UP Rajarshi Tandon Open University
Prayagraj, Uttar Pradesh, India

MASTER OF SCIENCE/MASTER OF ART

Syllabus & Structure

M.Sc. (Mathematics) (PGMM)/M.A. (Mathematics) (MAMM)

Semester	Course Code	Title of Papers	Credit	Max. Marks
1st SEM	PGMM-101N/ MAMM-101N	Advanced Real Analysis and Integral Equations	4	100
	PGMM-102N/ MAMM-102N	Classical Optimization Techniques	4	100
	PGMM-103N/ MAMM-103N	Discrete Mathematics	4	100
	PGMM-104N/ MAMM-104N	Numerical Analysis	4	100
	PGBR-01	Basic in Research	4	100
Total Credit of 1st Semester			20	
2nd SEM	PGMM-106N/ MAMM-106N	Advanced Algebra	4	100
	PGMM-107N/ MAMM-107N	Complex Analysis	4	100
	PGMM-108N/ MAMM-108N	Mathematical Statistics	4	100
	PGMM-109N/ MAMM-109N	Topology	4	100
	PGED-02	Entrepreneurship Development	4	100
Total Credit of 2nd Semester			20	

3rd SEM	**PGMM-111N/ MAMM-111N**	**Advanced Differential Equations**	**4**	**100**
	PGMM-112N/ MAMM-112N	**Functional Analysis**	**4**	**100**
	PGMM-113N/ MAMM-113N	**Measure Theory and Integration**	**4**	**100**
	PGMM-114N/ MAMM-114N	**Theory of Probability**	**4**	**100**
	PGRT-03	**Basic Research Tools**	**4**	**100**
Total Credit of 3rd Semester			**20**	
4th SEM	**PGMM-116N/ MAMM-116N**	**Operation Research**	**4**	**100**
	PGMM-117N/ MAMM-117N	**Fluid Dynamics**	**4**	**100**
	PGMM-122N/ MAMM-122N	**Dissertation with Viva-voce**	**4**	**100**
	Select any one of the following			
	PGMM-118N/ MAMM-118N	**Soft Computing**	**4**	**100**
	PGMM-119/ MAMM-119	**Number Theory and Cryptography**	**4**	**100**
	Select any one of the following			
	PGMM-120N/ MAMM-120N	**Machine Learning Techniques**	**4**	**100**
	PGMM-121N/ MAMM-121N	**Vedic Mathematics**	**4**	**100**
Total Credit of 4th Semester			**20**	
Total Credit			**80**	**2000**

I SEMESTER

PGMM-101N/MAMM-101N: Advanced Real Analysis and Integral Equations

Block-1: Real Analysis

Unit-1: Riemann Integral

Partition, lower and upper Riemann-Stieltjes sums, lower and upper Riemann-Stieltjes integrals, Definition of Riemann-Stieltjes integral, necessary and sufficient condition for Riemann-Stieltjes integrability, algebra of Riemann-Stieltjes integrable functions.

Unit-2: Integration and Differentiation

Integral Function, primitive, fundamental theorem of integral calculus, integration by parts, Integration of vector-valued functions.

Unit-3: Uniform Convergence of Sequences

Uniformly bounded sequence, uniform convergence of sequences, Uniform convergence of a series of function, Cauchy's general principle of uniform convergence, test for uniform convergence, Uniform convergence and integration, Uniform convergence and differentiation.

Unit-4: Power Series

Power series, Cauchy's theorem on limits, Radius of convergence, Uniform convergence of power series. Abel's and Tauber's theorems.

Block-2: Function of Several Variables

Unit-5: Limit and continuity of function of two variables

Introduction, simultaneous limit, Limit of a function of two variables, continuity of a function of two variables.

Unit-6: Partial Differentiation

Introduction, Partial derivatives, partial derivative of higher order, example based on partial derivatives.

Unit-7: Euler's Theorem

Introduction, Homogeneous function, Euler's theorem on Homogeneous function, some deductions from Euler's theorem.

Unit-8: Jacobians

Introduction, Jacobians and their properties.

Block-3: Fourier Series

Unit-9: Introduction to Fourier series

Trigonometric Fourier series, Periodic function, even and odd function, Euler formula for the Fourier coefficients, Convergence of Fourier series and Dirichlet's conditions.

Unit-10: Half Range Fourier series

Half-range expansions, Fourier sine series, Fourier Cosine series, Change of Interval, Parseval's identity for Fourier series.

Block-4: Integral Equations

Unit-11: Classifications of Integral Equations

Introduction, Integral equation, differentiation of a function under and integral sign, relation between differential and integral equation.

Unit-12: Fredholm Integral Equations-I

Fredholm Integral equation, Fredholm first theorem, Fredholm second theorem, Fredholm third theorem.

Unit-13: Fredholm Integral Equations-II

Fredholm Integral equation, Resolved kernel for Fredholm integral equation, separable kernel.

Unit-14: Volterra Integral Equations

Volterra Integral equation, Solution of non-homogeneous Volterra integral equation of second kind by the method of successive substitution and successive approximation, iterated kernels.

PGMM-102N/MAMM-102N: Classical Optimization Techniques

Block-1: Optimization Techniques

Unit-1: Introduction to Optimization Techniques

Introduction, Optimization techniques, applications of optimization techniques, optimization problems, classification of optimization problems.

Unit-2: Unconstrained Optimization Problem

Introduction, unconstrained optimization problem, single and multi-variable optimization problems.

Unit-3: Constrained Optimization Problem

Introduction, constrained optimization problem, constrained multi-variable optimization problem with equality and inequality constraints.

Block-2: Non-Linear Programming Problem

Unit-4: Non-Linear Programming-I

Introduction, unconstrained non-linear optimization problems, direct search method: Fibonacci method of search, Golden section method, Univariate method and Pattern search method, indirect search method: Steepest descent method.

Unit-5: Non-Linear Programming-II

Introduction, constraints non-linear optimization problem, direct methods: complex method and Zoutendijk method, indirect methods: transformation techniques and penalty function methods.

Unit-6: Quadratic Programming

Introduction, Kuhn-Tucker conditions, Quadratic programming, Wolfe's modified simplex method, Beale's method.

Unit-7: Separable Programming Problem

Introduction, Separable programming problem.

Block-3: Dynamic Programming Problem

Unit-8: Introduction to Dynamic Programming

Introduction, multi-decision process, Bellman's principle of optimality, dynamic programming algorithm.

Unit-9: Applications of Dynamic Programming

Introduction, solution of linear programming problem using dynamic programming and applications of dynamic programming problem.

Block-4: Advanced Optimization Techniques

Unit-10: Networking

Introduction, shortest route problem, minimum spanning tree problem and maximum flow problem.

Unit-11: Game Theory

Introduction, Game theory, lower and upper value of game, procedure to find saddle point, games without saddle point.

Unit-12: Goal Programming

Introduction, formulation of Goal programming, single goal models, goal programming algorithm and multi goal models.

Unit-13: Integer Programming Problem-I

Introduction, formulation of Integer programming problem, Gomory'scutting plane method.

Unit-14: Integer Programming Problem-II

Introduction, Branch and Bound Techniques.

PGMM-103N/MAMM-103N: Discrete Mathematics

Block-1: Set Theory

Unit-1: Sets

Introduction, Representation of sets, types of sets, subset, universal set, Venn diagram, operations on sets, and algebra of sets.

Unit-2: Relations

Introduction, inverse relation, representation of relations, types of relations, equivalence relation, and partial order relation.

Unit-3: Functions

Introduction, inverse function, types of functions, real valued function, identity function, constant function, composition of functions.

Unit-4: Techniques of counting

Introduction, partition, principle of inclusion-exclusion, pigeonhole principle, permutations and combinations.

Block-2: Logic

Unit-5: Mathematical Logic

Introduction, proposition, basic logical operations, truth table, logical equivalence, algebra of propositions, Tautology, contradiction.

Unit-6: Normal Form

Introduction, normal form, disjunctive normal form, conjunctive normal form, logic in proof, universal and existential quantifiers.

Unit-7: Mathematical Induction

Introduction, methods of proof, principle of mathematical induction.

Unit-8: Recurrence Relations

Introduction, generating function, properties of generating functions, numeric function, recurrence relation, solution of recurrence relation.

Block-3: Boolean Algebra

Unit-9: Boolean Algebra

Introduction, binary operations, algebraic structure, Boolean algebra, Boolean expression, Boolean functions and logic gates.

Unit-10: Lattices

Introduction, Lattice, properties of lattice, principle of duality, semi and complete lattice, sublattice, isomorphic and bounded lattice.

Block-4: Graph Theory

Unit-11: Introduction to Graph

Definition of a graph, simple and multi-graph, degree of a vertex, types of graph: null graph, complete graph, regular graph.

Unit-12: Advanced Graph Theory

Path, cycle and circuit, Eulerian and Hamiltonian graph, matrix representation of graph, planner graph, graph coloring.

Unit-13: Tree

Introduction, tree, types of tree.

Unit-14: Rooted and Binary Tree

Introduction, rooted tree, spanning tree, minimal spanning tree, binary tree.

PGMM-104N/MAMM-104N: Numerical Analysis

Block-1: Calculus of Finite Differences

Unit-1: Finite Differences

Introduction, finite differences, forward differences, backward differences, central differences, shift operator, relations between the relations.

Unit-2: Application of Finite Differences

Fundamental theorem of the difference calculus, factorial function, properties of factorial function.

Block-2: Interpolation

Unit-3: Newton's Interpolation formula with Equal Intervals

Introduction, to find one missing terms, to find two missing terms, Newton's forward and backward interpolation with equal intervals.

Unit-4: Gauss' and Stirling Interpolation formula with Equal Intervals

Introduction, Gauss's forward and backward interpolation with equal intervals, Stirling's difference formula.

Unit-5: Lagrange's Interpolation Formula for Unequal Intervals

Introduction, Lagrange's interpolation with unequal intervals.

Block-3: Solution of Linear Simultaneous Equations

Unit-6: Solution of Linear Simultaneous equations-I

Introduction, Linear equations, Gauss elimination method, Gauss-Seidel method.

Unit-7: Solution of Linear Simultaneous equations-II

Introduction, LU Decomposition method or triangular method, Crout's method and Choleski's method.

Block-4: Solving Algebraic and Transcendental Equations

Unit-8: Numerical Method for solving Algebraic and Transcendental Equations-I

Introduction, Polynomial, algebraic and transcendental equations, Bisection method and Newton Raphson Method.

Unit-9: Numerical Method for solving Algebraic and Transcendental Equations-II

Introduction, Regula-Falsi method and Secant method.

Block-5: Numerical Differentiation and Integration

Unit-10: Numerical Differentiation-I

Introduction, derivatives using forward difference formula, derivatives using backward difference formula.

Unit-11: Numerical Differentiation-II

Introduction, derivatives using Stirling difference formula, derivatives using Newton's divided difference formula.

Unit-12: Numerical Integration

Introduction, general quadrature formula for equally spaced arguments, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule.

Unit-13: Numerical Solution of Ordinary Differential Equations-I

Introduction, Euler's method, Euler's modified method, Taylor Series method.

Unit-14: Numerical Solution of Ordinary Differential Equations-II

Introduction, Picard's method. Runge-Kutta method for fourth order, Milne's predictor-corrector method.

PGBR-01: Basic in Research

Block-1: Basic of Research

Unit-1: Introduction to Research

Knowledge and the Approaches of Acquiring knowledge (deductive, inductive and scientific), Meaning of Research, Objectives of Research, Motivation in Research, Significance of Research, Importance of knowing How Research is Done?, Criteria of Good Research.

Unit-2: Approaches of Research

Types of Research, Research Approaches, Research Methods versus Methodology, Research and Scientific Method, Research Process.

Unit-3: Defining the Research Problem

What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Technique involved in Defining a Research Problem.

Unit-4: Research Design

Need for Research Design, Features of Good Design, Important Concepts Relating to Research Design, Different Research Design, Basic Principles of Experimental Designs.

Block-2: Literature Survey, Review and Synopsis Preparation

Unit-5: Literature Survey

Introductions: Sources of information, need for reviewing literature, primary-secondary and tertiary sources, journals, abstracts, text books, Web resources, E-journals, journal access, case study alerts. Citation index, UGC infonet, E-books, Impact Factors, Search engines- Google scholar, Science Direct, SciFinder, Scopus, web of science.

Unit-6: Literature Review

Establishing the Context, Identifying Gaps in Knowledge, Formulating Research Questions or Hypotheses, Defining Key Concepts and Terms, Selecting Research Methods, Supporting Research Design and Methodology, Evaluating Research Methods, Citing Relevant Studies, Avoiding Redundancy, Synthesizing Knowledge, Demonstrating Scholarly Engagement, Guiding the Organization of Your Research Paper, Providing a Theoretical Framework, Supporting Ethical Research, Contributing to the Research Conversation, Types of Review of literature.

Unit-7: Preparation of Research Synopsis

The structure of synopsis- Title, Introduction, Literature Review, Research Questions or Hypotheses, Methodology, Data Collection, Data Analysis, Expected Outcomes and Significance, Timeline, References, Budget, Appendices.

Block-3: ETHICS and IPR

Unit-8: Research Ethics

Regulatory bodies, practices and compliances, Good Laboratory Practices (GLP), Research Ethics & Misconduct.

Unit-9: Intellectual Property Rights

Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties. Plagiarism, Patents, Fundamentals of patents, Product and process patent, Patent Treaties and Convention, process of filing patent (Search and retrieval), copyrights, geographical indications, design and layout, trademarks.

Unit-10: Ethical consideration for research

Informed Consent, Privacy and Confidentiality, Minimizing Harm and Risks, Beneficence, Justice and Fairness, Deception, Publication Ethics, Peer Review, Conflict of Interest, Animal Welfare, Data Management and Sharing, Community and Stakeholder Involvement, International Research Ethics.

Block-4: Research Reference, Report and Paper Writing

Unit-11: Reference Writing

APA Style (American Psychological Association), MLA Style (Modern Language Association), Chicago Style, IEEE Style (Institute of Electrical and Electronics Engineers), AMA Style (American Medical Association), Harvard Style, Vancouver Style, Turabian Style, CSE Style (Council of Science Editors), Bluebook Style. Tips for writing references.

Unit-12: Report writing in academics and research

Various kinds' of academic and research activities. Necessity of report writing for achievement of academic and research goals. Various kinds of reports / presentations. Characteristics of academic and research reports / presentations. Conclusions.

Scientific Writing – Introduction to Technical writing, definition, types, characteristics, Report Writing, Research proposal writing.

Unit-13: Research paper writing

Choose a Topic, Conduct a Literature Review, Formulate a Research Question or Hypothesis, Plan Your Research, Gather Data, Organize Your Research, Write an Outline, Write the Introduction, Literature Review, Methodology, Results, Discussion, Conclusion, Cite Your Sources, Proofread and Edit, Formatting and References, Finding a Suitable Journal, Submit Your Paper, Peer Review and Revision, Final Proofreading.

Second Semester

2nd SEM	**PGMM-106N/ MAMM-106N**	**Advanced Algebra**	**4**	**100**
	PGMM-107N/ MAMM-107N	**Complex Analysis**	**4**	**100**
	PGMM-108N/ MAMM-108N	**Mathematical Statistics**	**4**	**100**
	PGMM-109N/ MAMM-109N	**Topology**	**4**	**100**
	PGED-02	**Entrepreneurship Development**	**4**	**100**
Total Credit of 2nd Semester			**20**	

II SEMESTER

PGMM-106N/MAMM-106N: Advanced Algebra

Block-1: Group Theory

Unit-1: Basic Set Theory

Introduction, Representation of sets, types of sets, subset, universal set, Venn diagram, operations on sets, and algebra of sets.

Unit-2: Relations and Functions

Introduction, relations, equivalence relation, and partial order relation, functions.

Unit-3: Introduction of Group Theory

Introduction, algebraic structure, group, Abelian group, finite and infinite group, composition tables for finite sets.

Unit-4: Permutations Groups

Introduction, permutations, groups of permutations, cyclic permutations, even and odd permutations, order of an element of a group, isomorphism on groups.

Unit-5: Subgroup and Cosets

Introduction, complexes and subgroups of a group, intersection of subgroups, cosets, Lagrange's theorem, Fermat's theorem, Cayley's theorem.

Block-2: Advanced Group Theory

Unit-6: Cyclic Group

Introduction, Cyclic groups, subgroup generated by a subset of a group, generating system of a group.

Unit-7: Normal Subgroup

Introduction to Normal subgroup, simple group, conjugate element, centre of a group, conjugate subgroup and quotient groups.

Unit-8: Homomorphism

Homomorphism on groups, Kernel of a homomorphism, fundamental theorem on homomorphism of groups, automorphisms and inner automorphisms, Maximal subgroup, Composition series of a group, Jordon Holder's theorem, Solvable groups, Direct products, Sylow's theorem.

Block-3: Rings and Field Theory

Unit-9: Rings

Introduction, Rings, elementary properties of a ring, ring with or without zero divisors, integral domain, field, subrings and subfields.

Unit-10: Ideals

Introduction, ideals, principal ideal, divisibility in an integral domain, greatest common divisor, polynomials rings, unique factorization domain and reminder theorem.

Unit-11: Advanced Rings Theory

Quotient rings, homomorphism on rings, kernel of a ring homomorphism, maximal ideals, prime ideals and Euclidean rings.

Block-4: Extension Fields and Galois Theory

Unit-12: Extension Fields

Introduction, field extensions, field adjunctions, simple and algebraic field extensions, separable extension and perfect field.

Unit-13: Galois Theory-I

The elements from Galois theory, fixed field, normal extension.

Unit-14: Galois Theory-II

Introduction, Galois group, fundamental theorem of Galois theory.

PGMM-107N/MAMM-107N: Complex Analysis

Block-1: Function of Complex Variables

Unit-1: Complex Numbers

Introduction, Graphical representation, exponential functions of complex numbers, circular and hyperbolic functions of complex numbers.

Unit-2: Analytic Functions

Introduction, single and multivalued functions, analytic functions, Cauchy Riemann equations, Polar form of C-R equation, Derivative of w in polar form.

Unit-3: Harmonic Functions

Orthogonal system, Laplace equations, harmonic functions, conjugate functions, Milne's Thomson method.

Block-2: Conformal Mappings

Unit-4: Introduction to Conformal Mappings

Mappings or Transformations, Jacobian of a transformations, ordinary and critical points, conformal mappings, some general transformations: Translation, Rotation, Magnification, Inversion.

Unit-5: Bilinear Transformations

Bilinear transformations, Fixed points of the Bilinear Transformations, Some important properties of Bilinear Transformations, Special conformal transformations, Joukowski's transformation and Schwarz-Christoffel transformation.

Block-3: Complex Integration and Series

Unit-6: Introduction to Complex Integration

Complex integration, Arc, Regular Arc, Contour, Connected and Non-connected region, simple and multi connected region.

Unit-7: Cauchy's Theorem

Cauchy Fundamental theorem, and Cauchy-Goursat theorem.

Unit-8: Cauchy's Integral Formula and its Applications

Cauchy's integral formula, an extension of the Cauchy's integral formula, Cauchy's integral formula for derivative, Cauchy's inequality.

Unit-9: Important Theorems in Complex Integration

Morera's Theorem, Liouville's theorem and its applications, The fundamental theorem of Algebra, Maximum modulus principle.

Unit-10: Series

Introduction, Entire functions, Taylor's theorem and its applications, Laurent's Theorem and its applications.

Block-4: The calculus of residues

Unit-11: Singularities and Residues

Zero of analytic functions, singularities of analytic functions, isolated and non-isolated singularities, removable singularities, pole, residue at pole, Cauchy's Residue theorem.

Unit-12: Applications of Complex Integration-I

Evaluation of real definite integrals, Integration round the unit circle, Jorden's inequality, Jordan's lemma, Evaluation of integrals in which no poles lie on the real axis.

Unit-13: Applications of Complex Integration-II

Introduction, Evaluation of integrals in which poles lie on the real axis, integral involved many valued functions.

Unit-14: Meromorphic Functions

Meromorphic functions, Mittag Leffler's expansion theorem, number of poles and zeroes of a meromorphic function, Principle of argument, Rouche's theorem.

PGMM-108N/MAMM-108N: Mathematical Statistics

Block-1: Data Collection and its Representation

Unit-1: Data Collection and Tabulation

Meanings, Definitions and Applications of Statistics, Measurements and Scale, Measurements of qualitative data, Methods of data collection, Types of data.

Unit-2: Representation of Data- I (Diagrammatical representation)

Frequency distribution, Tabulation of data, Diagrammatical Representation of data, Bar diagram, Multiple bar diagram, Divided bar diagram, Percentage bar diagram, Pie chart, Pictogram, leaf chart.

Unit-3: Representation of Data- II (Graphical representation)

Graphical representation of frequency distribution, Histogram, Frequency polygon, Frequency curve, Ogive.

Block-2: Measures of Central Tendency and Dispersion

Unit-4: Measures of Central Tendency-I

Types of measures of central tendency, Arithmetic mean, Fundamental Theorems on Arithmetic mean, Geometric mean, Harmonic mean.

Unit-5: Measures of Central Tendency-II

Median, Mode, Percentiles, Deciles, and Quartiles.

Unit-6: Measures of Dispersion

Types of measures of Dispersion, Range, Mean Deviation, Variance and Standard deviation, Effect of change of origin and scale, Relationship between measures of central tendency and measures of dispersion, Coefficient of variation.

Block-3: Moments, Skewness and Kurtosis

Unit-7: Moments, Raw Moments

Definition of moments, raw moments for ungrouped data, raw moments for grouped data.

Unit-8: Moments, Raw Moments and Central Moments

Central moments, Factorial moments, Interrelationship between various moments, effect of change of origin and scale on moments, Charlier's checks, Sheppard's correction for moments.

Unit-9: Skewness and Kurtosis

Definition of skewness, Measures of skewness, Pearson's coefficient, Bowley's coefficients, Kurtosis, Measures of Kurtosis, effect of change of origin and scale.

Block-4: Correlation and Regression

Unit-10: Bivariate Data and Correlation

Scatter Diagram, Karl Pearson's coefficient of correlation, Properties of correlation coefficient, limits of correlation coefficient, Effect of change of origin and scale on correlation coefficient.

Unit-11: Regressions-I

Regressions, linear regression model, principal of least square.

Unit-12: Regressions-II

Regression lines, Regression coefficient, Properties of Regression coefficients.

Unit-13: Correlation and Intra Class Correlation

Rank correlation coefficient, Spearman's rank correlation coefficients, rank correlation coefficient for tied ranks, Intra-class correlation, some remarks on Intra-class correlation.

Unit-14: Theory of Attributes

Combinations, Classes and Class frequencies of Attributes, Dichotomous Classification, Consistency of data, joint distribution of attributes, Contingency tables, Independence and Association of Attributes, Measures of Association, Yates Correction.

PGMM-109N/MAMM-109N: Topology

Block-1: Metric Spaces-I

Unit-1: Elements of Set Theory

Sets, subset, index set, power set, operations on set, relations, functions, finite and infinite sets, Countable and uncountable sets.

Unit-2: Introduction to Metric Spaces

Metric space, Pseudo Metric Space, Discrete Metric Space, Usual and Quasi Metric Space, inequalities.

Unit-3: Bounded and Unbounded Metric Spaces

Bounded and Unbounded Metric Space, Usual and Quasi Metric Space, inequalities.

Block-2: Metric Spaces-II

Unit-4: Spaces in Metric

Sequence spaces l^{∞}, Function space, sequence space l^{p}, Hilbert sequence space l^{2}, Open and closed ball, sphere, neighbourhood of a point, limit point, equivalent Metrics.

Unit-5: Sequence in Metric Spaces

Sequence in a Metric Space, Convergent Sequence in a Metric Space, Bounded Set, Cauchy Sequence, Continuity and Homeomorphism of metric spaces, Homeomorphic Spaces.

Unit-6: Complete Metric Space

Complete Metric Space, Incomplete Metric Space, Contor' Intersection theorem, Completeness of C.

Block-3: Introduction to Topological Spaces

Unit-7: Topological Spaces-I

Topological Spaces, Trivial topology, Non-Trivial topologies, Comparison of Topologies, Algebra of Topologies, Open Set, Neighbourhood, Usual Topology, Limit Points, Derived Set, Closed Sets, Door Space.

Unit-8: Topological Spaces-II

Closure of a Set, Separated Set, Interior points and the Interior of a Set, Exterior of a Set, Boundary Points, Dense Set.

Unit-9: Base and Sub-base

Relative Topology, Subspace, Base for a topology, Sub-bases, Local base, First Countable Space, Second Countable Space, Topologies Generated by Classes of Sets, Separable Space, Cover of a Space, Lindelof Space.

Unit-10: Continuous Maps and Homeomorphism

Continuous Function, Open Mapping, Closed Mapping, Bicontinuous Mapping, Bijective Mapping, Sequential Continuity, The pasting Lemma, Homeomorphism.

Block-4: Separation Axioms on Topological Spaces

Unit-11: Separation Axioms-I

Separation axioms – T_0, T_1, T_2, T_3, $T_{3/2}$, regular space, completely regular space, their characterizations and basic properties.

Unit-12: Separation Axioms-II

Separation axioms: normal space, completely normal space, T_4 and T_5, their characterizations and basic properties. Urysohn's lemma and Teitze Extension Theorem, Urysohn's Metrization Theorem.

Unit-13: Connectedness

Separated Sets, Connected Set, Disconnected Set, Connectedness on the Real Line, components, Maximal Connected Set, Locally Connected Space and Totally Disconnected Set.

Unit-14: Compactness

Cover, Open Cover, Compact Space, Compact Set, Finite Intersection Property, Locally Compact Space, Lindelof Space, Bolzano Weierstrass Property, Sequentially Compact, Uniformly Continuous, Lebesgue Covering Lemma, Heine-Borel Theorem, Product Topology, Projection Mappings.

PGED-02 Entrepreneurship Development

Block-1: Basic Concepts

Unit-1:
Meaning, Definition and concept of Enterprise, Entrepreneurship and Entrepreneurship Development.

Unit-2:
Evolution of Entrepreneurship, Theories of Entrepreneurship. Characteristics and Skills of Entrepreneurship.

Unit-3:
Concepts of Entrepreneurship, Entrepreneur v/s Entrepreneur, Entrepreneur Vs. Entrepreneurship, Entrepreneur Vs. Manager.

Unit-4:
Role of Entrepreneurship in Economic Development, Factors affecting Entrepreneurship, Problems of Entrepreneurship.

Block-2: Entrepreneurial Competency, Mobility and Motivation

Unit-5:
Meaning and concept of Entrepreneurial Competency, Developing Entrepreneurial Competencies, Entrepreneurial Culture.

Unit-6:
Entrepreneurial Mobility, Factors affecting Entrepreneurial mobility, Types of Entrepreneurial mobility.

Unit-7:
Entrepreneurial Motivation: Meaning and concept of Motivation, Motivation theories.

Unit-8:
Entrepreneurship Development Program: Needs and Objectives of EDPs, Phases of EDPs, Evaluation of EDPs.

Block-3: Role of Government and its Organization

Unit-9:
Role of Government in promoting Entrepreneurship, MSME policy in India.

Unit-10:
Agencies for Policy Formulation and Implementation: District Industries Centers (DIC).

Unit-11:
Small Industries Service Institute (SISI), Entrepreneurship Development Institute of India (EDII).

Unit-12:
National Institute of Entrepreneurship & Small Business Development (NIESBUD), National Entrepreneurship Development Board (NEDB).

Unit-13:
Financial Support System: Forms of Financial support, Long term and Short term financial support, Sources of Financial support, Development Financial Institutions, Investment Institutions.

Block-4: Women Entrepreneurship

Unit-14:
Women Entrepreneurship: Meaning, Characteristic features, Problems of Women Entrepreneurship in India, Developing Women Entrepreneurship in India.

Unit-15:
Concept of Social Enterprise and Social Entrepreneurship, Social Entrepreneurs, Sustainability Issues in Social Entrepreneurship, Rural Entrepreneurship, Family Business.

Unit-16:
Entrepreneurship, Concepts of Entrepreneurship Failure, Issues of Entrepreneurial failure, Fading of Entrepreneurial success among once leading corporate groups.

Unit-17:
Entrepreneurial resurgence, Reasons of Entrepreneurial Failure, Essentials to Avoid Unsuccessful Entrepreneurship.

Block-5: Project Management and Evaluation

Unit-18:
Forms of Business Ownership, Issues in selecting forms of ownership.

Unit-19:
Environmental Analysis, Identifying problems and opportunities, Defining Business Idea, Planning Business Process.

Unit-20:
Project Management: Concept, Features, Classification of projects, Issues in Project Management, Project Identification, Project Formulation, Project Design and Network Analysis.

Unit-21:
Project Evaluation, Project Appraisal, Project Report Preparation, Specimen of a Project Report.

Second Year

3rd SEM	PGMM-111N/ MAMM-111N	Advanced Differential Equations	4	100
	PGMM-112N/ MAMM-112N	Functional Analysis	4	100
	PGMM-113N/ MAMM-113N	Measure Theory and Integration	4	100
	PGMM-114N/ MAMM-114N	Theory of Probability	4	100
	PGRT-03	Basic Research Tools	4	100
Total Credit of 3rd Semester			20	
4th SEM	PGMM-116N/ MAMM-116N	Operation Research	4	100
	PGMM-117N/ MAMM-117N	Fluid Dynamics	4	100
	PGMM-122N/ MAMM-122N	Dissertation with Viva-voce	4	100
	Select any one of the following			
	PGMM-118N/ MAMM-118N	Soft Computing	4	100
	PGMM-119/ MAMM-119	Number Theory and Cryptography	4	100
	Select any one of the following			
	PGMM-120N/ MAMM-120N	Machine Learning Techniques	4	100
	PGMM-121N/ MAMM-121N	Vedic Mathematics	4	100
Total Credit of 4th Semester			20	

III SEMESTER

PGMM-111N/MAMM-111N: Advanced Differential Equations

Block-1: Ordinary Differential Equations

Unit-1: Power Series-I

Introduction to power series method, Ordinary points, Series solutions about ordinary points.

Unit-2: Power Series-II

Introduction, Singularities, Regular and Irregular singular points, Frobenius method, Series solutions about regular singular points.

Unit-3: Legendre's Function

Introduction, Legendre's function, generating function, orthogonal properties of Legendre's function, recurrence relations, Rodrigues's formula.

Unit-4: Bessel's Function

Introduction, Bessel's Function of first and second kind, generating function, orthogonal properties of Bessel's function, recurrence relations.

Block-2: Partial Differential Equations of First Order

Unit-5: Partial Differential Equations of First Order and First Degree

Introduction to Partial Differential Equations, Order and Degree of Partial Differential Equations, Derivation of Partial Differential Equations.

Unit-6: Lagrange Method

Introduction, Standard form of Linear Partial Differential Equations of order one, Lagrange method for solving first order Partial Differential Equations.

Unit-7: Standard Form

Introduction, Non-linear Partial Differential Equations, Standard form, Standard forms-I, II, III & IV (Clairaut's form).

Unit-8: Charpit's Method

Introduction, Charpit's method for first order Partial Differential Equations, working procedure for solving Partial Differential Equations using Charpit's Method.

Block-3: Partial Differential Equations of Higher Order

Unit-9: Partial Differential Equations of Higher Order-I

Introduction, Partial differential equations of higher order, classification of linear Partial differential equations, Separation of variable method.

Unit-10: Partial Differential Equations of Higher Order-II

Introduction, Two dimensional Laplace equation in Cartesian coordinates, one dimensional Heat equation, one dimensional Wave equation.

Block-4: Difference Equations and Calculus of Variations

Unit-11: Introduction to Difference equations

Introduction to difference equations, order and degree of difference equations, formulation of difference equations.

Unit-12: Applications of Difference Equations

Introduction, Linear difference equations, homogeneous linear difference equations with constant coefficient, non-homogeneous linear difference equations with constant coefficient.

Unit-13: Calculus of Variations-I

Introduction, functional, Euler's equation, equivalent forms of Euler's equation, solution of Euler's equations.

Unit-14: Calculus of Variations-II

Introduction, Strong and weak variations, isoperimetric problems, variational problems involving several dependent variables, functional involving second order derivatives.

PGMM-112N/MAMM-112N: Functional Analysis

Block-1: Vector Space and Normed Linear Space

Unit-1: Vector Space

Introduction, Vector or Linear Space, linear subspace, linear combination, linear span, linear dependence and linear independence, basis, finite and infinite dimensional vector spaces, dimension of a subspace.

Unit-2: Normed Linear Space

Normed linear space, sequence of series, l^p space, l^∞ space, unit sphere, closed and open ball, subspace of a Banach space.

Unit-3: Completeness

Introduction, completeness, closeness, equivalent norms, completeness and finite dimension, compactness, Friesz's lemma.

Unit-4: Linear Operators

Introduction, linear operators, null space, linear operator, identity operator, zero operator, inverse of a linear operator, bounded linear operator.

Unit-5: Linear Functional

Continuity and null space, linear functional, bounded linear functional, dot product, algebraic dual space, isomorphic.

Unit-6: Hilbert Spaces

Inner product spaces, Hilbert spaces, some properties of Hilbert spaces, orthonormal sets, conjugate space and adjoint of an operator.

Block-2: Fixed Point Theory

Unit-7: Banach Fixed Point

Introduction, Banach fixed point, contraction, Banach fixed point theorem, Kannon contraction

theorem, Reich contraction, Hardy and Rogers's contraction theorem.

Unit-8: Applications of Banach Theorem-I

Applications of Banach theorem to linear equations, Applications of Banach theorem to differential equations.

Unit-9: Applications of Banach Theorem-II

Picard's existence and uniqueness theorem, Applications of Banach theorem to integral equations.

Unit-10: Approximation in Normed Spaces

Introduction, best approximation, polynomials, uniqueness, convexity.

Unit-11: Housdorff Space

Introduction, distance, Housdorff metric space, Nadler's contraction theorem.

Block-3: Applied Functional Analysis

Unit-12: Differentiation and Integration in normed space

Integration, Gateaux derivative, Frechet derivative, Bochner integral.

Unit-13: Spectral Theory of Linear Operators in Normed Space-I

Introduction, Eigen values and Eigen vectors, resolvent set of a matrix, resolvent operators, regular value, resolvent set, spectrum.

Unit-14: Spectral Theory of Linear Operators in Normed Space-II

Introduction, spectral properties of bounded linear operators, holomorphic, local holomorphy.

PGMM-113N/MAMM-113N: Measure Theory and Integration

Block-1: Set Theory

Unit-1: Sets

Introduction, Representation of sets, types of sets, subset, universal set, Venn diagram, operations on sets, and algebra of sets.

Unit-2: Relations

Introduction, ordered pairs, representation of relations, types of relations, inverse relation, equivalence relation, and partial order relation.

Unit-3: Functions

Introduction, types of functions, inverse function, identity function, constant function, composition of functions, real valued function.

Unit-4: Countability of Sets

Introduction, Cardinality of a set, Schroder-Bernstein's equivalence theorem, Finite and infinite sets, countable and uncountable sets, cardinal numbers, Cantor's theorem, Continuum hypothesis, Algebraic and Transcendental numbers.

Unit-5: Advanced Set Theory

Introduction, Axiom of choice, Zorn Lemma, ordinal numbers.

Unit-6: Open and Closed Sets

Introduction, Open Sets, closed sets, Bolzano-Weierstrass theorem.

Block-2: Lebesgue Measure

Unit-7: Measure

Introduction, Length of an interval, measure of interval, Borel set, Boolean Ring, Boolean algebra, measure, Outer Measure, Carathedory's Postulates for Outer Measure.

Unit-8: Lebesgue Measure

Introduction, Exterior Measure, Measurable space and Measurable sets, First Fundamental Theorem, Interior Measure, Cantor's Ternary set.

Unit-9: Measurable Functions

Introduction, Measurable function, Borel Measurability, pointwise convergence, convergence in measure, Uniform convergence, F. Riesz theorem, Egoroff's theorem and Lusin's theorem.

Block-3: Lebesgue Integral

Unit-10: Lebesgue Integral

Introduction, Riemann Theory of Integral, Lebesgue integral, First Mean Value Theorem, Lebesgue Bounded Convergence Theorem, Fatou's Lemma, Monotone convergence Theorem, Beppo-Levi's Theorem and Lebesgue Dominated Convergence Theorem.

Unit-11: Differentiation and Integration

Introduction, Vitali's Lemma, Function of bounded variation, Fundamental Theorem of Integral Calculus, Lebesgue point and Lebesgue set.

Unit-12: The L^p -Space

Introduction, Conjugate number, Riesz-Holder's Inequalities, Cauchy-Schwarz's Inequality, Minkowski's Inequality, L^p -space, Convergent sequence and Cauchy sequence, Properties of L^p -spaces.

Block-4: Signed measures and Product measures

Unit-13: Signed measures

Introduction, Signed measures, Elementary properties, Hahn Decomposition theorem, Lebesgue Decomposition theorem, Radon Nikodym theorem, some important results.

Unit-14: Product measures

Introduction to product measures, Fubini's theorem, Tonelli's theorem.

PGMM-114N/MAMM-114N: Theory of Probability

Block-1: Introduction to Probability Theory

Unit-1: Random experiments and Probability

Deterministic and random experiments, Sample space, Events, Algebra of Events, Axiomatic definition of Probability, Classical definition of Probability, Statistical definition of probability, Addition Theorem of Probability.

Unit-2: Conditional Probability

Conditional probability, Multiplicative theorem of Probability, Independent events, Partition of sample space, Baye's Theorem.

Block-2: Probability Distributions and Expectations

Unit-3: Random Variables and Probability Distributions

Definition and types of random variables, Cumulative distribution function and its properties, Probability Mass Function, Probability Density Function.

Unit-4: Expectation

Definition and types of Mathematical Expectation, Moments in terms of expectation, Mathematical and Multiplication theorems of Expectation, other theorems on expectation.

Unit-5: Inequalities for Moments

Cauchy-Schwartz Inequality, Markov's inequality, Chebyshev's inequality.

Block-3: Concept of Probability Distributions

Unit-6: Univariate Distributions

Bernoulli Distribution, Binomial Distribution, mean and variance of binomial distribution, Moments, Moments Generating Function, Additive and Multiplicative property, Recurrence relation for moments, Fitting of Binomial Distribution, Poisson Distribution, Poisson Distribution as a limiting case of Binomial Distribution, mean and variance of Poisson distribution, Moments, Moment Generating Function, Additive and Reproductive property, Recurrence relation for moments, fitting of Poisson Distribution.

Unit-7: Discrete Distributions

Geometric Distribution, mean and variance, moment generating function of geometric distribution, Negative Binomial Distribution, Moment Generating Function, Mean and Variance, Recurrence formulae for negative Binomial Distribution, Poisson Distribution as a limiting case of Negative Binomial Distribution, Hyper Geometric Distribution, Mean and Variance, Recurrence relation for Hyper Geometric distribution.

Unit-8: Normal Distribution

Normal Distribution and its parameters, Standard Normal Distribution, Moments, Moments Generating Function, Area Property, properties of normal curve, Standard Scores, Advantages and Characteristics of Z Scores.

Unit-9: Continuous Distributions

Uniform Distribution, Moment Generating Function, Distribution Function, Moments of Uniform Distribution, Exponential Distribution, Moments, Moment Generating Function, Lack of Memory Property.

Unit-10: Sampling Distribution

Sampling distribution of a statistic, Parameter, Derivation of χ^2, t, F, z distributions, Beta, Gamma, Cauchy densities.

Block-4: Basic Principles of Statistical Inference

Unit-11: Estimation

Point Estimation, properties of a good estimators, Consistency, Unbiasedness, Efficiency, Sufficiency, Confidence Interval Estimation.

Unit-12: Method of Estimation

Procedures of Estimation, Method of Moments, method of Maximum Likelihood, Method of Scoring, Properties of Estimators.

Unit-13: Testing of Hypothesis

Statistical Hypothesis, Simple and Composite Hypothesis, Critical Region, Two kinds of Error, One-tailed and Two-tailed tests, Test of Significance, Most Powerful Test, Uniformly Most Powerful Test.

Block-5: Test of Significance

Unit-14: Exact Tests and Fisher's transformations

Tests of Significance based on Chi-Square Distribution, Tests of Significance based on t–Distribution, Tests of Significance based on F–Distribution, Tests of Significance based on Fisher's Z–Distribution.

Unit-15: Large Sample Tests

Testing Significance of Mean, Testing Equality of Means, Testing Significance of Proportion, Testing Equality of Proportions, Testing Significance of Standard Deviation, Testing Equality of Standard Deviation.

Unit-16: Non-Parametric Tests

Non Parametric Tests, Sign Test, Wilcoxon Signed- Rank Test, Mann- Whitney U-Test, Run Test.

PGRT-03: Basic Research Tools

Block-1: Introduction to Research Tools

Unit-1: Types and Methods of Data Collection

Meaning and concept of data, Types of data- primary and secondary, Introduction of data collection, Sources of data collection, Collection of Primary Data.

Unit-2: Sampling Design

Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selection of Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs.

Unit-3: Tools and Techniques of Data Collection

Tools of Primary data collection, -Observation, -Interview, -Questionnaire, -Schedules, -Checklist, Collection of secondary data.

Unit-4: Data Classification and Tabulation

Introduction, Classification of Data, Basis of Classification, Frequency Distribution, Tabulation of Data, Objectives of Tabulation.

Unit-5: Data Presentation

Graphical Presentation of Data, Functions of a Graph, Advantages and Limitations of Diagrams (Graph), General and Summary Tables, Types of Diagrams, One Dimensional Diagrams, Two Dimensional Diagrams, Three-Dimensional Diagrams.

Unit-6: Processing and Analysis of Data

Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship.

Unit-7: Fundamentals in Inferential Research

Research Hypothesis- Meaning, types and characteristics, Formulation of hypothesis, Concept of hypothesis testing, Measuring the power of hypothesis testing, Types of errors in hypothesis testing.

Unit-8: ICT Application in Research

Role of computer in knowledge management, Open Education Resource and Research, using word processing software- MS Word/Latex/others, data analysis, drawing graphs and diagrams through computer, Know how of power point presentation and MS-Excel.

Unit-9: Application of MS Office/Latex in research

Uses and application of MS Office (Documentation and Formatting)/ Latex Tools with MS-XL (Making Tabular data, charts & formatting, Use of general functions & formulae), Power point Presentation (Creating own design, design & formatting of a presentation, Use of Image, audio, video in the presentation.

Unit-10: Application of Software's

Uses and application of Softwares such as plagiarism software, Chem-Draw, Origin, SPSS, R-software, Uses and application of Softwares Octave, Matlab, Mercury, etc..

Unit-11: Reference management tools

Uses and application of Mendeley-software, EndNote, RefWorks and Zotero, etc..

Fourth Semester

Operation Research	**4**	**100**
Fluid Dynamics	**4**	**100**
Dissertation with Viva-voce	**4**	**100**
Select any one of the following		
Soft Computing	**4**	**100**
Number Theory and Cryptography	**4**	**100**
Select any one of the following		
Machine Learning Techniques	**4**	**100**
Vedic Mathematics	**4**	**100**
Total Credit of 4th Semester	**20**	

IV SEMESTER

PGMM-116N/MAMM-116N: Operations Research

Block-1: Introduction to Operations Research

Unit-1: History of Operations Research

Introduction, Historical development, Scope and phases of Operation Research, applications of operations research.

Unit-2: Simplex method

Introduction, Simplex method, Computational procedure for solving linear programming problem by Simplex method.

Unit-3: Big-M and Two-Phase Method

Introduction, Big-M method, Two-Phase method, Difference between Big-M method and Two-Phase method.

Block-2: Revised Simplex Method and Sensitivity Analysis

Unit-4: Revised Simplex method

Introduction, Revised Simplex method, Computational procedure for solving linear programming problem by Revised Simplex method.

Unit-5: Duality in Linear Programming Problem

Introduction, Symmetric form, dual of linear programming problem, primal dual relationship, fundamental theorem of duality, Dual Simplex method.

Unit-6: Sensitivity Analysis

Introduction, Sensitivity analysis, Change in c_{ij}'s (the coefficients of x_{ij}'s in the objective function), Change in b_{ij}'s (the right hand side of constraints), Change in a_{ij}'s (the columns of coefficient matrix, deletion and addition of constraints, deletion and addition of decision variables.

Block-3: Applications of Operations Research

Unit-7: Sequencing

Introduction, sequencing, Johnson's algorithm for processing n jobs through two machines, Johnson's algorithm for processing n jobs through k machines, processing two jobs through k machines.

Unit-8: Project Scheduling-I

Introduction, network, project development, network, activity, event, Fulkerson's rule for numbering events.

Unit-9: Project Scheduling-II

Introduction, program evaluation and review techniques, optimum scheduling by critical path method, time-cost optimization algorithm.

Unit-10: Simulation

Introduction, random numbers and pseudo random numbers, Monte Carlo simulation, applications of simulation.

Unit-11: Reliability Theory

Introduction, basic concept of reliability, Hazard rate function, system reliability: series and parallel, redundancy, reliability of preventive maintenance.

Block-4: Models in Operations Research

Unit-12: Inventory Models

Introduction, inventory, inventory control, inventory costs, economics order quantity, deterministic inventory models with shortages.

Unit-13: Queuing Models

Introduction, markovian queues, probability distribution of n arrivals, distribution of inter-arrivals time, birth and death process.

Unit-14: Replacement Models

Introduction, replacement policy model, replacement policy when the value of money does not change with time, replacement policy when the value of money changes with time.

PGMM-117N/MAMM-117N: Fluid Dynamics

Block-1: Motion in One Dimension

Unit-1: Kinematic (Equations of Motion)

Introduction, Hydrodynamics, Shearing stress, Viscosity, Lagrangian method, Eulerian method, Local and Individual time rates of change, Acceleration, Kinds of motion, Definition of some curves, Stream line, Path line, Streak line, Velocity potential, Vorticity vector, Beltrami flow.

Unit-2: Kinematic of Fluid in Motion

Introduction, Boundary surface, Lagrangian and Eulerian Equation of continuity, Equation of Continuity in different co-ordinates, Symmetrical forms of the equation of continuity.

Unit-3: Equation of Motion

Introduction, Equation of motion, Pressure equation, Lagrangian equation of motion, Bernoulli`s equation of motion.

Unit-4: Equation of Motion of Inviscid Fluid

Introduction, Helmholtz vorticity equation, Cauchy`s integrals, Equations for impulsive action, Kelvin`s circulation theorem, Equation of energy.

Block-2: Motion in Two Dimension

Unit-5: Source, Sink & Doublets (I)

Introduction, Motion in two dimension, Lagrange`s stream function, Irrotational motion in two dimensions, Complex potential, Definition of Source, sinks, doublets, Complex potential due to a source, Complex potential due to doublet.

Unit-6: Source, Sink & Doublets (II)

Introduction, Image w.r.t straight line, Images w.r.t. to circle, Circle theorem of Milne –Thomson, Blasius Theorem.

Unit-7: Motion of Sphere

Introduction, Equation of continuity, ϕ for the motion of a sphere with velocity U in a liquid, liquid

streaming past a fixed sphere, Equation of sphere.

Unit-8: Motion of Cylinder

Introduction, General motion of a cylinder, Kinetic energy, motion of circular cylinder, liquid streaming past a fixed circular cylinder.

Unit-9: Motion of Elliptic & Parabolic Cylinder

Introduction, Elliptic co-ordinate, Motion of an elliptic cylinder, liquid streaming past a fixed elliptic cylinder, Motion of a parabolic cylinder, liquid streaming past a fixed parabolic cylinder.

Block-3: Applications of Fluid Dynamics

Unit-10: The Navier Stokes Equations

Introduction, The Navier-stokes equation of motion of a viscous fluid (Fundamental equation of motion).

Unit-11: Energy Equation

Introduction, The energy equation- conservation of energy, Equation of state for perfect fluid, Diffusion of vorticity, equation for vorticity and circulation, Dissipation of energy, Dissipation of energy in Cartesian form.

Unit-12: Elementary Notions of Fluid Flow

Introduction, Body forces and surface forces, Nature of stresses, Transformation of stress components, Stress invariants, Principal stresses, Nature of strains, Rates of strain components, Relation between stress and rate of strain components. General displacement of a fluid element, Newton's law of viscosity, Navier- Stokes equation (sketch of proof).

Unit-13: Normal and Oblique Shock

Introduction, Normal and oblique shocks. Plane Poiseuille and Couette flows between two parallel plates.

Unit-14: Dynamical similarity, Inspection analysis and dimensional analysis

Introduction, Unsteady flow over a flat plate, Reynold's number.

PGMM-122N/MAMM-122N: Dissertation with Viva-voce

Course Objectives:

In the last semester of Masters, the main objectives of the exposure of students towards project/dissertation is to elevate their understanding into the applications areas of Mathematics. This course will develop their analytical ability and will provide them an apt exposure to work in any research group and will motivate them to execute research in the area of their interest in Mathematical sciences.

Course Outcomes:

CO-1. Students will be able to plan and strategize a scientific problem, and implement it within a reasonable time frame.

CO-2. It is expected that after completing this project dissertation, students will learn to work independently and how to keep accurate/readable record of assigned project.

CO-3. In addition, students will be able to know the library search and handle the data in a meaningful way.

CO-4. Also, students will be able to interpret the spectral data independently.

CO-5. Subsequently, the students should be able to critically examine research articles, and improve their scientific writing/communication skills and power point presentation.

For project work and dissertation, the area of the work would be to be decided by the advisor/mentor. On completion of the project work, students have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty members of the School in the University Campus Prayagraj.

PGMM-118N/MAMM-118N: Soft Computing

Block 1: Artificial Intelligence & Soft Computing

Unit-1: Introduction of Artificial Intelligence

Introduction of Artificial Intelligence, Definitions, Theoretical background, AI problem domain, General AI techniques, Underlying assumptions, possible goal of AI, Criteria of success. Problem state, state space, search space, State space representation, Production system, control strategy, water jug problem, 8-puzzle problem, Heuristic searching.

Unit-2: Knowledge Representation in Artificial Intelligence

Knowledge representation model, first order predicate logic, clauses, inference, rule base system, natural deduction and resolution, monotonic reasoning.

Unit-3: Introduction to Reasoning and Soft Computing

Non-monotonic reasoning, uncertainty, Bay's theorem, Bayesian network, dependency network, limitation of probabilistic reasoning, Soft computing definition, soft computing paradigm, applications, Pattern recognition, pattern classification, association and mapping.

Block 2: Fuzzy Set Theory

Unit-4: Introduction to Fuzzy Sets

Introduction of Fuzzy Logic, Uncertainty, Fuzzy set, Crisp vs. fuzzy sets, Membership function, Fuzzy sets and operations, Operations and relations; fuzzy relations, cardinalities, membership functions.

Unit-5: Fuzzy Logic

Fuzzy relations, fuzzy Cartesian product, fuzzy membership function formulation and parameterization, Fuzzy rules and reasoning, Formulation on fuzzy rules, extension principle and nested fuzzy relations.

Unit-6: Fuzzy System

Fuzzy rule base system, Fuzzy if-then rules, fuzzy inference, Fuzzy inference system, Defuzzification methods, Fuzzy control systems, and Applications of Fuzzy control systems.

Block 3: Neural Network

Unit-7 Introduction to Neural Networks

Introduction of neural networks, limitations of Rule based system, characteristics of neural networks, simple structure of biological neuron and modeling of artificial neuron. Difference between ANN and biological neural networks, artificial neuron models, artificial neural networks terminology, topology of ANN, Characteristics of ANN and its applications.

Unit-8: ANN and Perceptron Model

Activation and synaptic dynamics, Basic learning laws, Artificial neural network architectures, Basic artificial neural network models, perceptron architecture, Perceptron learning rule, ADLINE architecture, LMS learning rule, Linear classifier, convergence theorem, limitation of perceptron learning, Multi-layer perceptron architecture.

Unit-9: Feedforward Neural Networks

Pattern mapping network, Multilayer feed forward neural network architecture, Generalized delta learning rule, Backpropagation learning algorithm and issues, limitation of Backpropagation learning rule, improvement in BP algorithms, momentum term, conjugate descent, reuse gradient, generalization and approximation, ill posing, Radial basis network.

Block 4: Genetic Algorithm & Soft Computing

Unit-10: Introduction to Genetic Algorithm

Introduction of Genetic algorithm, Fundamental and basic concepts, terminology, Applications and advantages, Representation of chromosomes and gens, Population representation, working principle, search space, solution state, global vs local optimization, encoding methods.

Unit-11: Population Representation, Selection Criteria and Methods

Population representation, selection criteria and methods, fitness evaluation function, reproduction, basic genetic operators, Mutation, selection, crossover. Fitness criteria, convergence of GA, combinatorial optimization.

Unit-12: Problem Solution and Genetic Modelling

Problem solution and Genetic modeling, inheritance operator, crossover operator and its various forms, inversion & deletion, mutation operator, bitwise operator, Generation cycle, Differences & similarities between GA & other traditional method.

PGMM-119N/MAMM-119N: Number Theory and Cryptography

Block-1 Introduction to Number Theory

Unit-1: Divisibility

Introduction, Definition of divisibility, the division algorithm, Greatest common divisor, Euclidean algorithm in Z, Diophantine equation ax + by = C, Primes and their distribution, Fundamental Theorem of Arithmetic.

Unit-2: Congruence's

Introduction, Congruence's, Properties of Congruence's, linear congruence's, Special divisibility tests, Fermat's factorization method, Fermat's little theorem, Wilson's theorem.

Unit-3: Theoretical Function-I

Introduction, Definition and properties of the Dirichlet's product, Arithmetic and Number theoretic functions, functions τ and σ.

Unit-4: Theoretical Function-II

Introduction, Mobius Inversion formula, greatest integer function, Euler's Generalization of Fermat's theorem, Euler's $\phi(n)$ function, Euler's theorem, properties of $\phi(n)$ function.

Unit-5: Primitives

Introduction, Primitive roots, the order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, the theory of Indices.

Block-2: Fermat Numbers

Unit-6: Fermat numbers and Mersenne numbers

Introduction, Primes in certain arithmetical progressions, Fermat numbers and Mersenne numbers, System of linear congruence's Chinese Remainder Theorem, Congruence to prime power modulus.

Unit-7: Quadratic residue and non-residue

Introduction, Legendre's Symbol, Gauss Lemma and its applications, Quadratic Law of Reciprocity Jacobi's Symbol, arithmetic in Zp, group Un, Primitive roots, group Upn (p-odd) and U_2n, existence of primitive roots, group of quadratic residue, Quadratic residue for prime power modulii and arbitrary modulii.

Unit -8: Riemann Zeta Function

Introduction, Riemann Zeta Function $\xi(s)$ and its convergence, Application to prime numbers, ξ (s) as Euler's product, Evaluation of $\xi(2)$ and $\xi(2k)$, Dirichlet's series with simple properties, Dirichlet's series as analytic function and its derivative, Euler's products, Introduction to modular forms.

Block-3: Algebraic Number Theory

Unit-9 Diophantine equations

Introduction, Diophantine equations, $x^2 + y^2 = z^2$ and $x^4 + y^4 = z^4$, representation of number by two or four squares, Waring's problem, Four square theorem, number g(k) & G(k), Lower bounds for g(k) & G(k).

Unit-10: Algebraic number and Integers

Introduction, Gaussian integers and its properties, Primes and fundamental theorem in the ring of Gaussian integers, Integers and fundamental theorem in $Q(\omega)$ where ω is third root of unity, algebraic fields.

Unit-11: Primitive polynomials

Introduction, Primitive polynomials, general quadratic field $Q(\sqrt{m})$, Units of $Q(\sqrt{2})$, Fields in which fundamental theorem is false, Real and complex Euclidean fields, Fermat's theorem in the ring of Gaussian integers, Primes of Q(2) and Q(5), Luca's test for the primality of the Mersenne number.

Block-4: Cryptography

Unit-12: Public Key Cryptography

Introduction, Public-Key Cryptography Principles, RSA, Key Management: Diffi-Hellman key exchange.

Unit-13: Message Authentication and Hash Functions

Introduction, Authentication requirements, Authentication Functions, Message Authentication codes, Hash Functions, SHA-1 and MD5.

Unit-14: Digital Signatures

Introduction, Digital signatures, Authentication protocols, Digital Signature standard.

PGMM-120N/MAMM-120N: Machine Learning Techniques

Block 1: Artificial Intelligence & Soft Computing

Unit-1: Introduction

What is machine learning; Types of learning, Problems, Definition of learning systems. Goals and applications of machine learning. Aspects of developing a learning system: training data, concept representation, function approximation.

Unit-2: Computational Learning Theory

Data, probably approximately correct (PAC) learning model, Probabilistic Data Model, Loss Function and Expected Risk, Stability, Overfitting, Regularization, Bias variance, Cross validation, Nearest centroid, Least squares. Computational complexity.

Unit-3: Memory based methods

Nearest neighbour, k-nearest neighbours, Feature maps, Representer theorem, Kernels, Hypothesis space, Loss function, Target function.

Unit-4: Regression

Introduction to regression, usage of regression, types of regression, linear regression, Multi-linear regression, Logistic regression, Polynomial regression, Ridge and Lasso regression, Evaluation of regression.

Unit-5: Classification

Introduction to classification, Multi-class classification, Decision boundaries; Probability and classification, Bayes optimal decisions, Naive Bayes and Gaussian class-conditional distribution, Linear classifiers, Bayes' Rule and Naive Bayes Model, Gradient descent.

Unit-6: Decision Tree Learning

Representing concepts as decision trees, Recursive induction of decision trees, Picking the best splitting attribute: entropy and information gain, Searching for simple trees and computational complexity, Overfitting, noisy data, and pruning.

Unit-7: Ensemble Learning

Standard ensemble learning strategies, Bagging, Boosting, Stacking, Decorate, Active learning with

ensembles, Boosting: Concept of boosting, weak learnability, AdaBoost, AdaBoost for classification, Model selection, Validation, Train-validation split, Regularization, Stability.

Unit-8: Bagging and Random Forest

Bagging for classification, Issues with Bagging, Introduction to Random forest, Bagging vs. Random Forest, Out-of-Bag (OOB) error estimation, Variable importance measures, Majority voting, Soft Majority Voting, Random Forest Algorithm, Tuning random forest, Random forest issues.

Unit-9: Support Vector Machines

Support vectors, Hyperplane, Kernel for learning non-linear functions, Different types of kernels, Parameter tuning, Generative vs. discriminative training, Multi-class support vector machine (SVM), SVM for classification, Support vector for regression.

Unit-10: Clustering and Unsupervised Learning

Learning from unclassified data. Clustering. Hierarchical Aglomerative clustering, k-means clustering, partitional clustering, Expectation maximization (EM) for soft clustering, Semi-supervised learning with EM using labeled and unlabled data.

Unit-11: Language Learning

Classification problems in language: word-sense disambiguation, sequence labeling. Hidden Markov models (HMM's). Veterbi algorithm for determining most-probable state sequences. Forward-backward EM algorithm for training the parameters of HMM's. Use of HMM's for speech recognition, part-of-speech tagging, and information extraction.

Unit-12: Programming Languages for Machine Learning

Python Ecosystem for Machine Learning: Python, SciPy, scikit-learn, Python Ecosystem Installation. Crash Course in Python: Assignment, Flow Control, Data Structures. NumPy Crash Course: Create Array, Access Data, and Arithmetic. Matplotlib Crash Course: Line Plot, Scatter Plot. Pandas Crash Course: Series, Data Frame.

PGMM-121N/MAMM-121N: Vedic Mathematics

Block 1: Indian Mathematicians and their contributions

Unit-1: Contribution of the Indian Mathematicians-I

(1) Baudhayana (2) Aryabhata (3) Varahmihir

Unit-2: Contribution of the Indian Mathematicians-II

(1) Bhaskarachaarya-II (2) Srinivas Ramanujan (3) Bharti Krishna Tirtha.

Block 2: Vedic Arithmetic

Unit-3: Basic Vedic Mathematics

Introduction, Vedic Mathematics Sutra and Subsutra with explanation.

Unit-4: Introduction of Vedic Mathematics

Introduction, Sankalan, Vyavkalan, Friend and Fast Friend, Complements, Beejank, Deviation Methods.

Unit-5: Simple Calculation on Vedic Mathematics

Introduction, Forward Counting, Backward Counting, Addition, Subtraction, Vinculum, Tables Writing, Introduction to Meruprastara.

Unit-6: Multiplication in Vedic Mathematics

Introduction, Multiplication by Vedic Sutras (ekadhikenpurvena, vertically and crosswise etc.).

Unit-7: Division in Vedic Mathematics

Introduction, Division by Vedic Sutras, Flag Method,Test of Divisibility.

Unit-8: Squaring and Cubing Method

Introduction, Square of Numbers and Square roots of perfect square numbers. Cubing: Cube of Numbers and Cube roots of perfect cube numbers, mixed operation.

Block 3: Vedic Algebra

Unit-9: Introduction to Vedic Algebra

Introduction, Addition, Subtraction, Multiplication, Division of Algebraic Expression, Mixed operations in Vedic algebra.

Unit-10: Introduction to Partial Fractions

Introduction, LCM, HCF of algebraic expressions, Partial Fractions.

Unit-11: Solution of Algebraic Equations

Introduction, Solution of linear, quadratic, cubic equations.

Block 4: Vedic Geometry, Trigonometry and Calculus

Unit-12: Baudhayana Numbers

Introduction, Baudhayana triplet of angle, multiplication of triplet by constant, triplet of compliment angle, triplet of the sum and difference of angles. Baudhayana Numbers and its application to find trigonometrical ratios and identities.

Unit-13: Vedic Co-ordinate Geometry

Introduction, Baudhayana form of Co-ordinate, Introduction of line and its Baudhayana form, angle between two lines, perpendicular distance from points to line.

Unit-14: Introduction of Vedic Mathematics in Calculus

Introduction of Differentiation and Integration, derivative of sum and product, applications in derivative, integration by parts, integration using partial fractions.