk-neutral valuation	8
3	Speculation- Strategies involving options, trading an option and the underlying asset, Spreads: Bull spread, Bear spread, Box spread, Butterfly spread, Calendar spread, Diagonal spread, Combinations: straddle, strips and straps, strangles	8
4	Models- Binomial trees, one step binomial trees, two step binomial trees, a generalization of binomial trees, the Markov property, continuous time stochastic process, Wiener process, generalized Wiener process, the process for stock price, Ito's lemma, the log normal property, the Black-Scholes-Merton model, greeks	8

Learning Resources- References

Sr. No.	References
1.	John Hull, Option Futures and other derivatives, Prentice Hall.
2.	Luenberger, Investment Science, Cambridge University Press.
3.	Amber Habib, The Calculus of Finance, Universities Press

MTS-359 - Graph Theory **Major-Elective-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall fundamental concepts in graph theory, including definitions of graphs, vertices, edges, paths, cycles, and connectivity. Identify different types of graphs such as directed, undirected, weighted, bipartite, and planar graphs.	1
CO2	Explain key graph properties such as degree of vertices, adjacency, incidence, and graph isomorphism. Describe the fundamental algorithms for traversing graphs, including Depth-First Search (DFS) and Breadth-First Search (BFS), and understand their applications.	2
CO3	Apply graph traversal algorithms (DFS, BFS) to solve problems such as finding connected components, checking for cycles, and searching for specific nodes. Solve practical problems using graph-based models, such as shortest path problems (Dijkstra's, Bellman-Ford), and network flow problems (Ford-Fulkerson algorithm).	3
CO4	Analyze the properties and structure of graphs, such as planarity, connectivity, and the presence of Eulerian and Hamiltonian paths or cycles. Investigate the time and space complexity of graph algorithms, and analyze their efficiency in terms of input size and graph density.	4
CO5	Evaluate the suitability of various graph algorithms for different problem types, considering factors like graph size, edge weights, and the need for exact or approximate solutions.	5
CO6	Design and implement graph algorithms for solving advanced problems such as graph coloring, finding minimum spanning trees, or solving network flow optimization problems.	6

MTS-359 - Graph Theory
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	An Introduction to Graphs: The definition of a Graph, Graphs and Models, Vertex Degree, Subgraphs, Paths and Cycles, The Matrix Representation of Graphs, Fusion of graphs	8
2	Trees and Connectivity: Definition and Simple Properties, Bridges, Spanning Trees, Connector Problems, Shortest Path Problems, Cut Vertices and Connectivity.	8
3	Euler Tours and Hamiltonian Cycles: Euler Tours, The Chinese Postman Problem, Hamiltonian Graphs, The Travelling Salesman Problem.	8
4	Directed Graphs: Definitions, In degree and Out degree, Tournaments, Traffic Flow.	6

Learning Resources- References

Sr. No.	References
1.	A First Look at Graph Theory, John Clark and Derek Allan Holton, Allied Publishers Ltd.(1991)
2.	Introduction to Graph Theory, R. J. Wilson, Pearson(2003)
3.	Graph Theory, Hararay, Narosa Publishers, New Delhi(1989)
4.	Graph Theory, Narsing Deo, Prentice Hall of India Pvt. Ltd.(1987)
5.	Basic Graph Theory, K. R. Parthsarathy, TataMcGraw Hill Publisher Co. Ltd.

MTS-361 - Mathematics Practical-8 Major-Practical		
	Number of Credits:02 No. of Hours:60	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Create examples of convergent sequences of functions, examples of matrices with given property.	1
CO2	Evaluate limits of sequences of functions, integrals. Calculate the caninocal form of matrices, determinant of matrices.	2
CO3	Analyse the nature of sequence of functions, properties of matrices from the eigenvalues and eigenvectors.	3
CO4	Apply tests for convergence, properties of integrable functions. Apply basic properties of matrices to get the canonical forms.	4
CO5	Understand the properties of sequences, series of functions from the definitions. Relate the properties of a matrix with the similar matrix.	5
CO6	Remember the tests for convergence, properties of matrices.	6

MTS-361 - Mathematics Practical-8
Major -Practical

Practical No.	**Title of Unit and Contents**
1	Pointwise and uniform limit of sequence of functions
2	Rank of matrix, Systems of linear equations
3	Criteria for uniform convergence
4	Determinants, Properties of determinants, Vandermonde matrix, least square approximation
5	Interchange of limit and integration, limit and derivative of sequence of functions
6	Eigenvalues, Eigenvectors, Calley Hamilton theorem
7	Convergence of series of functions, convergence of poser series
8	Alternating forms,
9	Testes for convergence of series of functions
10	Generalized eigenvectors
11	Elementary functions: Cosx, sinx, exponential, logarithm
12	Jordan canonical forms

MTS-362 - Mathematics Practical-9 Major-Practical		
	Number of Credits: 02 **No. of Hours:60**	
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's cognitive level**
CO1	Create examples of differential systems with the specific behaviour.	1
CO2	Evaluate limits numerical solution of the differential system, solution of a problems from finance, solution of optimization problem.	2
CO3	Analyse the nature of the differential system from the numerical expression, integrability of the function.	3
CO4	Apply techniques to study the qualitative behaviour of the system, solve the problems form the finance, to solve the network.	4
CO5	Understand the properties of differential system. Relate financial problem with the mathematical structure.	5
CO6	Remember the methods to solve the differenetial systems, financial problems, network problems, optimization problems.	6

MTS-362 - Mathematics Practical-9
(Major-Practical)

Practical No.	Title of Unit and Contents	
1.	Practical 1	Cryptography, Optimization techniques, Lebesgue Integration
2.	Practical 2	Cryptography, Optimization techniques, Lebesgue Integration
3.	Practical 3	Cryptography, Optimization techniques, Lebesgue Integration
4.	Practical 4	Cryptography, Optimization techniques, Lebesgue Integration
5.	Practical 5	Cryptography, Optimization techniques, Lebesgue Integration
6.	Practical 6	Cryptography, Optimization techniques, Lebesgue Integration
7.	Practical 7	Dynamical Systems, Financial Mathematics-II, Graph Theory
8.	Practical 8	Dynamical Systems, Financial Mathematics-II, Graph Theory
9.	Practical 9	Dynamical Systems, Financial Mathematics-II, Graph Theory
10.	Practical 10	Dynamical Systems, Financial Mathematics-II, Graph Theory
11.	Practical 11	Dynamical Systems, Financial Mathematics-II, Graph Theory
12.	Practical 12	Dynamical Systems, Financial Mathematics-II, Graph Theory

MTS-382 - Mathematics Practical-10 Major-Practical		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Create hierarchical clustering and DBSCAN, training and tuning a neural network for image classification, etc.	1
CO2	Evaluate k-Means and PCA on a dataset.	2
CO3	Analyse the neural networks, regularization techniques.	3
CO4	Apply CNNs in image classification and object detection.	4
CO5	Understand the loss function and gradient descent	5
CO6	Remember the techniques of supervised and unsupervised learning.	6

MTS-382 - Mathematics Practical-10
Major-Practical

Practical No.	Title of Unit and Contents
1	Unsupervised Learning – Clustering and Dimensionality Reduction • Introduction to unsupervised learning. • k-Means clustering and evaluation metrics (Silhouette score, Elbow method). • Hierarchical clustering and DBSCAN. • Principal Component Analysis (PCA) for dimensionality reduction. • Hands-on: Implementing k-Means and PCA on a dataset.
2	Introduction to Deep Learning and Neural Networks • Overview of deep learning and neural networks. • Neural network architecture: Neurons, layers, activation functions. • Forward and backward propagation. • Introduction to TensorFlow and Keras. • Hands-on: Building a simple neural network using Keras.
3	Training and Tuning Neural Networks • Understanding the loss function and gradient descent. • Optimizers: Stochastic Gradient Descent (SGD), Adam. • Regularization techniques: Dropout, Early stopping. • Hyperparameter tuning for neural networks. • Hands-on: Training and tuning a neural network for image classification.
4	Convolutional Neural Networks (CNNs) for Computer Vision • Introduction to CNNs: Convolutional layers, pooling layers, fully connected layers. • Applications of CNNs in image classification and object detection. • Transfer learning and pre-trained models. • Hands-on: Implementing a simple CNN for image classification (e.g., CIFAR-10 dataset).
5	Recurrent Neural Networks (RNNs) for Sequential Data • Introduction to RNNs and LSTMs (Long Short-Term Memory networks). • Applications of RNNs in Natural Language Processing (NLP) and time series forecasting.

	• Training RNNs with sequences. • Hands-on: Implementing an RNN for text classification or sentiment analysis.
6	Natural Language Processing (NLP) with Deep Learning • Text preprocessing and tokenization. • Word embeddings (Word2Vec, GloVe, FastText). • Building text classification models using deep learning. • Introduction to transformer models (e.g., BERT, GPT). • Hands-on: Text classification or sentiment analysis with deep learning.
7	AI Applications, Model Deployment, and Review • AI applications in the real world: Healthcare, Finance, Autonomous Vehicles, etc. • Introduction to model deployment: Flask/Django for API development. • Deploying ML models on cloud platforms (e.g., AWS, Google Cloud). • Final project presentations. • Review of key topics and future directions in AI and ML.

Learning Resources- References

Sr. No.	References
1.	Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow
2.	Sebastian Raschka and Vahid Mirjalili , Python Machine Learning (3rd Edition)
3.	François Chollet, Deep Learning with Python
4.	Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach
5.	Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning
6.	Christopher Bishop, Pattern Recognition and Machine Learning
7.	Foster Provost and Tom Fawcett , Data Science for Business
8.	Kaggle – A platform for data science competitions with numerous datasets and ML challenges. https://www.kaggle.com/
9.	TensorFlow Documentation – Official documentation and tutorials for learning TensorFlow. https://www.tensorflow.org/
10.	Scikit-learn Documentation – Official documentation for the Scikit-learn machine learning library. https://scikit-learn.org/
11.	Fast.ai – Free deep learning courses and tutorials for practitioners. https://www.fast.ai/

MTS-371 - Numerical Linear Algebra Minor-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define eigenvalues, eigenvectors, and their relationship to matrices. List the steps to compute quadratic forms and constrained optimization. State the principles of duality in optimization.	1
CO2	Describe how discrete dynamical systems evolve over time. Describe the use of constrained optimization in practical image processing tasks. Explain the geometric and simplex methods of linear programming.	2
CO3	Solve systems involving iterative estimates for eigenvalues. Use diagonalization methods to simplify matrix computations in image processing. Solve practical optimization problems using the simplex method.	3
CO4	Differentiate between real and complex eigenvalues and their implications on systems. Examine the interrelationships between primal and dual problems.Break down statistical datasets using SVD.	4
CO5	Evaluate solutions to differential equations with respect to eigenvalue applications. Assess the efficiency of simplex and geometric methods in solving linear programs. Compare the outcomes of different matrix decomposition methods.	5
CO6	Develop models of discrete dynamical systems for practical applications. Design optimized solutions for multichannel image processing challenges. Develop linear programming models for complex real-world optimization tasks.	6

MTS-371 - Numerical Linear Algebra
(Minor-Theory)

Unit No.	**Title of Unit and Contents**	**No. of hours**
1.	Dynamical Systems 1.1 Eigenvectors and Eigenvalues 1.2 The Characteristic Equation 1.3 Diagonalization 1.4 Eigenvectors and Linear Transformations 1.5 Complex Eigenvalues 1.6 Discrete Dynamical Systems 1.7 Applications to Differential Equations 1.8 Iterative Estimates for Eigenvalues 1.9 Applications to Markov Chains	6
2.	Multichannel Image Processing 2.1 Diagonalization of Symmetric Matrices 2.2 Quadratic Forms 2.3 Constrained Optimization 2.4 The Singular Value Decomposition 2.5 Applications to Image Processing and Statistics	10
3.	The Platonic Solids	10

	3.1 Affine Combinations 3.2 Affine Independence 3.3 Convex Combinations 3.4 Hyperplanes 3.5 Polytopes 3.6 Curves and Surfaces	
4.	The Berlin Airlift 4.1 Matrix Games 4.2 Linear Programming Geometric Method 4.3 Linear Programming Simplex Method 4.4 Duality	4

Learning Resources- References

Sr. No.	**References**
1	David C. Lay, Linear Algebra and Its Applications, Pearson Ch.5,Ch.7,Ch.8,Ch.9 and Ch.10
2	Steven J. Leon, Linea Algebra with Applications, Pearson
3	Sheldon Axler, Linear Algebra Done Right, Springer
4	S. Kumaresan, Linear Algebra –A Geometric Approach, PHI Learning Private Limited.
5	Titu Andreescu, Essential Linear Algebra with Applications-A Problem Solving Approach, Birkhauser

MTS-372 - Integral Transforms **Minor-Theory**		
	Number of Credits: 02 **No. of Hours:30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define key terms related to integral transforms such as "Laplace transform," "Fourier transform," "inverse transform," "region of convergence," and "initial and final value theorems."	1
CO2	Explain the concept of an integral transform and how it is used to convert a function from one domain (e.g., time) to another (e.g., frequency). Describe the conditions under which integral transforms are valid and how they are applied to solve differential and integral equations.	2
CO3	Apply the Laplace transform to solve ordinary differential equations (ODEs) and partial differential equations (PDEs), and interpret the results. Use the Fourier transform to analyze periodic functions, signal processing, and to solve problems involving heat conduction or wave propagation.	3
CO4	Analyze the properties of integral transforms, such as linearity, scaling, time shifting, and differentiation in the transformed domain, and apply them to simplify complex problems.	4
CO5	Evaluate the usefulness of different types of transforms (Laplace, Fourier) in solving specific types of problems in engineering, physics, and applied mathematics. Critically assess the accuracy and efficiency of using numerical methods for computing Laplace and Fourier transforms, particularly for non-standard or complex functions.	5
CO6	Design custom problems or scenarios where integral transforms can be used to solve real-world applications in areas such as electrical engineering, control theory, or communications. Formulate original theoretical results or extensions of existing theorems related to integral transforms, such as the application of multi-dimensional transforms or the study of generalized transforms.	6

MTS-372 - Integral Transforms
(Minor-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Revision of improper integrals. Laplace Transform: Definition of Laplace Transform and examples, Properties of Laplace Transform, Differentiation and Integration properties of Laplace Transform, Inverse Laplace Transforms and its examples, Convolution theorem and related examples.	8
2	Applications of Laplace Transform: Solution of Ordinary Differential Equations, Solution of Integral equations, Solution of Boundary Value Problems, Solution of system of differential equations.	5
3	Fourier Series: Periodic function, Fourier series formula for periodic functions, Fourier series for Odd and Even functions, Fourier series for Discontinuous function, half range Fourier series, half range Cosine series, half range Sine series.	5

4	Fourier Integral: Fourier Integral of a function formula and examples, Fourier Cosine integral, Fourier Sine integral, Complex Fourier integral, Evaluation of integration using Fourier integral.	8
5	Fourier Sine and Cosine Transforms: Fourier sine and cosine transformation and its examples, Properties of Fourier sine and cosine transform and its examples, Application of Fourier sine and cosine transform on Partial differential equation.	4

Learning Resources- References

Sr. No.	References
1.	Erwin Kreyszig, Advanced Engineering Mathematics (8th Edition), Willey Publication, 2010
2.	L. Debnath, Integral transforms and their Applications, CRC Press, New YorkLondon-Tokyo, 1995.
3.	Wiley & Barrett: Advanced Engineering Mathematics, Mc Graw Hill publication
4.	H. K.Dass, Advanced Engineering Mathematics, S. Chand Publication.
5.	Ravish R. Singh and Mukul Bhatt, Advanced Engineering Mathematics (4^{th} Edition), McGrawHill publication, 2018

MTS-373 - Operations Research (CS) Minor-Theory		
	Number of Credits: 02 No. of Hours:30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define basic terms and concepts in operations research such as "optimization," "linear programming," "simplex method," "transportation problem," "decision analysis," and "network flow."	1
CO2	Describe the key principles behind linear programming, such as the feasible region, objective function, and constraints. Explain the concepts of duality and sensitivity analysis in the context of linear programming.	2
CO3	Apply the simplex method to solve linear programming problems and interpret the results in real-world contexts. Solve transportation and assignment problems using appropriate algorithms.	3
CO4	Analyze optimization problems and formulate them into mathematical models, identifying the appropriate objective function and constraints. Evaluate different optimization techniques (e.g., linear vs. nonlinear programming, simplex vs. interior-point methods) to determine their effectiveness in solving specific real-world problems.	4
CO5	Evaluate the optimality of solutions obtained from linear programming models and assess the impact of changes in parameters through sensitivity analysis. Critically evaluate the applicability of operations research models	5
CO6	Develop optimisation models for complex business or engineering problems, including formulating the objective function, constraints, and decision variables.	6

MTS-373 - Operations Research (CS)
(Minor-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Modelling with Linear Programming:** 1.1 Two-Variable LP Model 1.2 Graphical LP Solution 1.3 Linear Programming Applications	**4**
2	**Simplex Method** 2.1 Standard form, Canonical form, IBFS 2.2 Simplex Method 2.3 Big M Method 2.4 Introduction to Dual LPP	**10**
3	**Transportation Model** 3.1 Introduction 3.2 Finding IBFS by using various methods 3.3 Optimal solution by MODI method	**7**
4	**Assignment Model** 4.1 Introduction 4.2 Hungarian Algorithm	**4**

5	**Game Theory** 5.1 Two Person Zero Sum Game 5.2 Algebraic Method 5.3 Dominance Principle 5.4 Graphical Method 5.5 Representation of Game as an LPP.	**5**

Learning Resources- References

Sr. No.	References
1.	S.D. Sharma. Operations Research, Kedar Nath Ram Nath & Company, 1992
2.	Taha, H. (2017). Operations Research: An Introduction (10th ed.). London: Pearson.

	MTS-395 – On Job Training (OJT) **Major** **Theory/Practical**	
	Number of Credits: 04 **No. of Hours: 120**	

Guidelines for Field Project

Here is a set of guidelines for undergraduate field projects in science subjects like Botany, Chemistry, Geology, Electronics, Mathematics, Physics, Statistics, and Zoology. These guidelines align with the requirement that each teacher supervises a batch of 15 students.

Field Project Guidelines for Undergraduate Students

1. Objective

The field project aims to:

- Provide hands-on experience in the application of theoretical knowledge.
- Enhance skills in data collection, analysis, and scientific inquiry.
- Promote teamwork and independent research capabilities.

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2. Structure and Framework

Batch Size

- Each batch will consist of a maximum of **15 students**, supervised by one teacher.
- Students will work collaboratively but must submit individual reports.
- Each group may comprise of 3/ 4 students.

Duration

- Projects should be spread over a semester or at least a period of 12 weeks. (total of 60 hours minimum)
- Weekly progress reviews should be conducted by the supervisor.

3. Suggested Topics

- Topics should align with the subject's curriculum and include practical, real-world applications.
  Illustrative Examples:
  - **Mathematics**: Data modelling, statistical analysis, or optimization problems.

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4. Roles and Responsibilities

Students

- Actively participate in all phases of the project.
- Collect, analyse, and interpret data using appropriate methodologies.
- Maintain proper records and submit a detailed report at the end of the project.

Supervisors

- Guide students in topic selection, planning, and execution.
- Ensure ethical and safety standards are met during fieldwork.
- Review weekly progress and provide constructive feedback.
- Evaluate reports and presentations.

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5. Illustrative Evaluation Criteria

- **Topic Understanding (20%)**: Clarity on the purpose and scope of the project.
- **Methodology (20%)**: Appropriateness and rigor in data collection and analysis.
- **Execution (20%)**: Timeliness, teamwork, and innovation.
- **Report (20%)**: Presentation, accuracy, and depth of analysis.
- **Presentation (20%)**: Clarity, confidence, and ability to answer questions.

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6. Safety and Ethical Considerations

- Adhere to all safety protocols for field and laboratory work.
- Obtain necessary permissions for field studies (e.g., working in protected areas).
- Ensure ethical treatment of living organisms, if applicable.
- Avoid plagiarism in reporting.

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7. Logistics and Support

- Departments should provide guidance for the requirements of tools, equipment.

8. Expected Deliverables

- **Proposal**: Outline of project goals, methodology, and expected outcomes.
- **Weekly Progress Reports**: Brief updates shared during supervisory meetings.
- **Final Report**: Comprehensive documentation of the project.
- **Presentation**: Oral presentation supported by slides, videos, or demonstrations.