M.Sc.,

MATHEMATICS

Syllabus

From the Academic Year
2023-2024

Madurai Kamaraj University

Madurai – 625 021

<div align="center">**NEW INITIATIVE IN MODERNISING**</div>

<div align="center">**POST - GRADUATE PROGRAMME IN MATHEMATICS**</div>

1. Preamble

In pursuit of the Higher Education Department Policy Note 2022-23 Demand 20, Section 1.4, Tamil Nādu State Council for Higher Education took initiative to revamp the curriculum. On 27 July 2022, a meeting was convened by the Member-Secretary Dr. S. Krishnasamy enlightening the need of the hour to restructure the curriculum of both Under-graduate and Post-graduate programmes based on the speeches at the Tamil Nādu Legislative Assembly Budget meeting by the Honourable Higher Education Minister Dr K. Ponmudy and Honourable Finance Minister   Dr. P. Thiagarajan. At present there are three different modes of imparting education in most of the educational institutions throughout the globe. Outcome Based Education, Problem Based Education, and Project Based Education.

Now our Honourable Higher Education Minister announced Industry Aligned Education. During discussion, Member Secretary announced the importance of question papers and evaluation as envisaged by the Honourable Chief Secretary to Government Dr, V. IraiAnbu. This is very well imbedded in Revised Bloom's Taxonomy.

Taxonomy forms three learning domains: the cognitive (knowledge), affective(attitude), and psychomotor (skill). This classification enables to estimate the learning capabilities of students. Briefly, it is aimed to restructure the curriculum as student-oriented, skill-based, and institution-industry-interaction curriculum with the various courses under

"Outcome Based Education with Problem Based Courses, Project Based Courses, and Industry Aligned Programmes" having revised Bloom's Taxonomy for evaluating students skills.

Three domains:

(i) Cognitive Domain

    (Lower levels: K1: Remembering ; K2: Understanding ; K3: Applying;

    Higher levels: K4: Analysing ; K5: Evaluating; K6: Creating)

(ii) Affective Domain

(iii) Psychomotor Domain

Post Graduate Programme

Programme Outcomes:

PO1: Disciplinary Knowledge: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of an Post graduate programme of study.

PO2: Critical Thinking: Capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.

PO3: Problem Solving: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge; and apply one's earning to real life situations.

PO4: Analytical & Scientific Reasoning: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyze and synthesize data from a variety of sources; draw valid conclusions and support them with evidence and examples and addressing opposing viewpoints.

PO5: Research related skills: Ability to analyse, interpret and draw conclusions from quantitative / qualitative data; and critically evaluate ideas, evidence, and experiences from an open minded and reasoned research perspective; Sense of inquiry and capability for asking relevant questions / problem arising / synthesizing / articulating / ability to recognize cause and effect relationships / define problems. Formulate hypothesis, Test / analyse / Interpret the results and derive conclusion,   formulation and designing mathematical models

PO6: Self-directed & Lifelong Learning: Ability to work independently, identify and manage a project. Ability to acquire knowledge and skills, including "learning how to learn", through

self-placed and self-directed learning aimed at personal development, meeting economic, social and cultural objectives.

M.Sc Mathematics

Programme Specific Outcomes:

PSO1: Acquire good knowledge and understanding, to solve specific theoretical & applied problems in different area of mathematics & statistics.

PSO2: Understand, formulate, develop mathematical arguments, logically and use quantitative models to address issues arising in social sciences, business and other context /fields.

PSO3: To prepare the students who will demonstrate respectful engagement with other's ideas, behaviors, beliefs and apply diverse frames of references to decisions and actions.

To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.

To encourage practices grounded in research that comply with employment laws, leading the organization towards growth and development.

Mapping of Course Learning Outcomes (CLOs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)can be carried out accordingly, assigning the appropriate level in the grids:

	POs							PSOs		
	1	2	3	4	5	6	…	1	2	…
CLO1										
CLO2										
CLO3										
CLO4										
CLO5										

Course Learning Outcome: ALGEBRAIC STURUCTURES

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Recall basic counting principle, define class equations to solve problems, explain Sylow's theorems and apply the theorem to find number of Sylow subgroups

CLO 2: Define Solvable groups, define direct products, examine the properties of finite abelian groups, define modules

CLO 3: Define similar Transformations, define invariant subspace, explore the properties of triangular matrix, to find the index of nilpotence to decompose a space into invariant subspaces, to find invariants of linear transformation, to explore the properties of nilpotent transformation relating nilpotence with invariants.

CLO 4: Define Jordan, canonical form, Jordan blocks, define rational canonical form, define companion matrix of polynomial, find the elementary devices of transformation, apply the concepts to find characteristic polynomial of linear transformation.

CLO 5: Define trace, define transpose of a matrix, explain the properties of trace and transpose, to find trace, to find transpose of matrix, to prove Jacobson lemma using the triangular form, define symmetric matrix, skew symmetric matrix, adjoint, to define Hermitian, unitary, normal transformations and to verify whether the transformation in Hermitian, unitary and normal

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: REAL ANALYSIS I

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Analyze and evaluate functions of bounded variation and Rectifiable Curves.
CLO2: Describe the concept of Riemann-Stieltjes integral and its properties.
CLO3: Demonstrate the concept of step function, upper function, Lebesgue function and their integrals.
CLO4: Construct various mathematical proofs using the properties of Lebesgue integrals and establish the Levi monotone convergence theorem.
CLO5: Formulate the concept and properties of inner products, norms and measurable functions.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: ORDINARY DIFFERENTIAL EQUATIONS

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Establish the qualitative behavior of solutions of systems of differential equations

CLO2: Recognize the physical phenomena modeled by differential equations and dynamical systems.

CLO3: Analyze solutions using appropriate methods and give examples.

CLO4: Formulate Green's function for boundary value problems.

CLO5: Understand and use various theoretical ideas and results that underlie themathematics in this course.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome : ADVANCED ALGEBRA

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Prove theorems applying algebraic ways of thinking.

CLO2: Connect groups with graphs and understanding about Hamiltonian graphs.

CLO3: Compose clear and accurate proofs using the concepts of Galois Theory.

CLO4: Bring out insight into Abstract Algebra with focus on axiomatic theories.

CLO5: Demonstrate knowledge and understanding of fundamental concepts including extension fields, Algebraic extensions, Finite fields, Class equations and Sylow's theorem.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome : REAL ANALYSIS II

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Understand and describe the basic concepts of Fourier series and Fourier integrals with respect to orthogonal system.

CLO2: Analyze the representation and convergence problems of Fourier series.

CLO3: Analyze and evaluate the difference between transforms of various functions.

CLO4: Formulate and evaluate complex contour integrals directly and by the fundamental theorem.

CLO5: Apply the Cauchy integral theorem in its various versions to compute contour integration.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: PARTIAL DIFFERENTIAL EQUATIONS

(for Mapping with POs and PSOs)

Students will be able to

CLO1: To understand and classify second order equations and find general solutions

CLO2: To analyse and solve wave equations in different polar coordinates

CLO3: To solve Vibrating string problem, Heat conduction problem, to identify and solve Laplace and beam equations

CLO4: To apply maximum and minimum principle's and solve Dirichlet, Neumann problems for various boundary conditions

CLO5: To apply Green's function and solve Dirichlet, Laplace problems, to apply Helmholtz operation and to solve Higher dimensional problem

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	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: COMPLEX ANALYSIS

(for Mapping with POs and PSOs)

Students will be able to

    CLO1: Analyze and evaluate local properties of analytical functions and definite integrals.

    CLO2: Describe the concept of definite integral and harmonic functions.

    CLO3: Demonstrate the concept of the general form of Cauchy's theorem

    CLO4: Develop Taylor and Laurent series .

    CLO5 Explain the infinite products, canonical products and jensen's formula .

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome PROBABILITY THEORY

(for Mapping with POs and PSOs)

Students will be able to

CLO1: To define Random Events, Random Variables, to describe Probability, to apply Bayes, to define Distribution Function, to find Joint Distribution function, to find Marginal Distribution and Conditional Distribution function, to solve functions on random variables.

CLO2: To define Expectation, Moments and Chebyshev Inequality, to solve Regression of the first and second types.

CLO3: To define Characteristic functions, to define distribution function, to find probability generating functions, to solve problems applying characteristic functions

CLO4: To define One point, two-point, Binomial distributions, to solve problems of Hypergeometric and Poisson distributions, to define Uniform, normal, gamma, Beta distributions, to solve problems on Cauchy and Laplace distributions

CLO5: To discuss Stochastic convergence, Bernaulli law of large numbers, to elaborate Convergence of sequence of distribution functions, to prove Levy-Cramer Theorems and de Moivre-Laplace Theorems, to explain Poisson, Chebyshev, Khintchine Weak law of large numbers, to explain and solve problems on Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome :TOPOLOGY
(for Mapping with POs and PSOs)

Students will be able to

CLO1: Define and illustrate the concept of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space. **CLO2**: Understand continuity, compactness, connectedness, homeomorphism and topological properties.

CLO3: Analyze and apply the topological concepts in Functional Analysis.

CLO4: Ability to determine that a given point in a topological space is either a limit point or not for a given subset of a topological space.

CLO5: Develop qualitative tools to characterize connectedness, compactness, second countable, Hausdorff and develop tools to identify when two are equivalent(homeomorphic).

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: Functional Analysis

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Understand the Banach spaces and Transformations on Banach Spaces.
CLO2: Prove Hahn Banach theorem and open mapping theorem.
CLO3: Describe operators and fundamental theorems.
CLO4: Validate orthogonal and orthonormal sets.
CLO5: Analyze and establish the regular and singular elements.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: DIFFERENTIAL GEOMETRY

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Explain space curves, Curves between surfaces, metrics on a surface, fundamental form of a surface and Geodesics.

CLO2: Evaluate these concepts with related examples.

CLO3: Compose problems on geodesics.

CLO4: Recognize applicability of developable.

CLO5: Construct and analyze the problems on curvature and minimal surfaces

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: MECHANICS

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Demonstrate the knowledge of core principles in mechanics.

CLO2: Interpret and consider complex problems of classical dynamics in a systematic way.

CLO3: Apply the variation principle for real physical situations.

CLO4: Explore different applications of these concepts in the mechanical and electromagnetic fields.

CLO5: Describe and apply the concept of Angular momentum, Kinetic energy and Moment of inertia of a particle

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: NUMBER THEORY AND CRYPTOGRAPHY
(for Mapping with POs and PSOs)

Students will be able to
CLO 1: understand the problems in elementary number theory
CLO 2: apply elementary number theory to Cryptography

CLO 3: develop a deep understanding of theoretical basis of number theory and

cryptography.

CLO 4: identify how number theory is related and applied in Cryptography

CLO 5: develops the knowledge of encryption and decryption and their application in

Managing the security of data.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	3	3	2	1	2	3	3	2
CLO2	2	3	3	3	2	2	2	3	2
CLO3	3	2	2	2	1	1	3	2	1
CLO4	2	3	1	2	2	3	2	2	2
CLO5	3	1	2	2	2	1	3	2	1

Course Learning Outcome: GRAPH THEORY AND APPLICATIONS
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: study the properties of Trees, Connectivity and Blocks with its applications.

CLO 2: discuss Euler tour, Hamiltonian cycles and its suitable applications.

CLO 3: understand the concepts of Matching's, Coverings and Perfect Matching's.

CLO 4: apply domain knowledge in Chromatic number, Brook's Theorem, Hajos'
Conjecture
 and Chromatic polynomials.

CLO 5: define Directed graphs, Directed paths and Directed cycles and apply results to
Practical problems.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	2	2	1	2	2	1	1
CLO2	3	2	3	2	1	2	2	1	2
CLO3	3	1	2	1	1	2	1	2	2
CLO4	2	3	3	2	2	2	2	3	3
CLO5	3	3	3	2	2	1	3	2	2

Course Learning Outcome: FORMAL LANGUAGES AND AUTOMATA THEORY
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: understand the basic properties of formal languages and grammars.

CLO 2: make grammars to produce strings from a specific language..

CLO 3: design sample Automata

CLO 4: minimize Finite Automata and grammar of context-free languages.

CLO 5: differentiate regular, context-free and recursively enumerate languages.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	1	1	2	1	2	2	1
CLO2	2	3	3	2	2	1	2	3	1
CLO3	1	3	3	3	2	2	2	3	2
CLO4	1	3	3	3	2	2	3	2	2
CLO5	3	3	3	2	2	1	1	3	1

Course Learning Outcome: PROGRAMMING IN C++ AND NUMERICAL METHODS
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: understand the iterative methods for finding the roots of transcendental and algebraic equations with C++ Programme.

CLO 2: solve a system of linear algebraic equations and study Convergence of iterative methods.

CLO 3: fit a Curve for given set of data through C++ Programme.

CLO 4: approximate the polynomial by interpolation method via C++ Programme.

CLO 5: analyse Numerical Differentiation and Integration using Programming in C++.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome: Lie Algebras and Lie Groups

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: understand the definition of Lie Groups and Lie Algebras.

CLO 2: studied exponential map, The commutator, Adjoint action and Jacobi identity.

CLO 3: gained the Subalgebras, ideals, and centre, Lie algebra of vector fields, Stabilizers and the center.

CLO 4: Campbell-Hausdorff formula, Fundamental theorems of Lie theory, Complex and real forms, Example: $so(3, \mathbb{R})$, $su(2)$, and $sl(2, \mathbb{C})$

CLO 5: Operations on representations, Irreducible representations, Intertwining operators and Schur lemma.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome :Mathematical Programming

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Integer Linear Programming

CLO 2: Deterministic dynamic Programming

CLO 3: Decision analysis   and games

CLO 4: Simulation Modeling

CLO 5: Nonlinear Programming algorithm

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome: Fuzzy Sets and their Applications

 (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Crisp sets and fuzzy sets

CLO 2: Operation on Fuzzy sets

CLO 3: Fuzzy relation

CLO 4: Decision making in Fuzzy environment

CLO 5: Applications

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

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Course Learning Outcome :Discrete Mathematics
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Semigroups and Monoids

CLO 2: Lattices

CLO 3: Grammars and Languages

CLO 4: Boolean Algebra

CLO 5: Boolean functions:

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome: ALGEBRAIC TOPOLOGY

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Geometric Complexes and Polyhedra

CLO 2: Simplicial Homology Groups

CLO 3: Simplicial Approximation

CLO 4: The Fundamental Group

CLO 5: Covering spaces

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome: MATHEMATICAL STATISTICS

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Sample Moments and their functions

CLO 2: Limit distribution of sample moments

CLO 3: Limit distribution of sample quantiles

CLO 4: An Outline of the Theory of Runs

CLO 5: Significance Test

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome: STATISTICAL DATA ANALYSIS USING R-PROGRAMMING

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: The Comprehensive R Archive Network

CLO 2: Essentials of the R Language

CLO 3: Graphics, Plots with two variables

CLO 4: Probability functions

CLO 5: Discrete probability distributions

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome :TENSOR ANALYSIS AND RELATIVITY

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Cartesian Tensor

CLO 2: Tensor in Physics

CLO 3: Tensor in Analytic Solid Geometry

CLO 4: General Tensor

CLO 5: Tensor in Relativity

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	1	2	3	2	2
CLO2	3	2	3	2	1	2	3	2	2
CLO3	3	2	3	2	1	2	3	2	2
CLO4	3	2	3	2	1	2	3	2	2
CLO5	3	2	3	2	1	2	3	2	2

Course Learning Outcome: Wavelets (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Understand Wavelets and to make use of the tools of Fourier Analysis.

CLO 2: Characterize the smoothness of functions using wavelets.

CLO 3: Understand Haar Wavelet Expansions and to construct general wavelets.

CLO 4: Develop a systematic method to produce orthonormal wavelets.

CLO 5: Understand scaling functions along with convergence properties and speed of convergence.

	Pos						PSOs		
	1	2	3	4	5	6	2	2	3
CLO1	3	2	3	2	3	3	3	3	3
CLO2	3	2	3	2	2	3	3	3	2
CLO3	3	2	3	2	2	3	3	2	1
CLO4	2	2	2	2	2	3	3	2	1
CLO5	2	2	2	2	2	3	3	2	1

Course Learning Outcome: Modelling and Simulation with Excel
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Understand a model's structure, its capabilities, and its underlying assumptions.

CLO 2: Deal models in various forms and to understand the visual models of the behaviour of a system.

CLO 3: Perform data analysis on both quantitative and qualitative data leading to models of general and specific behaviour.

CLO 4: Understand the critical role of Excel in the early or rapid prototyping of problems

CLO 5: Construct a useful and thoroughly conceived simulation model

	POs						PSOs		
	1	2	3	4	5	6	2	2	3
CLO1	3	2	3	2	3	3	3	3	3
CLO2	3	2	3	2	2	3	3	3	2
CLO3	3	2	3	2	2	3	3	2	1
CLO4	2	2	2	2	2	3	3	2	1
CLO5	2	2	2	2	2	3	3	2	1

Course Learning Outcome :Machine Learning and Artificial Intelligence
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Understand the AI Foundations.

CLO 2: Deal with Data.

CLO 3: Work with Data in an AI project.

CLO 4: Construct Machine Learning Algorithms.

CLO 5: Understand Deep learning.

	POs						PSOs		
	1	2	3	4	5	6	2	2	3
CLO1	3	2	3	2	3	3	3	3	3
CLO2	3	2	3	2	2	3	3	3	2
CLO3	3	2	3	2	2	3	3	2	1
CLO4	2	2	2	2	2	3	3	2	1
CLO5	2	2	2	2	2	3	3	2	1

Course Learning Outcome: Neural Networks
(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Understand the Basics of Artificial Neural Networks.

CLO 2: Understand the Basic Learning Laws and Activation Dynamic Models.

CLO 3: Deal with Pattern Recognition Problems.

CLO 4: Analyze Feedforward Neural Networks, Pattern Association Networks and Pattern Classification Networks.

CLO 5: Deal with Feedback Neural Networks, Linear Autoassociative FF Networks and Analysis of Pattern Storage Networks.

	POs						PSOs		
	1	2	3	4	5	6	2	2	3
CLO1	3	2	3	2	3	3	3	3	3
CLO2	3	2	3	2	2	3	3	3	2
CLO3	3	2	3	2	2	3	3	2	1
CLO4	2	2	2	2	2	3	3	2	1
CLO5	2	2	2	2	2	3	3	2	1

**Course Learning Outcome : ALGEBRAIC NUMBER THEORY
(for Mapping with POs and PSOs)**

Students will be able to

CLO 1: understand the concept of Modules

CLO 2: deal with algebraic integers and its applications

CLO 3: understand the concept of Quadratic fields and cyclotomic fields

CLO 4: learn Ramanujan-Nagell Theorem

CLO 5: understand Prime Factorization of Ideals

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

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Course Learning Outcome: FLUID DYNAMICS
 (for Mapping with POs and PSOs)

Students will be able to
CLO 1: Understand the basic properties and principles of viscous and non-viscous fluids

CLO 2: Derive and deduce the consequences of the governing equations of fluids

CLO 3: Solve kinematics problems such as finding particle paths and streamlines

CLO 4: Understand the basic theorems of fluid mechanics and its applications

CLO 5: Derive the boundary layer equations of some basic flows and its solutions

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: STOCHASTIC PROCESSES
 (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Acquire in-depth knowledge about stationary stochastic processes and Markov chains.

CLO 2: Proficient in Markov Process with discrete state space.

CLO 3: Proficient in Markov processes with continuous state space.

CLO 4: Proficient in Branching processes and age dependent branching process.

CLO 5: Proficient in solving stochastic processes in queuing systems.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: MATHEMATICAL PYTHON – I

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Appreciate the importance and features of Python

CLO 2: Define and classify functions

CLO 3: Understand the use and application of iterators

CLO 4: Understand how to create a class in Python

CLO 5: Differentiate between inheritance and composition

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: ALGEBRAIC GEOMETRY

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Analyze and evaluate Affine and Projective algebraic sets.
CLO2: Describe the concept of Morphism integral and standard embeddings
CLO3: Demonstrate the concept Rational Maps.
CLO4: Construct Jacobian Criterian and Jacobian Conjecture
CLO5: Formulate the Intersections in projective space.

	Pos						PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome : FINANCIAL MATHEMATICS **(for Mapping with POs and PSOs)**

Students will be able to

CLO1: Analyze Brownian motion and evaluate stochastic integrals
CLO2: Describe the concept Financial market
CLO3: Demonstrate the finite market model and incomplete markets.
CLO4: Construct Balck Scholes model
CLO5: Formulate the Multi-dimensional Black Scholes model

	POs						PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: RESOURCE MANAGEMENT TECHNIQUES

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Analyze Critical Path Calculation
CLO2: Describe the simplex method using the restricted basis
CLO3: Demonstrate the Two person zero-sum game and finding the optimal solutions
CLO4: Construct Karush-Kuhn-Tucker conditions
CLO5: Formulate the Non-linear programming

	POs						PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: MATHEMATICAL PYTHON –II

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Implement operator overloading for complex numbers and fractions
CLO2: Use try/except and manually throw exceptions
CLO3: Create uni-dimensional and multi-dimensional arrays
CLO4: Create three dimensional plots using MATPLOTLIB
CLO5: Understand the concept of clipping

	POs						PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: COMPUTATIONAL MATHEMATICS USING SageMath

(for Mapping with POs and PSOs)

Students will be able to

CLO1: Deal with Symbolic Variables
CLO2: Describe the symbolic expressions and some Pitfalls
CLO3: Demonstrates the analysis concepts
CLO4: Solve the simultaneous equations
CLO5: Displaying the solutions of Differential Equations

	POs						PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PS01	PS02	PSO3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: MATHEMATICAL DOCUMENTATION USING LATEX

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: know how to create basic types of LaTex documents (article).

CLO 2: typeset latex commands.

CLO 3: create a paragraph, symbols, comments and font style.

CLO 4: change font characteristics.

CLO 5: know about various environments.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	1	1	1	2	3	2	1
CLO2	3	2	1	1	1	2	3	3	2
CLO3	3	2	1	1	1	1	3	2	2
CLO4	3	1	1	1	1	1	3	2	1
CLO5	3	2	1	1	1	2	3	2	2

Course Learning Outcome : Office Automation and ICT Tools

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Perform basic editing functions, formatting text, copy and moving objects and text.

CLO 2: Learn the formatting skills on paragraphs, tables, lists, and pages.

CLO 3: Handle data in Excel spreadsheet.

CLO 4: Understand the need and use of using Excel templates.

CLO 5: Learn to modify presentation themes, formatting techniques and presentation styles.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	1	3	2	3	3	3	2	1
CLO2	2	1	3	1	3	3	3	2	1
CLO3	3	2	3	1	3	3	3	2	1
CLO4	1	2	3	2	3	3	3	2	1
CLO5	3	1	2	3	3	3	3	2	1

Course Learning Outcome: Numerical analysis using Python

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Learn foundations of Python and numerical calculus of Python.

CLO 2: Learn the linear equations and study the different elimination and iterative methods and write the Python programs to solve this linear equations

CLO 3: Obtain the solutions of nonlinear equation using different iterative methods and write the Python programs to solve this nonlinear equations.

CLO 4: Define Interpolation. Methods for calculating the interpolation and write the Python programs to find the interpolation

CLO 5: Learn different numerical methods to solve ODE and systems of ODE and write the Python programs to solve ODE.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	3	3	3	2	2
CLO2	3	2	3	2	3	3	3	2	2
CLO3	3	2	3	2	3	3	3	2	2
CLO4	3	2	3	2	3	3	3	2	2
CLO5	3	3	3	2	3	3	3	2	2

Course Learning Outcome: Differential equations using Python

(for Mapping with POs and PSOs)

Students will be able to

CLO 1: Learn the basics of Python and write simple Python programs.

CLO 2: Learn to create the single and multi-dimensional arrays, to use the linear algebra functions available in Python and packages numpy, scipy and scikits

CLO 3: Create various types of two and three dimensional graphs using Python programs.

CLO 4: Solve the ODE, IVP, BVP and delay differential equation using Python programs

CLO 5: Solve the PDE using different methods and write the program for solving PDE.

	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	3	2	3	2	3	3	1	2	2
CLO2	3	2	3	2	3	3	1	3	2
CLO3	3	2	3	2	3	3	2	2	2
CLO4	3	2	3	2	3	3	2	3	2
CLO5	3	3	3	2	3	3	2	2	2

Course Learning Outcome: Industrial Statistics with Minitab **(for Mapping with POs and PSOs)**

Students will be able to
CLO 1: Understand the basics of Minitab software.
CLO 2: Use Tools and Techniques to analyze Industrial Problems.
CLO 3: Get better views of Problems.
CLO 4: Produce Visual Solutions.
CLO 5: Make use of Minitab to arrive better Decisions.

	POs						PSOs		
	1	2	3	4	5	6	2	2	3
CLO1	3	3	3	2	3	3	3	3	3
CLO2	3	2	2	2	2	3	3	3	2
CLO3	3	2	2	2	2	3	3	2	2
CLO4	2	2	2	2	2	3	3	2	2
CLO5	2	2	2	2	2	3	3	2	2