



Deccan Education Society's
Fergusson College (Autonomous), Pune-4
Department of Mathematics



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

Syllabus
for

T. Y. B. Sc. (Mathematics)
[NEP 2.0]
(B.Sc. Semester-V and VI)

**With Effect From
2026-2027**

Syllabi NEP 2.0 Implemented from Academic Year 2026-27**T. Y. B. Sc. Semester : V and 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. Mathematics (NEP 2.0) Course Structure

T. Y. B. Sc. NEP 2.0						
Semester	Paper	Paper Code	Title	Type	Credits	Exam Type
V	Major	MTS-3005	Real Analysis-I	Theory	2	CE+ESE
		MTS-3015	Group Theory	Theory	2	CE+ESE
		MTS-3025	Metric Spaces	Theory	2	CE+ESE
	Major Elective 1	MTS-3045	Number Theory	Theory	2	CE+ESE
		MTS-3055	Financial Mathematics-I	Theory	2	CE+ESE
		MTS-3065	Combinatorics	Theory	2	CE+ESE
	Major Elective 2	MTS-3075	Dynamical Systems	Theory	2	CE+ESE
		MTS-3085	Operations Research	Theory	2	CE+ESE
		MTS-3095	Integral Transforms	Theory	2	CE+ESE
	Major Practical	MTS-3115	Mathematics Practical-7 (Based On Mts3005 & Mts3015)	Practical	2	CE+ESE
		MTS-3125	Mathematics Practical-8(Based On Elective 1 And Elective 2)	Practical	2	CE+ESE
		MTS-3135	Mathematics Practical-9 (Problems In Metric Spaces And Applied Linear Algebra)	Practical	2	CE+ESE
	VSC	MTS-3305	AI And ML With Python	Practical	2	CE
	Minor	MTS-3215	Special Functions and Integral Transforms			CE+ESE
		MTS-3225	Numerical Linear Algebra	Theory	2	CE+ESE
		MTS-3235	Optimization Techniques (CS)	Theory	2	CE+ESE
	Field Project	MTS-3455	Field Project	Theory/ Practical	4	CE
VI	Major	MTS-3006	Real Analysis-II	Theory	2	CE+ESE
		MTS-3016	Ring Theory	Theory	2	CE+ESE
		MTS-3026	Complex Analysis	Theory	2	CE+ESE
	Major Elective 1	MTS-3046	Cryptography	Theory	2	CE+ESE
		MTS-3056	Financial Mathematics-II	Theory	2	CE+ESE
		MTS-3066	Lebesgue Integration	Theory	2	CE+ESE
	Major Elective 2	MTS-3076	Differential Geometry	Theory	2	CE+ESE
		MTS-3086	Optimization Techniques	Theory	2	CE+ESE
		MTS-3096	Graph Theory	Theory	2	CE+ESE
	Major Practical	MTS-3116	Mathematics Practical-8 (Based On MTS 3006 & Mts3016)	Practical	2	CE+ESE
		MTS-3126	Mathematics Practical-9(Based On Elective 1 And Elective 2)	Practical	2	CE+ESE
		MTS-3136	Mathematics Practical-10 (Problems In Analysis And Mathematics For Machine Learning)	Practical	2	CE+ESE
	VSC	MTS-3816	Applied Machine Learning And Deep Learning	Practical	2	CE
	OJT	MTS-3956	On Job Training	Theory/ Practical	4	CE

SEMESTER V		
	MTS-3005 - 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-3005 - Real Analysis-I
(Major- Theory)**

Unit No.	Title of Unit and Contents	No. of hours
1	Real Numbers: Revision of Algebraic Structure of $\mathbb{R}$, 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, Birkhauser, (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-3015 – Group Theory 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-3015 - Group Theory
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Groups : Definition and examples, Abelian group, finite group, infinite group. Properties of groups. Order of an element- definition, examples, properties such as Uniqueness of identity, inverse etc. Examples of groups	4
2	Subgroups : Definition, necessary and sufficient conditions, examples on finding subgroups of finite groups, union and intersection of subgroups. Cosets: definition and properties, Lagrange's theorem (with proof) and corollaries. HK is a subgroup of G if and only if HK=KH. Order of HK, Subgroup generated by an element of the group.	6
3	Cyclic groups : Definition, Examples of cyclic groups such as Z and the group of the n-th roots of unity and properties of cyclic groups	4
4	Normal Subgroups : Definition. Properties with examples, Quotient groups and examples	8
5	Homomorphism and isomorphism : Homomorphism and Isomorphism: Definition, examples, establish isomorphism of two finite groups). Fundamental Theorem of homomorphisms of groups. The group $\mathbb{Z}/n\mathbb{Z}$ of residue classes modulo n. Statement of Cauchy's theorem and Sylow's theorem for Abelian Groups, Results such as inverse image under a homomorphism of a subgroup and of a normal subgroup. Characterization of cyclic groups (as being isomorphic to $\mathbb{Z}$ or $\mathbb{Z}/n\mathbb{Z}$ for some n in $\mathbb{N}$. Automorphisms, Cayley's Theorem for finite groups	8
6	Permutation Groups : Definition of and detail discussion of the group Cycles and transpositions, even and odd permutations. Order of permutation. Discussion of the group including converse of Lagrange's theorem does not hold	6

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-3025 - 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-3025 - 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.	R. R. Goldberg, Methods of Real Analysis, Oxford and IBH publishing C. Pvt. Ltd.
2.	Wilson S Sutherland, Introduction to Metric and Topological spaces, Oxford Press
3.	S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House.
4.	Dhananjay Gopal, Aniruddha Deshmukh and Abhay Randive, Introduction to Metric Spaces, CRC Press
5.	Robert Magnus, Metric Spaces-a Companion to Analysis, Springer

	MTS-3045 - 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-3045 - Number Theory
(Major-Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Revision of Divisibility Divisibility in Integers, Division Algorithm, GCD, LCM, Fundamental Theorem of Arithmetic, Infinitude of Primes, Mersenne Numbers and Fermat Numbers	3
2	Primitive roots Order of an integer modulo n, definition of Primitive Roots, existence of primitive roots, finding primitive roots, number and generation of primitive roots, indices and applications.	5
3	Congruences Definition, Properties of congruences, Residue classes, complete and reduced residue system, their properties, Fermat's theorem. Euler's theorem, Wilson's 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
4	Diophantine Equations $ax + by = c, x^2 + y^2 = z^2$	2
5	Greatest integer function Arithmetic functions Euler's function, the number of divisors $d(n)$, sum of divisors $\sigma(n)$; $\Omega(n)$, Multiplicative functions, Mobius function, Mobius inversion formula	6
6	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, 5 th Edition, John Wiley and Sons.
2.	David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991

	MTS-3055 - 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-3055 - 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-3065 - 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-3065 - 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-3075 - 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-3075 - 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	6
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	5
3	Phase Plane Analysis 1.1 Phase Plane Analysis, Phase portrait 1.2 Local Stability of two dimensional systems 1.3 Linearization and its applications 1.4 Nonlinear Simple pendulum, Linear Oscillators	8

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 4.5 Linear stability, Cobweb diagram 4.6 Periodic points, periodic cycles, stability of periodic points and periodic cycles	9
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Learning Resources- References

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

	MTS-3085 - 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-3085 - 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-3095 - 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-3095 - 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-3115 - Mathematics Practical-7 (Based On Mts3005 &Mts3015)		
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-3115 - Mathematics Practical-7
Major-Practical (Based on MTS-3005 & MTS-3015)

Unit No.	Title of Unit and Contents
1	Properties of real numbers and LUB axiom
2	Examples of groups
3	Countability, uncountable sets
4	Convergent sequences, monotone sequences
5	Subgroup and normal subgroup
6	Subsequences and Cauchy sequences
7	Quotient group, isomorphic groups
8	Convergence of series and examples
9	Cyclic groups and their properties
10	Tests for convergence of series
11	Simple group, Sylow-p groups
12	Riemann integral of functions, Properties of integrable functions, mean value theorems

	MTS-3125 - 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 numbers with specific 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-3125 - Mathematics Practical-8
(Major-Practical) (Based on Elective 1 and Elective 2)**

Unit No.	Title of Unit and Contents	
1	Practical 1	Based on Elective 1
2	Practical 2	
3	Practical 3	
4	Practical 4	
5	Practical 5	
6	Practical 6	
7	Practical 7	Based on Elective 2
8	Practical 8	
9	Practical 9	
10	Practical 10	
11	Practical 11	
12	Practical 12	

	MTS-3135 - 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	Recall and explain the fundamental concepts of metric spaces, including open and closed sets, convergence, completeness, compactness, and continuity	1
CO2	Apply the concepts and theorems of metric spaces to solve theoretical and problem-oriented exercises involving sequences, continuity, and compactness.	2
CO3	Analyze the structure and properties of metric spaces by distinguishing between complete, compact, connected, and separable spaces through examples and counterexamples.	3
CO4	Use numerical methods for solving systems of linear equations, interpolation problems, and eigenvalue problems arising in applied mathematics.	4
CO5	Analyze and compare different numerical linear algebra techniques with respect to accuracy, convergence, computational efficiency, and stability.	5
CO6	Construct and implement algorithms related to numerical linear algebra and interpret the obtained numerical results critically.	6

**MTS-3135 - Mathematics Practical-9
(Major-Practical) (Problems from Metric Spaces and Computational Linear Algebra)**

Unit No.	Title of Unit and Contents	
1	Practical 1	Examples of metrics, Metric spaces
2	Practical 2	Open Ball, Opens set, closed set
3	Practical 3	Convergent sequences in metric spaces, Continuous functions on Metric spaces
4	Practical 4	Connected spaces and Applications
5	Practical 5	Compact spaces and applications
6	Practical 6	Complete spaces and applications
7	Practical 7	Floating Point Arithmetic and Numerical Errors: Floating point representation, Round-off and truncation errors, Machine epsilon, Stability and conditioning
8	Practical 8	Conditioning of Linear Systems and Matrix Norms: Vector and matrix norms, Condition number, Sensitivity analysis, III-conditioned systems
9	Practical 9	Numerical Solution of Linear Systems: Gaussian elimination, Partial and complete pivoting, LU factorisation, Computational complexity
10	Practical 10	QR Decomposition and Orthogonalisation Methods: Classical Gram–Schmidt, Modified Gram–Schmidt, Householder transformations, Givens rotations
11	Practical 11	Least Squares Problems and Linear Regression: Overdetermined systems, Normal equations, QR-based least squares, Polynomial curve fitting
12	Practical 12	Eigenvalue Problems and Power Method: Eigenvalue algorithms, Power method, Rayleigh quotient, Applications

	MTS-3305 - 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-3305 - 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. - The three learning paradigms: Supervised, Unsupervised, and Reinforcement Learning with concrete examples - Key concepts: training/testing, overfitting/underfitting, bias-variance tradeoff (preview) - Neural network fundamentals: neurons, layers, activation functions (sigmoid, ReLU), - Ethics and responsible AI: algorithmic bias, fairness, data privacy (brief but essential) Python for data science: NumPy, Panda, Matplotlib, Seaborn - Hands-on: Environment setup(Jupyter/Anaconda) and exploratory data analysis on a dataset	6
2	Data Preprocessing and Feature Engineering - Data types and structures for ML, exploratory data analysis - Data cleaning: handling missing values, outlier detection, encoding categorical variables - Feature scaling: normalization vs standardization (mathematical foundations)	5

	- Feature selection (correlation, mutual information) and extraction(brief PCA preview) - Hands-on: Complete preprocessing pipeline on a messy real world dataset	
3	Supervised Learning – Linear Regression - Regression vs classification overview, mathematical problem framing - Simple linear regression:equation, matrix formulation (normal equation: $\theta = (X^T X)^{-1} X^T y$), geometric interpretation - Gradient descent: intuition, learning rate, convergence, mathematical derivation of partial derivatives - Model evaluation: MSE, RMSE, MAE, R-squared - mathematical meaning and interpretation - Multiple regression, feature selection, multicollinearity - Train-test split methodology, validation sets, data leakage - Hands-on: Building and evaluating regression models with Scikit-learn	6
4	Supervised Learning – Classification Algorithms - Classification problem formulation, decision boundaries - Logistic regression: sigmoid function, log-odds, decision boundary, mathematical derivation for math students - k-Nearest Neighbors: distance metrics, choosing k, curse of dimensionality - Decision Trees: entropy, information gain, Gini impurity, tree pruning - Support Vector Machines: maximum margin, kernel trick (mathematical intuition) - Brief introduction to ensemble methods: RandomForest as extension of decision trees - Hands-on: Building and comparing multiple classifiers on a dataset	7
5	Model Evaluation and Hyperparameter Tuning - Comprehensive model evaluation: accuracy, precision, recall, F1, AUC-ROC, confusion matrix (consolidated from Unit 4) - Cross-validation: k-fold, stratified k-fold, leave-one-out - Overfitting vs underfitting, bias- variance tradeoff (mathematical treatment) - Regularization: L1 (Lasso), L2 (Ridge), ElasticNet - mathematical foundations (constraint geometry) - Hyperparameter tuning: Grid Search, Random Search - End-to-end ML pipeline design: integrating preprocessing, feature engineering, model selection, evaluation, and brief discussion of model deployment via Flask APIs - Hands-on: Complete pipeline from raw data to evaluated model	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-3215 - 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-3215 - 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-3225 - Numerical Linear Algebra 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	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 diagonalise 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-3225 - Numerical Linear Algebra
(Minor - Theory)**

Unit No.	Title of Unit and Content	No. of Hours
1	Floating Point Arithmetic and Numerical Errors: - Floating point representation - Round-off and truncation errors - Machine epsilon - Stability and conditioning	3
2	Conditioning of Linear Systems and Matrix Norms - Vector and matrix norms - Condition number - Sensitivity analysis - Ill-conditioned systems	3
3	Numerical Solution of Linear Systems - Gaussian elimination - Partial and complete pivoting - LU factorisation - Computational complexity	3

4	QR Decomposition and Orthogonalisation Methods • Classical Gram–Schmidt • Modified Gram–Schmidt • Householder transformations • Givens rotations	3
5	Least Squares Problems and Linear Regression • Overdetermined systems • Normal equations • QR-based least squares • Polynomial curve fitting	2
6	Eigenvalue Problems and Power Method • Eigenvalue algorithms • Power method • Rayleigh quotient • Applications	2
7	QR Algorithm for Eigenvalue Computation • Hessenberg reduction • QR iteration • Convergence analysis	2
8	Singular Value Decomposition (SVD) • Computation of SVD • Low-rank approximation • Pseudoinverse • Applications	3
9	Principal Component Analysis (PCA) • Covariance matrix • PCA via eigen-decomposition • SVD-based PCA • Dimensionality reduction	3
10	Optimization and Gradient-Based Algorithms • Convex optimization • Gradient descent • Stochastic gradient descent • Convergence analysis	3
11	Linear Models for Machine Learning • Linear regression • Ridge regression • Logistic regression • Matrix formulation	3
12	Mini Projects and Applications • Image compression using SVD • Face recognition using PCA • Handwritten digit recognition • Recommendation systems	

Sr. No.	References
1.	David Lay, Steven Lay, Judi McDonald, Linear Algebra and Its Applications, Pearson
2.	Steven Leon, Linear Algebra with Applications, Pearson
3.	G. H. Golub and C. F. Van Loan, <i>Matrix Computations</i> , 4th Edition, Johns Hopkins University Press, 2013.
4.	L. N. Trefethen and D. Bau, <i>Numerical Linear Algebra</i> , SIAM, 1997.
5.	Gilbert Strang, <i>Linear Algebra and Learning from Data</i> , Wellesley–Cambridge Press, 2019.

	MTS-3235 Optimization Techniques	
	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	Formulate real-world problems into mathematical Linear Programming Models (LPP) by identifying decision variables, constraints, and objective functions.	1
CO2	Apply the Simplex Method to solve multi-variable optimization problems that cannot be solved graphically.	2
CO3	Analyze and solve multi-source, multi-destination distribution problems by applying transportation methods to minimize total logistical costs while satisfying supply and demand constraints.	3
CO4	Implement the Hungarian Method to solve optimization problems involving the one-to-one allocation of distinct resources to specific tasks, ensuring the minimization of total time, cost, or machine idle-time.	4
CO5	Evaluate optimal strategies in competitive scenarios using Game Theory (Saddle point, Dominance, Graphical methods) and make informed decisions under conditions of uncertainty.	5
CO6	Analyze complex projects using PERT and CPM techniques to identify critical tasks, calculate project duration, and optimize resource "crashing" to meet deadlines.	6

MTS-3235 – Optimization Techniques
(Minor - Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	Modeling with Linear Programming: 1.1 Two-Variable LP Model 1.2 Graphical LP Solution 1.3 Linear Programming Applications	3
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	9
3	Transportation and Assignment Model 3.1 Introduction to Transportation model 3.2 Finding IBFS of transportation model by using various methods. 3.3 Optimal solution of transportation model by MODI method. 3.4 Introduction to Assignment model 3.5 Hungarian method to solve Assignment model.	8

4	Game Theory 4.1 Two Person Zero Sum Game 4.2 Algebraic Method 4.3 Dominance Principle 4.4 Graphical Method 4.5 Representation of Game as an LPP.	5
5	CPM and PERT 5.1 Network representation 5.2 Network path computation 5.3 Construction of time schedule 5.4 Linear programming formulation of CPM 5.5 PERT networks	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.
3.	P Shankara Iyer. Operations Research, McGraw Hill Companies, 2009.

	MTS-3455 – Field Project (FP) Major-Theory/Practical	
	Number of Credits: 02 No. of Hours: 60	

SEMESTER VI		
	MTS-3006 - 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-3006 - 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, Weierstrass 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-3016 – Ring Theory 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 and explain fundamental concepts of rings, including basic properties, examples, polynomial rings, matrix rings, ideals, and ring homomorphisms.	1
CO2	Apply the concepts of quotient rings, rings of fractions, and the Chinese Remainder Theorem to solve algebraic problems and simplify computations in rings.	2
CO3	Analyze the structure and properties of ideals in rings and investigate homomorphic images to determine isomorphism between algebraic structures.	3
CO4	Distinguish between Euclidean Domains, Principal Ideal Domains (PID), and Unique Factorisation Domains (UFD) , and evaluate their interrelationships through examples and proofs.	4
CO5	Examine polynomial rings over fields, determine factorization properties, and apply irreducibility tests such as criteria for degree 2 and 3 polynomials.	5
CO6	Formulate and prove results related to rings, domains, and polynomial structures, and solve advanced problems involving factorization and ring theory concepts.	6

**MTS-3016- Ring Theory
(Major- Theory)**

Unit No.	Title of Unit and Contents	No. of hours
1	Introduction to Rings: Basic Definitions and Examples, Polynomial Rings, Matrix Rings, Ring Homomorphisms and Quotient Rings, Properties of Ideals, Rings of Fractions, The Chinese Remainder Theorem, Finite fields	10
2	Euclidean Domains, Principal Ideal Domains and Unique Factorisation Domains: Euclidean Domains, Principal Ideal Domains, Unique Factorisation Domains.	10
3	Polynomial Rings: Definitions and Basic Properties, Polynomial Rings over Fields I, Polynomial Rings that are Unique Factorisation Domains, Irreducibility Criteria for polynomials of degree 2 and 3, Eisenstein's Irreducibility Criteria	10

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-3026 - 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-3026 - 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-3046 - 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-3046 - 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 1.2.1. Cryptanalysis of Substitution cipher 1.2.2. Cryptanalysis of Affine Cipher	9
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 Cryptograph 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-3056 - 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-3056 - 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, pricing American options, factor influencing option premiums, options on assets with dividends,	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, dynamic hedging, risk-neutral valuation, 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-3066 - 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.	2
CO3	Apply the definitions of Lebesgue integrability to determine whether a function is Lebesgue integrable and calculate the Lebesgue integral for simple 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.	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.	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-3066 - 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, 2 nd Edition, Prentice Hall of India, 1994.
4.	R. G. Bartle and D. R. Scherbert, Introduction to Real Analysis, 4 th Edition, John Wiley, 2012
5.	D. Somasundaram and B. Choudhari, A first course in Mathematical Analysis, Narosa Publishing House, 1997.

	MTS-3076 - 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-3076 - 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-3086 - 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-3086 - 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-3096 - 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.	1
CO2	Explain key graph properties such as degree of vertices, adjacency, incidence, and graph isomorphism.	2
CO3	Apply graph traversal algorithms (DFS, BFS) to solve problems such as finding connected components, checking for cycles, and searching for specific nodes.	3
CO4	Analyze the properties and structure of graphs, such as planarity, connectivity, and the presence of Eulerian and Hamiltonian paths or cycles.	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-3096 - 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	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	Introduction to Matchings (Definitions, examples and theorems without proof), Introduction to Planar Graphs (Definitions, examples and theorems without proof), Introduction to Colouring Graphs (Definitions, examples and theorems without proof), Introduction to Directed Graphs (Definitions, examples and theorems without proof)	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-3116 - Mathematics Practical-10 (Based on MTS-3006 & MTS-3016) 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 canonical 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-3116 - Mathematics Practical-10
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	Applications of DUIS
7	Examples of rings, subrings
8	Ideals, quotient rings
9	Ring homomorphism and applications
10	Principal ideal domain
11	Euclidean domain
12	Unique Factorization domain

MTS-3126 - Mathematics Practical-11 (Based on Elective 1 and Elective 2) 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-3126 - Mathematics Practical-11
(Major-Practical)

Practical No.	Title of Unit and Contents	
1.	Practical 1	BASED ON ELECTIVE 1
2.	Practical 2	
3.	Practical 3	
4.	Practical 4	
5.	Practical 5	
6.	Practical 6	
7.	Practical 7	BASED ON ELECTIVE 2
8.	Practical 8	
9.	Practical 9	
10.	Practical 10	
11.	Practical 11	
12.	Practical 12	

	MTS-3136 - Mathematics Practical-12 12 (Problems In Analysis And Mathematics) 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	Recall and explain the fundamental concepts of complex analysis, including analytic functions, Cauchy–Riemann equations, complex integration, and series expansions	1
CO2	Apply techniques of complex analysis to solve problems involving contour integration, residues, conformal mappings, and analytic functions.	2
CO3	Analyze the behavior of complex functions and classify singularities, zeros, poles, and residues using appropriate mathematical methods.	3
CO4	Use numerical linear algebra methods to solve systems of linear equations, eigenvalue problems, and matrix factorization problems.	4
CO5	Evaluate the effectiveness of numerical algorithms for solving practical computational problems arising in mathematics and applied sciences.	5
CO6	Construct and implement mathematical and numerical algorithms for complex analysis and linear algebra problems using logical and computational techniques.	6

**MTS-3136 - Mathematics Practical-12
Major-Practical**

Practical No.	Title of Unit and Contents
1	Complex numbers and
2	Analytic functions
3	Taylor and Maclaurin series
4	Residue and poles
5	Singularities
6	Applications of residue and poles
7	QR Algorithm for Eigenvalue Computation • Hessenberg reduction • QR iteration • Convergence analysis
8	Singular Value Decomposition (SVD) • Computation of SVD • Low-rank approximation • Pseudoinverse • Applications
9	Principal Component Analysis (PCA) • Covariance matrix • PCA via eigen-decomposition • SVD-based PCA • Dimensionality reduction

10	Optimization and Gradient-Based Algorithms • Convex optimization • Gradient descent • Stochastic gradient descent • Convergence analysis
11	Linear Models for Machine Learning • Linear regression • Ridge regression • Logistic regression • Matrix formulation
12	Mini Projects and Applications • Image compression using SVD • Face recognition using PCA • Handwritten digit recognition • Recommendation systems

Learning Resources- References

Sr. No.	References
1	David Lay, Steven Lay, Judi McDonald, Linear Algebra and Its Applications, Pearson
2	Steven Leon, Linear Algebra with Applications, Pearson
3	G. H. Golub and C. F. Van Loan, <i>Matrix Computations</i> , 4th Edition, Johns Hopkins University Press, 2013.
4	L. N. Trefethen and D. Bau, <i>Numerical Linear Algebra</i> , SIAM, 1997.
5	Gilbert Strang, <i>Linear Algebra and Learning from Data</i> , Wellesley–Cambridge Press, 2019.

	MTS-3816 – VSC- Applied Machine Learning and Deep Learning 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	Explain fundamental concepts of machine learning, including clustering, dimensionality reduction, neural networks, and deep learning architectures.	1
CO2	Apply unsupervised learning techniques and basic neural network models to analyze datasets and extract meaningful patterns.	2
CO3	Implement data preprocessing, cleaning pipelines, and feature engineering techniques for real-world datasets.	3
CO4	Analyze model performance using appropriate evaluation metrics and interpret results in terms of bias-variance tradeoff and generalization ability.	4
CO5	Design and build end-to-end machine learning solutions, including predictive systems and neural network-based applications.	5
CO6	Develop deployable machine learning applications such as web services and automated report generation systems.	6

**MTS-3816 – VSC- Applied Machine Learning and Deep Learning
Major-Practical**

Practical No.	Title of Unit and Contents
1	Practical 1 Unsupervised Learning - Clustering and Dimensionality Reduction
2	Practical 2: Introduction to Deep Learning and Neural Networks
3	Mini-Project 1: Mathematical Dataset Explorer
4	Mini-Project 2: Data Cleaning Pipeline for Real-World Messy Data
5	Mini-Project 3: House Price Predictor - From Scratch and with Scikit-learn
6	Mini-Project 4: Disease Classifier - Multi-Algorithm Comparison
7	Mini-Project 5: Customer Segmentation with Clustering
8	Mini-Project 6: Handwritten Digit Recognizer with Neural Networks
9	Mini-Project 7: Feature Engineering Challenge
10	Mini-Project 8: Bias-Variance Tradeoff Visualizer
11	Mini-Project 9: ML Model as a Web Service
12	Mini-Project 10: ML Algorithms from Scratch - Mathematical Foundations to Code
13	Capstone 1: End-to-End Predictive Analytics Web Application
14	Capstone 2: Automated ML Report Generator
15	Case Study 1: Netflix Recommendation System - The \$1 Million Prize
16	Case Study 2: Predicting Hospital Readmissions - When ML Meets Healthcare
17	Case Study 3: Amazon's Hiring Algorithm Bias - When ML Goes Wrong
18	Case Study 4: Zillow's Zestimate - A \$500 Million Regression Failure
19	Case Study 5: COVID-19 Forecasting Models - The Limits of ML
20	Case Study 6: Spotify's Discover Weekly - Clustering and Personalization at Scale

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

	MTS-3956 – 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.

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.

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.

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.

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.

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.