MANGALAYATAN UNIVERSITY, ALIGARH

CENTRE FOR DISTANCE AND ONLINE EDUCATION

PROGRAMME PROJECT REPORT

MASTER OF SCIENCE (MATHEMATICS)

2023-24

Registrar
Mangalayatan University
Beswan, Aligarh

M.Sc. (Mathematics)

Introduction

Master of Science in Mathematics (M.Sc. Mathematics) is a postgraduate program that focuses on advanced mathematical concepts and theories. This program is designed to help students develop a deep understanding of various mathematical principles and their applications in diverse fields such as engineering, physics, computer science, and finance. The curriculum includes topics such as advanced calculus, algebra, topology, number theory, and probability theory, among others. Students pursuing M.Sc. in Mathematics learn how to use mathematical models to solve real-world problems and develop critical thinking and analytical skills. Graduates of this program are well-equipped to pursue careers in academia, research, data analysis, finance, and many other fields that require strong quantitative skills.

M.Sc. Mathematics students are trained to work independently and collaboratively on research projects, helping them to develop valuable teamwork and communication skills. They are exposed to modern mathematical tools and techniques, such as computer simulations and programming languages, which further enhances their problem-solving abilities. This program also encourages students to apply their knowledge in practical settings, allowing them to develop innovative solutions to complex problems. This is a challenging and rewarding program that provides students with a strong foundation in mathematics and prepares them for a wide range of exciting career opportunities.

A. Programme's Mission and Objectives

Mission

- To cater and ensure excellent theoretical and practical training through teaching, counseling, and mentoring with a view to achieve professional and academic excellence.
- To connect with industry and incorporating knowledge for research enhancement.
- To generate, disseminate and preserve knowledge for the benefit and betterment of society.

Objectives

M.Sc. in Mathematics programme aims to provide students with advanced mathematical skills and knowledge in areas such as algebra, analysis, topology, geometry, and applied mathematics. The programme aims to develop students' skills in mathematical analysis, problem-solving, logical reasoning, and critical thinking. Additionally, it offers advanced coursework in specialized areas of mathematics such as algebra, topology, geometry, number theory, and applied mathematics. The programme also aims to provide students with the skills required to carry out independent research in mathematics, including skills in literature review, mathematical modeling, data analysis, and technical writing. Furthermore, the program prepares students for further studies in mathematics, including Ph.D. programmes or research-based careers in academia, industry, or government. Ultimately, the programme aims to prepare students for a wide range of career opportunities, including roles in academia, research, industry, finance, technology, and government, by providing them with the necessary skills and knowledge to succeed in these fields.

B. Relevance of the Programme with HEI's Mission and Goals

The vision and mission of HEI, Mangalayatan University, Aligarh are:

Vision:

To be an institution where the most formative years of a young mind are spent in the guided pursuit of excellence while developing a spirit of inquisitive questioning, an ability to excel in the pressure of a fast-changing professional world, and a desire to grow into a personality

rather than a person, in an environment that fosters strong moral and ethical values, teamwork, community service and environment consciousness.

Mission:

- To be the enablers of the confluence of academic rigor and professional practicality.
- To bring global best practices to students through widespread use of technology.
- To empower our faculty to constantly develop new skills and excel professionally.
- To provide the best campus environment to students and faculty with all facilities to nurture their interest.

M.Sc. (Mathematics) programme of the University strives to realize its vision and mission by rectifying student centric issues on priority and also to empower local community with the help of various social clubs running in University like NSS, KADAM and Alumni association. The University promotes multidisciplinary and allied research in various fields that supports and harnesses joyful learning environment. The goals of ODL (Open Distance Learning) program is to provide educational facilities to all qualified and willing persons who are unable to join regular courses due to personal or professional reasons. There are many potential learners who cannot afford to join regular courses due to professional responsibilities and personal commitments. For such cases M.Sc. (Mathematics) through ODL mode can be helpful in increasing knowledge base and skill up-gradation.

The program aims to provide alternative path to wider potential learners who are in need of refresher courses to update their skills.

C. Nature of Prospective Target Group of Learners

Distance Education of Mangalayatan University (MU) shall target the working professional's executives as well as those who cannot attend a full-time program due to prior occupation or other assignments. The candidates desirous of taking admission in M.Sc. (Mathematics) program shall have to meet the eligibility norms as follows-

1. To obtain admission in M.Sc. (Mathematics) program offered through ODL mode.
2. The learner must have completed graduation in science stream (PCM/PCMB).

D. Appropriateness of Programme to be conducted in ODL mode to acquire specific skills and competence

The University has identified the following **Programme Outcomes** and **Programme Specific Outcomes** as acquisition of specific skills and competence in M.Sc. (Mathematics) Program.

Programme Outcomes (PO's)

After completing the M.Sc. (Mathematics) programme through ODL Mode, students will be able to:

a. PO1: Knowledge outcomes: Acquire knowledge and ability to develop creative solutions, and better understanding of the future developments of the subject. Also, evolve analytical and logical thinking abilities.
b. PO2: Skill Outcomes: Learn and understand the new concepts and get prepared for placement by developing scientific skills. Further ability to communicate scientific information in a clear and concise manner.

c. PO3: General Competence: Be able to understand the role of science in solving real life problems and get an ability to participate in debates and discussions constructively.
d. PO4: Scientific Aptitude and Innovation: Know the recent developments, future possibilities and able to gather, assess, and make use of new information and applying this knowledge to find creative solutions.

Programme Specific Outcomes:

After completing the M.Sc. (Mathematics) programme through ODL Mode, students will be able to:

a. PSO1: Evaluate hypotheses, theories, methods and evidence within their proper contexts.
b. PSO2: Select, interpret and critically evaluate information from a range of sources that include books, scientific reports, journals, case studies and the internet.
c. PSO3: Develop proficiency in the analysis of complex problems and the use of mathematical techniques to solve them.
d. PSO4: Provide a systematic understanding of the concepts and theories of mathematics and their application in the real world – to an advanced level, and enhance career prospects in a huge array of fields.

E. Instructional Design

The program is divided into four semesters and minimum credit requirement is 80 to get M.Sc. (Mathematics) degree in ODL mode from Mangalayatan University. Minimum time period for acquiring M.Sc. (Mathematics) degree will be two years and maximum time period to acquire is 4 years.

Evaluation Scheme

Semester-I							
S. No.	**Course Code**	**Course Name**	**Category**	**Credit**	**Continuous Assessment Marks**	**Term End Exam Marks**	**Grand Total**
					Max. Marks	**Max. Marks**	
1	MAL-6111	Abstract Algebra	DCC	4	30	70	100
2	MAL-6112	Classical Mechanics	DCC	4	30	70	100
3	MAL-6113	Partial Differential Equations	DCC	4	30	70	100
4	MAL-6114	Real Analysis	DCC	4	30	70	100
5	MAL-6115	Computer Graphics	SEC	4	30	70	100
6	MAP-6111	Computer Graphics Lab	SEC	2	0	100	100
Total				22	150	450	600

Semester-II							
S. No.	**Course Code**	**Course Name**	**Category**	**Credit**	**Continuous Assessment Marks**	**Term End Exam Marks**	**Grand Total**
					Max. Marks	**Max. Marks**	
1	MAL-6211	Operations Research	DCC	4	30	70	100
2	MAL-6212	General Topology	DCC	4	30	70	100
3	MAL-6213	Complex Analysis	DCC	4	30	70	100
4	MAL-6214	Numerical Methods	DCC	4	30	70	100
5	MAL-6215	Programming in C	SEC	4	30	70	100
6	MAP-6211	Programming in C Lab	SEC	2	0	100	100
Total				22	150	450	600

Semester-III							
S. No.	**Course Code**	**Course Name**	**Category**	**Credit**	**Continuous Assessment Marks**	**Term End Exam Marks**	**Grand Total**
					Max. Marks	**Max. Marks**	
1	MAL-7111	Research Methodology	GE	6	30	70	100
2	MAL-7112	Axiomatic Set Theory	DCC	4	30	70	100
3	MAL-7113	Functional Analysis	DCC	4	30	70	100
4	MAL-7114	Integration Theory	DCC	4	30	70	100
5	MAL-7115	Measure Theory	DCC	4	30	70	100
Total				22	150	350	500

Semester-IV							
S. No.	**Course Code**	**Course Name**	**Category**	**Credit**	**Continuous Assessment Marks**	**Term End Exam Marks**	**Grand Total**
					Max. Marks	**Max.**	

						Marks	
1	MAL-7211	Mathematical Statistics	DCC	4	30	70	100
2	MAL-7212	Graph Theory	GE	4	30	70	100
3	MAD-7211	Project	DCC	6	0	100	100
Total				14	60	240	300

MOOCs

The University shall give flexibility in opting for MOOCs (Massive Online Open Courses) by the students pertaining to the prescribed curriculum and also the credits earned in the MOOCs may be dealt as part of the evaluation scheme as per UGC (Open and Distance Learning Programmes and Online Programmes) Regulations,2020.

Syllabi and Course Materials

Syllabi, PPR and self-learning materials are developed mostly by experienced faculty members of Mangalayatan University in consultation with contents experts and the same will be forwarded to CIQA and BoS/Academic Council/ Executive Council for further suggestions and approval.

Semester: I

Course Name: Abstract Algebra
Code: MAL-6111 Credits: 4

Course Objectives: To provide students with a comprehensive understanding of the fundamental concepts, structures, and properties of abstract algebra, including groups and rings, enabling them to apply these concepts in various mathematical and theoretical contexts.

Block I: Basic Concepts of Groups

Unit 1: Generating Sets
Unit 2: Groups: Definitions and examples
Unit 3: Subgroups and its examples
Unit 4: Cyclic Groups

Block II: Permutation Groups, Isomorphism and Lagrange's theorem

Unit 5: Permutation groups, Homomorphism
Unit 6: Isomorphism and Automorphism
Unit 7: Coset Decomposition, Lagrange's theorem
Unit 8: Quotient Groups

Block III: Sylow Theorems and Direct Products

Unit 9: Sylow p-subgroups
Unit 10: Sylow groups in Sp^k
Unit 11: Direct products
Unit 12: Finite abelian groups

Block IV: Solvable and Nilpotent Groups

Unit 13: Solvable Groups
Unit 14: Nilpotent Groups
Unit 15: Composition Series, Jordan Holder Theorem

Block V: Rings

Unit 16: Rings and Subrings
Unit 17: Characteristic and product of rings
Unit 18: Ideals and Ring homomorphisms
Unit 19: Integral domains
Unit 20: Euclidean domains and Principal ideal domains

Books Recommended/Suggested Reading:

1. *Herstein I. N.; Topics in Algebra, Wiley Eastern.*
2. *Dummit D. S. and Foote R. M.; Abstract Algebra, John Wiley & Sons.*
3. *Bhattacharya P. B., Jain S. K. and Nagpal S. R.; Basic Abstract Algebra, Cambridge University Press.*
4. *Gallian J. A.; Contemporary Abstract Algebra, Thomson Press.*
5. *Sahai Vivek and Bist Vikas; Algebra, Narosa Publishing House.*
6. *Malik D. S., Mordeson J. N. and Sen M. K.; Fundamentals of Abstract Algebra, McGraw-Hill.*
7. *Khanna V. K. and Bhambri S. K.; A Course in Abstract Algebra, Vikas Publishing House.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Understand the basic concepts of groups, including generating sets, definitions, examples, subgroups, and cyclic groups.
2. Analyze permutation groups, homomorphism, isomorphism, automorphism, and Lagrange's theorem to identify patterns, structures, and relationships within abstract algebraic systems.
3. Apply their knowledge of quotient groups, Sylow theorems, direct products, and finite abelian groups to solve problems and prove theorems in abstract algebra.
4. Evaluate solvable groups, nilpotent groups, composition series, and the Jordan Holder theorem to assess the properties and classifications of algebraic structures.
5. Create and construct mathematical arguments and proofs related to rings, subrings, characteristic, product of rings, ideals, ring homomorphisms, integral domains, and Euclidean domains, demonstrating their ability to synthesize abstract algebraic concepts.

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Course Name: Classical Mechanics

Code: MAL-6112 Credits: 4

Course Objectives: This course enables the students to revise Newtonian mechanics and introduces the Lagrangian formulation of mechanics. It emphasizes the understanding of Classical Mechanics using the Lagrangian and Hamiltonian approaches. Furthermore, students will understand various relations that remain valid when changing coordinate systems, emphasizing the utilitarian aspect. The course is intended to help learners in relativity, differential geometry, engineering mathematics, etc.

Block I: Classical Mechanics Fundamentals and Principles

Unit 1: General idea of Newtonian physics; Mechanics of a particle, mechanics of a system of particles

Unit 2: Constraints, generalized coordinates, D'Alembert's principle and Lagranges equations

Unit 3: Hamilton's principle, derivation of Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-holonomic systems

Unit 4: Conservation theorems and symmetry properties, Generalized momenta, cyclic co-ordinates

Block II: Canonical Transformations and Hamilton-Jacobi Method

Unit 5: Equation of canonical transformation, examples of canonical transformation

Unit 6: Poisson and Lagrange brackets and their invariance under canonical transformation, Jacobi's Identity, Poisson's Theorem

Unit 7: Equations of motion infinitesimal canonical transformation in the poisson bracket formulation

Unit 8: Hamilton Jacobi Method, Generating functions.

Block III: Celestial Mechanics and Small Oscillations

Unit 9: Two body central force problem: bound state, reduction of two-body problem to one body problem

Unit 10: Motion in a central force field, Thevirial theorem, the inverse square law of force

Unit 11: The motion in central force in the Kepler problem

Unit 12: Concept of small oscillations, eigen value equation, simple application (CO_2), Normal coordinates and modes

Block IV: Introduction to Tensors

Unit 13: Elementary idea of tensors: co-variant, contra variant and mixed tensor

Unit 14: Addition, subtraction, multiplication of Tensors

Unit 15: Characterization of tensors, quotient law

Block V: Relativistic mechanics

Unit 16: Four-dimensional representation of the Lorentz transformations, covariance of the laws of nature

Unit 17: Four vectors; velocity momentum, force and their transformation, equation of motion of a point particle in four vector form

Unit 18: Relativistic Lagrangian and Hamiltonian of a charged particle in an em field

Books Recommended/Suggested Reading:

1. *Goldstein H.; Classical Mechanics, 2nd edition, Narosa Publishing House.*
2. *Rana N.C. and Joag P. S.; Classical Mechanics, McGraw-Hill Education.*
3. *Gupta K. C.; Classical Mechanics, Wiley Publication.*
4. *Moller, M.C.; Theory of relativity, Oxford University.*

Course Outcomes

On successful completion of this course, students shall be able to:

1. Identify the motion of a mechanical system using the Lagrange-Hamilton formalism.
2. Demonstrate understanding of the shifting theorems, Fourier integral theorems, and the inverse Fourier sine and cosine transforms by applying them to appropriate examples.
3. Compare Lagrangian and Hamiltonian formalisms, Galilean and Lorentz transformations, and various reference frames.
4. Apply the theory of relativity to determine time dilation, length contraction, and simultaneity.
5. Explain the cause-effect relationship between coordinates, the transformation of mathematical quantities from one space to another, and their expressions.

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Course Name: Partial Differential Equations
Code: MAL-6113 Credits: 4

Course Objectives: The main objectives of this course are to teach students to form andsolve partial differential equations and use them in solving some physical problems.

Block I: Basic concepts and First order PDEs

Unit 1: Definition of a partial differential equation, Formation of partial differential equations, equations easily integrable.
Unit 2: Classification of first order partial differential equations and their solutions.
Unit 3: Solution of quasilinear partial differential equations of first order by Lagrange's Method.
Unit 4: Non-linear partial differential equation of first order with two independent variables (Charpit's method).

Block II: First order PDEs

Unit 5: Integral surfaces of first order quasilinear partial differential equations through a given curve.
Unit 6: Cauchy's problem for first order partial differential equations.
Unit 7: Cauchy's method of characteristics,
Unit 8: Compatible system of first order partial differential equations;

Block III: Second order PDEs

Unit 9: Classification of second order linear partial differential equations.
Unit 10: Characteristics and canonical forms for hyperbolic and parabolic equations.
Unit 11: Solution of quasilinear partial differential equation of second order by Monge's Method
Unit 12: Monge's Method of Integrating.

Block IV: Higher order PDEs

Unit 13: Homogeneous linear partial differential equations of higher order with constant coefficients.
Unit 14: Non-homogeneous partial differential equations of higher order with constant coefficients.
Unit 15: Reducible andIrreducible equations.
Unit 16: Equations reducible to linear partial differential equations with constant coefficients.

Block V: Series Solution of Differential Equations

Unit 17: Introduction, Frobenius Method, Solution near a Regular Singular Point.
Unit 18: Some Cases of Failure of the Method of Frobenius.
Unit 19: Legendre's Equation, General Solution of Legendre's Equation.
Unit 20: Orthogonal Properties of Legendre's Polynomials.

Books Recommended/Suggested Reading:

1. *Evans L. C.; Partial Differential Equations, Graduate Studies in Mathematics.*
2. *Jurgen Jost; Partial Differential Equations, Graduate Text in Mathematics, Springer Verlag Heidelberg.*

3. *Robert C. Mcowen; Partial Differential Equations: Methods and Applications, Pearson Education Inc.*
4. *John Fritz, Partial Differential Equations, Sringer-Verlag.*
5. *Sneddon I. N.; Elements of Partial Differential Equations, McGraw-Hill.*
6. *Raisinghania M. D.; Ordinary and Partial Differential Equations, S. Chand & Sons.*
7. *S. L. Ross: Differential equations, John Wiley and Sons, 2004.*

Course Outcomes

On successful completion of this course, students shall be able to:

1. Formulate and classify partial differential equations.
2. Solve Cauchy problems for first and second order PDE and their solutions by using method of characteristic.
3. Solve linear and nonlinear partial differential equations using various methods and apply these methods in solving some physical problems.
4. Classify partial differential equations and transform into canonical form.
5. Solve homogeneous linear partial differential equations of higher order.

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Course Name: Real Analysis
Code: MAL-6114 Credits: 4

Course Objectives: To understand the uniform convergence, sequence and series of real valued functions, the properties of certain real-valued functions and Riemann integration of bounded functions on a closed and bounded interval.

Block I: Review of Properties of Real Numbers

Unit 1: Topology of Real Numbers
Unit 2: Sequence and Series of Real Numbers
Unit 3: Limit, Continuity and Differentiability of Single Variable Functions

Block II: Analytic Functions

Unit 4: Power Series
Unit 5: Exponential Functions
Unit 6: Logarithmic Functions
Unit 7: Trigonometric Functions

Block III: Sequence and Series of Functions

Unit 8: Pointwise Convergence
Unit 9: Uniform Convergence
Unit 10: Tests for Uniform Convergence

Block IV: Functions of Several Variables

Unit 11: Limit
Unit 12: Continuity
Unit 13: Partial Derivatives and Differentiability

Block V: Riemann Integral

Unit 14: Functions of Bounded Variation
Unit 15: Definitions and Existence of the Integral
Unit 16: Riemann Sums
Unit 17: The Fundamental Theorem of Calculus

Books Recommended/Suggested Reading:

1. *Walter Rudin; Principles of Mathematical Analysis, McGraw-Hill International.*
2. *Malik S. C. and Arora Savita;Mathematical Analysis, New Age International Publication.*
3. *Mapa S. K.; Introduction to Real Analysis, Levant Books.*
4. *Bartle R. G. and Sherbert D. R.; Introduction to Real Analysis, Wiley Edition.*
5. *Apostol T.M.; Mathematical Analysis, 2nd Ed., Narosa Distributors, New Delhi, 2002.*
6. *Kumar A. and Kumaresan S.; A Basic Course in Real Analysis, CRC Press.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Understand and analyze the topology of real numbers.
2. Investigate limits, continuity, and differentiability of single-variable functions.
3. Study and manipulate power series, exponential functions, logarithmic functions, and trigonometric functions.
4. Apply tests for uniform convergence to analyze the behavior of functions.
5. Apply Riemann sums and the Fundamental Theorem of Calculus to evaluate integrals.

Course Name: Computer Graphics
Code: MAL-6115 Credits: 4

Course Objectives: To provide students with a solid foundation in the principles and techniques of computer graphics, including graphic systems, output primitives, transformations, windowing and clipping techniques, and animation. Students will gain the necessary knowledge and skills to create and manipulate digital graphics for various applications.

Block I: Graphic Systems

Unit 1: Display devices, Physical input and output devices.
Unit 2: Display processors graphics software coordinate representation.
Unit 3: Graphics functions and standards.

Block II: Output Primitives

Unit 4: Point plotting, Line drawing algorithms – DDA algorithms, Bresenham's line algorithms.
Unit 5: Circle generating algorithms, ellipses**.**
Unit 6: Attributes and construction techniques.

Block III: Two-Dimensional Transformations

Unit 7: Basic transformations-translations, rotation, matrix representation and homogeneous coordinates.
Unit 8: Composite transformations-scaling relative to a fixed pivot, rotation about a pivot point.
Unit 9: General transformation equations, other transformation-reflection**.**

Block IV: Windowing and Clipping Techniques

Unit 10: Windowing concepts clipping algorithms**.**
Unit 11: Area clipping, line clipping, polygon clippings, text clipping.
Unit 12: Blanking, window-to-viewpoint transformation, Cohen Sutherland algorithm**.**

Block V: Animation Techniques

Unit 13: Animation perspectives, computer animation hardware.
Unit 14: Computer animation software and applications, PC animation.
Unit 15: Concept of simulations.

Books Recommended/Suggested Reading:

1. *Chopra R.; Computer Graphics: with an Introduction to Multimedia, S. Chand Publications.*
2. *Boreskov A., Shikin E.; Computer Graphics, CRC Press.*
3. *Sinha A. N., Udai A. D.; Computer Grapics, McGraw Hill Education.*
4. *Marschner S. and Shirley P.; Fundamentals of Computer Graphics, CRC Press.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Understand graphic systems, including display devices, input/output devices, graphics software, coordinate representation, and graphics functions and standards.
2. Apply various output primitives, such as point plotting, line drawing algorithms (DDA and Bresenham's algorithms), circle generating algorithms, and ellipses, to create basic shapes and construct graphical elements.
3. Analyze and perform two-dimensional transformations, including translations, rotations, scaling, reflection, and composite transformations, using matrix representation and homogeneous coordinates.
4. Evaluate windowing and clipping techniques, including area clipping, line clipping, polygon clipping, and text clipping, and apply algorithms like Cohen-Sutherland algorithm to determine visible regions in a given viewport.
5. Create computer animations using animation perspectives, hardware and software tools, and gain an understanding of animation applications, PC animation, and the concept of simulations.

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Course Name: Computer Graphics Lab
Code: MAP-6111 Credits: 2

Course Objectives: To provide students with a practical understanding of computer graphics principles and techniques. The course aims to develop students' skills in creating and manipulating graphical elements, implementing algorithms for graphics rendering, and applying various transformations to two-dimensional and three-dimensional objects.

1. Line Drawing
2. DDA Bresenham's
3. Circle Generation
4. Two-Dimensional Transformation
5. Computer Animation
6. Windowing and Clipping
7. Projection of a cube or any other dimensional figure using parallel and perspective transformation

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Apply knowledge of line drawing, circle generation, and two-dimensional transformations to create and manipulate graphical elements using appropriate algorithms and techniques.
2. Demonstrate an understanding of windowing and clipping, as well as the projection of three-dimensional objects using parallel and perspective transformations, to create realistic computer animations and visualizations.

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Semester: II

Course Name: Operations Research
Code: MAL-6211 Credits: 4

Course Objectives: To introduce students to the fundamental concepts, methodologies, and techniques of operations research, with a focus on linear programming, duality, sensitivity analysis, transportation and assignment problems, game theory, and non-linear programming.

Block I: Introduction of Linear Programming Problem

Unit 1: Origin, Definition and Scope of OR
Unit 2: Methodology, Applications and phases of OR
Unit 3: Formulation of Linear Programming Problem, Graphical Method
Unit 4: Simplex method and its variants: Big-M method and Two-phase method
Unit 5: Degeneracy and Cycling in LPP

Block II: Duality and Sensitivity Analysis

Unit 6: Duality in LPP and interpretation of dual variables
Unit 7: Primal-Dual relationship, Dual Simplex Method
Unit 8: Sensitivity Analysis

Block III: Transportation and Assignment Problem

Unit 9: Mathematical formulation and initial basic feasible solution of Transportation Problem
Unit 10: Balanced and Unbalanced Transportation Problem
Unit 11: Optimal Solution of Transportation Problem
Unit 12: Mathematical formulation and solution of Assignment Problem

Block IV: Game Theory

Unit 13: Two person zero games, Minimax and maximum principle
Unit 14: Game with and without Saddle point, Dominance rule
Unit 15: Matrix, Algebraic and Graphical Method

Block V: Non-Linear Programming

Unit 16: Lagrange multipliers, Farkas Lemma
Unit 17: Constraint qualification, KKT optimality conditions
Unit 18: Sufficiency of KKT under convexity
Unit 19: Quadratic programming, Wolfe's method

Books Recommended/Suggested Reading:

1. *Hadley G.; Operations Research, Oxford IBH publishing Company.*
2. *Sinha S. M.; Mathematical Programming-Theory and Methods, Elsevier.*
3. *Minoux M.; Mathematical Programming-Theory and Algorithms, Wiley-Blackwell.*
4. *Bradley S. P.; Applied Mathematical Programming, Addison-Wesley.*
5. *Hillier F. S. and Lieberman G. J.; Introduction to Operations Research, McGraw-Hill.*
6. *Walker R. C.; Introduction to Linear Programming, Prentice Hall.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Understand the origin, definition, scope, and applications of operations research, as well as the formulation and solution methods of linear programming problems, including the simplex method, Big-M method, and Two-phase method.
2. Analyze duality in linear programming problems, interpret dual variables, and apply the dual simplex method.
3. Apply mathematical formulations and solution techniques to solve transportation problems, including balanced and unbalanced cases, as well as assignment problems.
4. Evaluate matrix, algebraic, and graphical methods in game theory and assess the sufficiency of Karush-Kuhn-Tucker (KKT) optimality conditions under convexity.
5. Create mathematical models using Lagrange multipliers and apply Farkas Lemma.

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Course Name: General Topology
Code: MAL-6212 Credits: 4

Course Objectives: To introduce basic concepts of point set topology, basis and subbasis for a topology and order topology. Further, to study continuity, homeomorphisms, open and closed maps, product and box topologies and introduce notions of connectedness, path connectedness, local connectedness, local path connectedness, countability axioms and compactness of spaces.

Block I: Basic Notions

Unit 1: Sets and Relations
Unit 2: Functions
Unit 3: Cardinality and Order of Sets

Block II: Topology of Spaces

Unit 4: Topology of the Line and Plane
Unit 5: Topological Spaces
Unit 6: Bases and Subbases

Block III: Continuity and Metric Spaces

Unit 7: Continuity and Topological Equivalence
Unit 8: Metric and Normed Spaces
Unit 9: Countability

Block IV: Separation Axioms and Compactness

Unit 10: Separation Axioms
Unit 11: Compactness
Unit 12: Product Spaces

Block V: Connectedness and Function Spaces

Unit 13: Connectedness
Unit 14: Complete Metric Spaces
Unit 15: Function Spaces

Books Recommended/Suggested Reading:

1. *Munkres J. R.; Topology, Pearson Education India.*
2. *Simmons G.; Introduction to Topology and Modern Analysis, McGraw-Hill Education.*
3. *Sharma J. N. and Chauhan J. P.; Topology (General and Algebraic), Krishna Publication.*
4. *Martin D. Crossley.; Essential Topology, Springer Undergraduate Mathematics Series.*
5. *M. A. Armstrong; Basic Topology, Undergraduate Text in Mathematics, 1983.*
6. *Joshi K. D.; Introduction to General Topology, New Age International Publishers.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Understand and apply concepts related to sets and relations.
2. Apply concepts of topology in different spaces.
3. Analyze continuity and its relationship with topological equivalence.
4. Evaluate and apply separation axioms and compactness.
5. Analyze and apply concepts of connectedness and function spaces.

Course Name: Complex Analysis
Code: MAL-6213 Credits: 4

Course Objectives: This course enables the student to understand how complex numbers provide a satisfying extension of the real numbers and learn techniques of complex analysis that make practical problems to understand signals and systems in terms of both the time and transform domains, taking advantage of the complementary insights and tools that these different perspectives provide.

Block I: Functions of a complex variable

Unit 1: Limit, continuity and differentiability

Unit 2: Analytic functions and Cauchy-Riemann equation

Unit 3: Analyticity of elementary functions

Block II: Complex integration-I

Unit 4: Curves in the complex plane and Properties of complex line integrals

Unit 5: Fundamental theorem of line integrals (or contour integration) and Simplest version of Cauchy's theorem

Unit 6: Cauchy-Goursat theorem, Symmetric, starlike, convex and simply connected domains

Block III: Complex integration-II

Unit 7: Cauchy's theorem for a disk and Cauchy's integral theorem

Unit 8: Index of a closed curve, Advanced versions of Cauchy integral formula and applications

Unit 9: Cauchy's estimate, Morera's theorem, Riemann's removability theorem and Examples

Unit 10: Liouville's theorem, the fundamental theorem of algebra, Maximum moduli of functions.

Block IV: Power Series

Unit 11: Convergence of sequences and series of functions,

Unit 12: Weierstrass' M-test, Power series as an analytic function

Unit 13: Root test, Ratio test, Uniqueness theorem for power series, Zeros of analytic functions

Unit 14: Identity theorem and related results, Maximum/Minimum modulus principles and theorems, Schwarz' lemma and its consequences

Block V: Calculus of Residue

Unit 15: Residue at a finite point, Results for computing residues, Residue at the point at infinity,

Unit 16: Cauchy's residue theorem, Residue formula and Meromorphic functions,

Unit 17: Number of zeros and poles and Argument principle, Isolated and non-isolated singularities, Removable singularities and Poles.

Unit 18: Evaluation of integrals, Rouche's theorem, Mittag-Leffer expansion theorem, Examples

Books Recommended/Suggested Reading:

1. *Ahlfors L. V.; Complex Analysis, McGraw-Hill Education.*
2. *Goyaland Gupta; Functions of a Complex Variable, Pragati Prakashan.*
3. *Sharma J. N.; Functions of a Complex Variable, Krishna Prakashan.*
4. *Brown J. W. and Churchill R. V.; Complex Variables and Applications, McGraw-Hill Education.*
5. *Kasana H. S.; Complex Variables: Theory and Applications, Prentice Hall India Learning*.

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Recall the concept of limit for real functions and to calculate limits of standard functions and construct simple proofs involving this concept.
2. Analyze limit, continuity and differentiation of functions of complex variables.
3. Understand the concept of the differentiability of a real valued function and be familiar with the statements and proofs of the standard results about differentiable real functions.
4. Understand Cauchy-Riemann equations, analytic functions and various properties of analytic functions.
5. Compute the residue of a function and able to apply the concepts of the calculus of residues in the evaluation of integrals.

******

Course Name: Numerical Methods
Code: MAL-6214 Credits: 4

Course Objectives: To equip students with the necessary skills and knowledge to understand and apply various numerical techniques for solving mathematical problems, including error analysis, algebraic and transcendental equation solving, interpolation, statistical computation, and numerical differentiation and integration.

Block I: Errors

Unit 1: Errors and their Analysis
Unit 2: Error in Numerical computations, mathematical preliminaries
Unit 3: Errors in series approximation
Unit 4: Floating point Representation of Numbers

Block II: Solution of Algebraic and Transcendental Equations

Unit 5: Bisection Method, Iteration method
Unit 6: Method of false position, Newton-Raphson method
Unit 7: Muller's method
Unit 8: Methods of finding complex roots

Block III: Interpolation

Unit 9: Finite differences
Unit 10: Polynomial Interpolation
Unit 11: Central Difference Formulae
Unit 12: Interpolation with Unequal Intervals

Block IV: Statistical Computation

Unit 13: Frequency Chart
Unit 14: Frequency Curve
Unit 15: Fitting of an Exponential curve
Unit 16: Regression Analysis

Block V: Numerical Differentiation and Integration

Unit 17: Numerical Differentiation
Unit 18: Numerical Integration.
Unit 19: Numerical Solution of ordinary Differential Equations
Unit 20: Numerical Solution of Differential Equations using Runge-Kutta Methods

Books Recommended/Suggested Reading:

1. *Ranganatham S., Prasad M. V. S. S. N. and Ramesh Babu V.; Numerical Analysis, S. Chand Publishing.*
2. *Sastry S. S.; Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd.*
3. *Hildebrand F. B.; Introduction to Numerical Analysis, McGraw-Hill Education.*
4. *Gupta R. S.; Elements of Numerical Analysis, Algebra, Cambridge University Press.*
5. *Conte S. and Deboor C.; Elementary Numerical Analysis, McGraw-Hill Education.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Analyze and solve several errors and approximation in numerical methods.
2. Discuss different methods of interpolation.
3. Determine numerical differentiation & integration.
4. Apply several methods to solve curve fitting and interpolation questions and its related techniques.
5. Apply several methods to solve the equations in one variable or simultaneous equations.

******

Course Name: Programming in C
Code: MAL-6215 Credits: 4

Course Objectives: To equip students with a solid foundation in the C programming language, enabling them to understand programming paradigms, utilize fundamental programming constructs, manipulate data structures, and perform file processing operations.

Block I: Basics of C programming

Unit 1: Introduction to programming paradigms, Applications of C Language, Structure of C program.
Unit 2: C programming: Data Types, Constants, Enumeration Constants, Keywords.
Unit 3: Operators: Precedence and Associativity, Expressions, Input/Output statements, Assignment statements**.**
Unit 4: Decision making statements, Switch statement, Looping statements, Preprocessor directives, Compilation process.

Block II: Arrays and Strings

Unit 5: Introduction to Arrays: Declaration, Initialization, One dimensional array, Two dimensional arrays.
Unit 6: String operations: length, compare, concatenate, copy**.**
Unit 7: Selection sort, linear and binary search**.**

Block III: Functions and pointers

Unit 8: Modular programming - Function prototype, function definition, function call, Built-in functions (string functions, math functions).
Unit 9: Recursion, Binary Search using recursive functions, Pointers, Pointer operators, Pointer arithmetic, Arrays and pointers, Array of pointers.
Unit 10: Parameter passing: Pass by value, Pass by reference.

Block IV: Structures and union

Unit 11: Structure, Nested structures, Pointer and Structures, Array of structures.
Unit 12: Self referential structures, Dynamic memory allocation.
Unit 13: Singly linked list, typedef, Union, Storage classes and Visibility.

Block V: File processing

Unit 14: Files, Types of file processing: Sequential access, Random access, Sequential access file.
Unit 15: Random access file.
Unit 16: Command line arguments.

Books Recommended/Suggested Reading:

1. *Kamthane A. N. and Kamthane A. A.; Programming in C, Pearson Education India.*
2. *Reema Thareja; Computer Fundamentals and Programming in C, Oxford University Press.*
3. *Dey P. and Ghosh M.; Programming in C, Oxford University Press.*
4. *Kernighan B. W. and Dennis M. R.; The C Programming Language, Pearson Education India.*

5. *Kanetkar Y. P.; Let us C, BPB Publications.*
6. *Jones J. A. and Harrow K.; Problem solving with C, Pearson Education India.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Understand the basics of C programming, including program structure, data types, operators, decision-making and looping statements, and the compilation process.
2. Apply their knowledge of arrays and strings to declare, initialize, manipulate, and search for elements, using sorting algorithms and string operations effectively.
3. Analyze the concepts of functions and pointers to modularize programs, implement recursion and binary search, work with pointers and arrays, and comprehend parameter passing mechanisms.
4. Create and design structures and unions, including nested structures, pointers to structures, self-referential structures, and arrays of structures, while also understanding dynamic memory allocation and storage classes.
5. Evaluate file processing techniques, such as sequential and random access, as well as command line arguments, to read from and write to files, demonstrating their ability to manipulate data in external storage efficiently.

******

Course Name: Programming in C Lab
Code: MAP-6211 Credits: 2

Course objectives: This course aims to provide students with the fundamental knowledge and practical skills necessary for programming in the C language. Through hands-on programming exercises, students will develop proficiency in solving computational problems using C programming constructs and techniques.

1. Write a C program to find roots of a quadratic equation.
2. Write a C program to find the total no. of digits and the sum of individual digits of a positive integer.
3. Write a C program to generate the Fibonacci sequence of first N numbers.
4. Write a C program to compute sin(x) using Taylor series approximation given by

   $$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + ...$$

   Compare output of the program with the built- in Library function. Print both the results with appropriate messages.
5. Write a C program to input two matrices and perform matrix multiplication on them.
6. Write a C program to check whether the given string is palindrome or not without using Library functions.
7. Write a C program to count the number of lines, words and characters in a given text.
8. Write a C program to generate prime numbers in a given range using user defined function.
9. Write a C program to find factorial of a given number using recursive function.
10. Write a C program to maintain a record of n student details using an array of structures with four fields - Roll number, Name, Marks and Grade. Calculate the Grade according to the following conditions.

Marks	Grade
>=80	A
>=60	B
>=50	C
>=40	D
<40	E

    Print the details of the student, given the student roll number as input.

Course Outcomes:

On successful completion of this course, students should be able to:

1. Apply understanding of C programming concepts to develop C programs that solve specific computational problems, such as finding roots of a quadratic equation, generating the Fibonacci sequence, performing matrix multiplication, checking for palindromes, counting lines/words/characters in a text, generating prime numbers, and calculating the grade of a student based on their marks.
2. Analyze and compare the output of their C programs with the results obtained from built-in library functions or other reference solutions. They will also be able to evaluate the efficiency and correctness of their programs by examining the logic, syntax, and algorithmic design employed.

******

Course Name: Research Methodology
Code: MAL-7111 Credits: 6

Course Objectives: To familiarize students with basic of research, research process and enable the participants in conducting research work and formulating research synopsis and report.

Block I: Research Formulation

Unit 1: Introduction, meaning of research,
Unit 2: Types, Role of research in important area and Process of Research,
Unit 3: Defining research Problems, Hypothesis Formulation.

Block II: Research Elaborated

Unit 4: Research Design, Research plan, Concept of sample, Sample size, various types of sampling techniques.
Unit 5: Types of Data and Methods of its Collection**;** Questionnaire Design,
Unit 6: Precautions in preparation of questionnaire, Measurement scales.

Block III: Data Analysis and Interpretation-1

Unit 7: Processing and Analysis of Data by application of statistical tools
Unit 8: various kinds of charts and diagrams used in data analyses
Unit 9: Application of Data Analysis

Block IV: Data Analysis and Interpretation-2

Unit 10: Hypothesis Testing (F-test, ANOVA, Chi –square test, t-test)
Unit 11: Multivariate Statistical techniques- Multiple regression, discriminate analysis, Factor analysis, Multivariate analysis of variance
Unit 12: Conjoint analysis, Cluster analysis, Multidimensional Scaling, Role of computer in research, Excel- A tool for statistical analysis, SPSS, Interpretation and conclusion

Block V: Report Writing

Unit 13: Report Writing, Significance of report writing, Steps in report writing
Unit 14: Layout of research report, Types of reports; Appendices
Unit 15: Bibliography, Characteristics of a good report; Precautions for report writing; Ethics in business research.

Books Recommended/Suggested Reading:

1. *Kothari C. R.: Research Methodology, New Age International Publishers.*
2. *Sinha S. C. and Dhiman A. K.; Research Methodology, EssEss Publications.*
3. *Anderson T. W.; An Introduction to Multivariate Statistical Analysis, Wiley.*
4. *Garg B. L., Karadia R., Agarwal F. and Agarwal U. K.; An Introduction to Research Methodology, RBSA Publishers.*

Course Outcomes:

After the completion of the course, student shall be able to:

1. Elaborate various concepts related to research.
2. Enumerate various kinds of research design & process.
3. Develop adequate knowledge on measurement & scaling techniques as well as the quantitative data analysis.
4. Demonstrate various techniques of data analysis-and hypothesis testing procedures.
5. Articulate appropriate research ethics for doing meaningful research.

******

Course Name: Axiomatic Set Theory
Code: MAL-7112 Credits: 4

Course Objectives: Axiomatic set theory usually assumes that there are no objects in the universe except sets (so that all quantifiers apply only to sets); other useful mathematical objects like numbers or functions must be represented as set before they can be used.

Block I: Axioms and classes

Unit 1: Classes, sets and axioms
Unit 2: Constructing classes and sets
Unit 3: Operations on classes and sets
Unit 4: Cartesian products

Block II: Relations and Functions

Unit 5: Relations on a class or set, Equivalence relations and order relations
Unit 6: Partitions induced by equivalence relations, Equivalence classes and quotient sets
Unit 7: Functions: A set-theoretic definition
Unit 8: Operations on functions

Block III: From sets to numbers

Unit 9: The natural numbers
Unit 10: The natural numbers as a well-ordered set
Unit 11: Arithmetic of the natural numbers

Block IV: Ordinal numbers

Unit 12: Well-ordered sets.
Unit 13: Ordinal numbers: Definition and properties.
Unit 14: Properties of the class of ordinal numbers.
Unit 15: Initial ordinals: "Cardinal numbers are us!"

Block V: Ordinal arithmetic

Unit 16: Ordinal arithmetic: Addition
Unit 17: Ordinal arithmetic: Multiplication
Unit 18: Ordinal arithmetic: Exponentiation

Books Recommended/Suggested Reading:

1. *Suppes Patrik; Axiomatic Set Theory, Dover Publications Inc.*
2. *Cunningham Daniel W.; Set Theory: A First Course, Cambridge University Press.*
3. *Stoll Robert R.; Set Theory and Logic, Dover Publications Inc.*
4. *Tiles Mary; The Philosophy of Set Theory, Algebra, Dover Publications Inc.*
5. *Pinter Charles; A Book of Set Theory, Dover Publications Inc.*

Course Outcomes:

On successful completion of this course, students shall be able to:
1. Understand the basic concepts of sets and axioms, including constructing classes.

2. Analyze Relations and Functions.
3. Identify and list natural numbers. Add, subtract, multiply, and divide natural numbers. Use the number line to illustrate arithmetic operations.
4. To Ordinal numbers designate the position or order of things or objects.
5. Apply ordinal arithmetic describes the three usual operations on ordinal numbers addition, multiplication, and exponentiation.

******

Course Name: Functional Analysis

Code: MAL-7113 Credits: 4

Course Objectives: To familiarize with the basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another**.**

Block I: Normed Spaces

Unit 1: Normed linear spaces
Unit 2: Quotient spaces, Product spaces
Unit 3: Infinite series in normed space
Unit 4: Finite dimensional normed spaces

Block II: Banach Space

Unit 5: Bounded linear operators and bounded linear functional.
Unit 6: Unbounded linear operators,
Unit 7: Open Mapping and Closed Graph Theorem
Unit 8: Reflexive normed spaces and their properties

Block III: Spaces of Bounded Linear Functional

Unit 9: Dual Spaces
Unit 10: Duals of some standard normed spaces,
Unit 11: Hahn-Banach Theorems

Block IV: Hilbert Space and Orthonormality

Unit 12: Complete Inner Product Spaces
Unit 13: Orthonormal Sets
Unit 14: Projections and Riesz Representation Theorems

Block V: Operators on Hilbert spaces

Unit 15: Adjoint of an Operator
Unit 16: Normal, Unitary, and Self-Adjoint Operators
Unit 17: Positive Operators
Unit 18: Compact Self-Adjoint Operators

Books Recommended/Suggested Reading:

1. *Kesavan S.; Functional Analysis, Springer.*
2. *Kreyszig Erwin; Introductory Functional Analysis with Applications, Wiley.*
3. *Sen Rabindranath; A First Course in Functional Analysis: Theory and Applications, Anthem Press.*
4. *Shalit Orr Moshe; A First Course in Functional Analysis, Chapman and Hall/CRC.*
5. *Robinson James C.; An Introduction to Functional Analysis, Cambridge University Press.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. To learn to recognize the fundamental properties of normed spaces and of the transformations between them.
2. Distinguish between Banach spaces and Hilbert spaces, decompose a Hilbert space in terms of orthogonal complements, check totality of orthonormal sets and sequences, represent a bounded linear functional in terms of inner product.
3. Extend a linear functional under suitable conditions, check reflexivity of a space, ability to apply uniform boundedness theorem, open mapping theorem and closed graph theorem, check the convergence of operators and functional and weak and strong convergence of sequences.
4. Understand the notions of dot product and Hilbert space and apply the spectral theorem to the resolution of integral equations.
5. Verify the requirements of a norm, completeness with respect to a norm, relation between compactness and dimension of a space, check boundedness of a linear operator and relate to continuity, convergence of operators by using a suitable norm, compute the dual spaces.

******

Course Name: Integration Theory
Code: MAL-7114 Credits: 4

Course Objectives: The theory leads to a new perspective on integration of functions, which is not only more general than the Riemann setting when working on the real line, but also allows one to integrate in an abstract setting. This is of crucial importance for the development of functional analysis and probability theory. Thus, the students will learn a lot about the advancement of basic integration theory and will also learn some application of this theory.

Block I: Lebesgue Integral-I

Unit 1: Shortcomings of Riemann Integral, Lebesgue Integral of a bounded function over a set of finite measure and its properties.
Unit 2: Lebesgue integral as a generalization of Riemann integral
Unit 3: Bounded convergence theorem

Block II: Lebesgue Integral-II

Unit 4: Lebesgue theorem regarding points of discontinuities of Riemann integrable functions
Unit 5: Integral of non-negative functions.
Unit 6: Fatou Lemma and Monotone convergence theorem and general Lebesgue Integral

Block III: Spaces of Lebesgue Integrable

Unit 7: Functions L p -spaces,
Unit 8: Jensen's inequality, Minkowski inequality and Hölder inequality
Unit 9: Convergence in Lp , Completeness of Lp, Lp (μ)spaces and their properties

Block IV: Signed Measures

Unit 10: Signed measure, Hahn decomposition theorem and Jordan decomposition theorem
Unit 11: Mutually singular measure and Radon Nikodym theorem
Unit 12: Lebesgue decomposition and Lebesgue-Stieltjes integral

Block V: Product Measures

Unit 13: Product measures and Fubini's theorem.
Unit 14: Baire sets and Baire measure
Unit 15: Continuous functions with compact support and Regularity of measures on locally compact support
Unit 16: Riesz-Markoff theorem

Books Recommended/Suggested Reading:

1. *Lerner Nicolas; A Course on Integration Theory, Birkhäuser Basel.*

2. *Malik A. K., Malik A. K., Gupta S. K.; Measure Theory and Integration, I K International Publishing House Pvt. Ltd.*
3. *Jain P. K.; Lebesgue Measure and Integration, New Age International Publishers.*
4. *H. L. Royden: Real Analysis, Macmillan, 1993.*
5. *P. R. Halmos: Measure Theory, Van Nostrand, Princeton, 1950.*
6. *K. Rana: An Introduction to Measure and Integration, Narosa, 1997.*
7. *S. Shirali: A Concise Introduction to Measure Theory, Springer, 2018.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Define the basic concepts of the theory of Lebesgue integration
2. Find out which functions can be integrated, and prove the main properties of the Lebesgue integral.
3. Apply and manipulate convergence theorem for the integrals.
4. Understand Radon Nikodym theorem, Fubini's theorem and Riesz-Markoff theorem.

******

Course Name: Measure Theory
Code: MAL-7114 Credits: 4

Course Objectives: Revision of basic tools, including in particular the concept of countable/uncountable sets. Be able to describe at least one approach to the construction of Lebesgue measure and measure spaces. Know the principal theorems as treated and their proofs and be able to use them in the investigation of examples. Also to prove simple unseen propositions concerning measure spaces and Lebesgue measure. To gain understanding of the abstract measure theory and Lebesgue's measure on the real line and in n-dimensional Euclidean space.

Block I: Lebesgue Measure

Unit 1: Set functions, Intuitive idea of measure and Elementary properties of measure

Unit 2: Measurable sets and their fundamental properties

Unit 3: Lebesgue measure of a set of real numbers and Algebra of measurable sets

Block II: Measurable functions-I

Unit 4: Borel set, Equivalent formulation of measurable sets in terms of open

Unit 5: Closed, F_σ and G_δ sets, Non measurable sets.

Unit 6: Definition of measurable function and their equivalent formulations and Properties of measurable functions.

Block III: Measurable functions-II

Unit 7: Approximation of a measurable function by a sequence of simple functions

Unit 8: Measurable functions as nearly continuous functions, Egoroff theorem and Lusin theorem,

Unit 9: Convergence in measure, F. Riesz theorem and Almost uniform convergence.

Block IV: Abstract Measure Ring-I

Unit 10: Algebra, σ-ring and σ-algebra and Set functions, Measure, Measure space and Measurable spaces

Unit 11: Measurable functions, General integration and General Convergence Theorem

Unit 12: Outer measure and measurability, Extension of a measure and Uniqueness of measure

Block V: Absolutely continuous functions

Unit 13: Absolutely continuous functions, Examples and properties.

Unit 14: Absolute continuity of indefinite integral of Lebesgue integrable functions

Unit 15: Differentiation of indefinite integrals and Characterization of absolutely continuous functions as indefinite integrals.

Books Recommended/Suggested Reading:

1. *Pundir S. K.; Measure Theory, CBS Publishers.*
2. *Shirali Satish; A Concise Introduction to Measure Theory, Springer.*
3. *Bauer Heinz, Burckel Robert B.; Measure and Integration Theory, De Gruyter.*

4. *Malik A. K., Malik A. K., Gupta S. K.; Measure Theory and Integration, I K International Publishing House Pvt. Ltd.*
5. *Jain P. K.; Lebesgue Measure and Integration, New Age International Publishers.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Describe the Measure and the measurable functions.
2. Apply convergence in measure and almost uniform convergence to solve F. Riesz theorem.
3. Explain Lebesgue measure and to exploit its special properties.
4. Understand Differentiation of indefinite integrals and Characterization of absolutely continuous functions as indefinite integrals.

******

Semester: IV

Course Name: Mathematical Statistics
Code: MAL-7211 Credits: 4

Course Objectives: To provide students with a solid foundation in statistical methods, focusing on data collection, representation, descriptive statistics, probability distributions, bivariate data analysis, and hypothesis testing. Through theoretical concepts and practical applications, students will develop skills in analyzing data, making informed decisions, and drawing meaningful conclusions.

Block I: Data Collection and Representation

Unit 1: Data Types and Collection
Unit 2: Scales and Classification of Data
Unit 3: Diagrammatic Representation of Data

Block II: Descriptive Statistics

Unit 4: Measures of Central Tendency
Unit 5: Measures of Dispersion
Unit 6: Elementary Probability and Random Variables

Block III: Probability Distributions

Unit 7: Standard Probability Distributions
Unit 8: Bernoulli and Binomial Distributions
Unit 9: Poisson Distributions
Unit 10: Normal Distributions

Block IV: Bivariate Data Analysis

Unit 11: Scatter Diagram and Correlation
Unit 12: Regression Lines and Coefficients
Unit 13: Fitting of Polynomials and Exponential Curves

Block V: Hypothesis Testing and Analysis of Variance

Unit 14: Testing of Hypothesis
Unit 15: Z-test, t-test, and F-test
Unit 16: Chi-square Test and Goodness of Fit
Unit 17: Introduction to Analysis of Variance

Books Recommended/Suggested Reading:

1. *Spiegel, M. R. Theory and Problems of Statistics, Schaum Publishing Company.*
2. *Gupta S. C. and Kapoor V. K.; Fundamentals of Mathematical Statistics, S. Chand and Sons.*
3. *Hogg R. V., Mckean J. and Craig A. T.; Introduction to Mathematical Statistics, Pearson.*
4. *Miller I. and Miller M.; John E. Freund's Mathematical Statistics with Applications, Pearson.*
5. *Rohatgi V. K. and Saleh A. K. Md. E.; An Introduction to Probability and Statistics, Wiley.*
6. *Kapoor J. N. and Saxena H. C.; Fundamentals of Mathematical Statistics, S. Chand and Sons.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Apply appropriate methods to collect and classify different types of data, including qualitative and quantitative data, using suitable scales and classification techniques.
2. Analyze data sets using measures of central tendency and dispersion to summarize and interpret the distribution and variability of the data.
3. Demonstrate an understanding of elementary probability concepts and random variables to analyze and predict outcomes in statistical situations.
4. Interpret and apply standard probability distributions, including Bernoulli, binomial, Poisson, and normal distributions, to model and analyze real-world scenarios.
5. Perform bivariate data analysis by utilizing scatter diagrams, correlation coefficients, regression lines, and fitting techniques for polynomials and exponential curves to explore relationships and make predictions based on data patterns.

******

Course Name: Graph Theory
Code: MAL-7212 Credits: 4

Course Objectives: The objective of the course is to understand basic concepts in combinatorial graph theory and its applications in science, business and industry.

Block I: Introduction

Unit 1: Basic concepts of graphs and its types
Unit 2: Subgraphs and degrees of vertices
Unit 3: Paths, connectedness and automorphism of a simple graph
Unit 4: Directed graphs

Block II: Connectivity and Trees

Unit 5: Introduction of connectivity, vertex cut and edge cut
Unit 6: Connectivity and edge connectivity
Unit 7: Introduction of Trees, characterization and simple properties, centers and centroids
Unit 8: Cutting the number of spanning trees, Cayley's formula

Block III: Independent Sets, Matchings and Cycles

Unit 9: Introduction of vertex, independent sets and vertex coverings
Unit 10: Edge, independent sets, matchings and factors
Unit 11: Matchings in bipartite graphs, Cycles
Unit 12: Eulerian graphs and hamiltonian graphs

Block IV: Graph Colorings

Unit 13: Introduction to vertex colorings
Unit 14: Critical graphs and edge colorings of graphs
Unit 15: Kirkman's schoolgirl problem
Unit 16: Chromatic polynomials

Block V: Planarity

Unit 17: Introduction to planar and non-planar graphs
Unit 18: Euler formula and its consequences, K5 and K3,3 are non-planar graphs
Unit 19: Dual of a plane graph, The Four-Color Theorem and the Heawood Five Color Theorem
Unit 20: Hamiltonian plane graphs, Tait coloring

Books Recommended/Suggested Reading:

1. *West D. B.; Introduction to Graph Theory, Pearson.*
2. *Deo Narsingh; Graph Theory with Applications to Engineering and Computer Science, PHI Learning Pvt. Ltd.*
3. *Harary F.; Graph Theory, Narosa Publishing House.*
4. *Trudeau R. J.; Introduction to Graph Theory, Zaccheus Entertainment.*
5. *Choudum S. A.; A First Course in Graph Theory, Laxmi Publications.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Understand the graphs of connectivity and tree.
2. Identify independent set and cycle graph.
3. Describe graph coloring.
4. Identify the planarity of the graphs.
5. Apply Four colour theorem and Heawood five colour theorem.

******

Course Name: Project
Code: MAD-7211 Credits: 6

Course Objectives: The objective of the course is to work with students to identify mathematical problem. The course also focuses to find out probable solution of that mathematical problem.

Syllabus

Every student shall, in the Fourth (final) Semester, submit a Dissertation reporting the results of original research on a topic assigned at the beginning of the semester by the concerned research guide (faculty member) in consultation with the student, in his/her area(s) of special interest. The research guide shall be chosen by the student according to his/her interest and the faculty member's area of expertise. No faculty member shall guide more than five students.

The topic of the Dissertation shall be approved by the Head of the Department. For this purpose the candidate shall submit to the Head an application stating the topic for the dissertation along with a synopsis within three weeks of the commencement of classes of the Fourth Semester. Once approved, the topic of dissertation shall not be altered without a fresh proposal from the student accompanied by a written request stating the reason for change. No such request shall be entertained after five weeks of the commencement of classes of the Semester in question.

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Identify and Define appropriate mathematical problems.
2. Explain appropriate research approaches for addressing mathematical problems.
3. Apply various tools and techniques to complete research.
4. Analyse research report and make robust conclusion.

******

Faculty and Support Staff

The University has identified the dedicated requisite faculty and support staff as mandated by the UGC and they are allocated the positions exclusively for ODL mode. The course material prepared by the CDOE faculty is at par with the regulations 2020.

List of Faculty associated with M.Sc.-Mathematics program is as follows:-

S. No.	Name of Faculty	Designation	Nature of Appointment	Qualification	Subject
1	Dr. Hibah Islahi	Assistant Professor	Full-Time	Ph.D	Math
2	Dr. Prabhat Bansal	Assistant Professor	Full-Time	Ph.D	Math

Delivery Mechanism

The ODL of MU follows a modern ICT (Information & Communication Technology) enabled approach for instruction. The methodology of instruction in ODL of MU is different from that of the conventional/regular programs. Our ODL system is more learner-oriented and the learner is an active participant in the teaching-learning process. ODL of MU academic delivery system comprises:

A. **Print Material**
The printed material of the programme supplied to the students will be unit wise for every course.

B. Counselling Sessions
There will be 6 counselling/ contact classes in face to face mode of two hours each for a course of 4 credits in case of 2 credit course contact hours required 6 hours). The counselling sessions / face to face contact classes will be held on the campus of the University on Saturdays and Sundays.

C. Medium of Instruction
Medium of Course Instruction: English
Medium of Examination: English

Student Support Systems
Universities Study Centres or Learner Support Centre shall be headed by a coordinator, not below the rank of Assistant professor and shall be augmented with academic and non-academic staff depending on the learner.
The university has made appropriate arrangements for various support services including counselling schedule and resource-oriented services evaluation methods and dates both online and offline modes for easy and smooth services to the students of distance mode.

At present the university have only one study centre on the campus. The institution is not promoting any study centres outside the campus. All student support services will be provided to the student through a single window method/mode onsite and online.

F. Procedure for Admissions, Curriculum, Transaction and Evaluation

Admission Process

Admission to the M.Sc. (Mathematics) Programme will be done on the basis of screening of candidate's eligibility on first come first serve basis. The University will follow the reservation policy as per norms of the Government. Admission shall not be a right to the students and MU, CDOE shall retain the right to cancel any admission at any point of time if any irregularity is found in the admission process, eligibility etc..

Maximum Duration

A. The maximum duration of the M.Sc. (Mathematics) Programme is four years. Thereafter, students seeking completion of the left-over course(s) will be required to seek fresh admission.
B. The student can complete his programme within a period of 4 years failing which he/she shall seek fresh admission to complete the programme.

Eligibility

Science (PCM) Graduate from a recognised University is eligible for admission into M.Sc. (Mathematics) programme.

Fee Structure

Name of the Program	Degree	Duration	Year	Tuition Fee/Year	Exam Fee/Year	Total (in Rs.)
Master of Science (Mathematics)	PG	2 to 4 Years	1	15000	2000	17000
			2	13500	2000	15500
					Total	32500

Activity Schedule

S. No.	Name of the Activity	Tentative months schedule (specify months) during year			
		From	To	From	To
1	Admission	Jul	Sep	Jan	Mar
2	Assignment submission (if any)	Sep	Oct	Mar	Apr
3	Evaluation of Assignment	Oct	Nov	Apr	May
4	Examination	Dec		Jun	
5	Declaration of Result	Jan		Jul	
6	Re-registration	Jul		Jan	
7	Distribution of SLM	Jul	Sep	Jan	Mar
8	Contact Programmes (counseling, Practicals.etc.)	Sep	Nov	Mar	May

Credit System

MU, CDOE proposes to follow the 'Credit System' for most of its programs. Each credit amounts to 30 hours of study comprising all learning activities. Thus, a 8 credit course requires 240 hours, 6 credit course requires 180 hours , 4 credit course requires 120 hours and 2 credit course requires 60 hours of study. This helps the student to understand the academic effort to complete a course. Completion of an academic programme requires successful clearing of both, the assignments and the term-end examination of each course in a programme.

Duration of programme	Credits	Name of programme	Level of programme
2 to 4 Yrs.	80	M.Sc. (Mathematics)	Master's Degree

Assignments

Distance Education learners have to depend much on self study. In order to ascertain the writing skill and level of comprehension of the learner, assignment work is compulsory for

all learners. Each assignment shall consist of a number of questions, case studies and practical related tasks. The Assignment Question Papers will be uploaded to the website within a scheduled time and the learners shall be required to respond them within a specified period of time. The response of the learner is examined by a faculty member.

Evaluation: The evaluation system of the programme is based on two components:

A. Continuous Evaluation in the form of assignments (weightage 30%): This Component carries a weightage of 30%. There will be at least one graded assignment and test per course. These assignments are to be submitted to the Co-ordinator of the CDOE/Study Centre to which the student is assigned or attached with.

B. Term-end examination (weightage 70%): This will be held twice every year in the months of June and December. The students are at liberty to appear in any of the examinations conducted by the University during the year. A student will be allowed to appear in the Term-End Examination only after she/he has registered for that course and submitted the assignment. For appearing in the Examination, every student has to submit an Examination form through online (www.mangalayatan.in)/ or offline before the due dates as given in the schedule of operations. If a student misses any term-end examination of a course for any reason, s/he may appear for any of them or all the courses subject to the maximum of 8 courses in the subsequent term-end examinations. This facility will be available until a student secures the minimum pass grade in the courses but up to a maximum period of four semesters, since the date of registration of the course is valid for four semesters. Beyond this period s/he may continue for another four semesters by getting Re-registration by paying fee again. In that case, the score of qualified assignments and/or term-end examination will be retained and the student will be required to complete the left out requirements of such re-registered courses. Minimum requirement for passing a course will be 40% marks.

G. Laboratory Support and Library Resources

The library of Mangalayatan University aims to empower the teaching mission and intellectual culture of the community through availability through an organized collection of information as well as instruction in its access, relevance and evaluation.
The University Library enriches advance learning and discovery by providing access to a broad array of resources for education, research and creative work to ensure the rich interchange of ideas in the pursuit of knowledge.

The Centre of Distance Education of Mangalayatan University has initiated the process of setting up a dedicated Library for ODL program and acquiring printed books and e-books for this purpose. The required International and National subject journals are also provided. We have a full functioning community radio service onboard (90.4 FM). We already have annual journal subscriptions and the capacity can be enlarged at later stages as the University lines up with more online journals.

The collection of the Library is rich and diverse especially in terms of the breadth and depth of coverage. Collection encompasses subjects in Management, Commerce, Information Technology, Computer Applications, and other allied areas. This collection further includes Books, Research Journals, Project Reports/Dissertations and online Journals.

The Mathematics laboratory is outfitted with essential software tools, including Scilab, Python, SciPy, SageMath, etc., which are indispensable for the computational resolution of mathematical problems.

The University has well equipped Computer Laboratories, Lecture Capturing Systems, Audio Video facilities, ICT enabled class rooms, Wi-Fi facilities etc.

H. Cost estimate of the programme and the provisions

Initial expenses have been done by the University in terms of provision of infrastructure, manpower, printing of Self Study Material etc. The University intends to allocate expenses out of the total fee collection as per following details:

a) SLM Development and Distribution	:	20%
b) Postal and ICT Expenses	:	10%
c) Salary and other Administrative expenses	:	60%
d) Future Research development reserve	:	10%

Once programmes are operational, the programme budget from fee receipts will be planned as per the guidelines of University Grants Commission.

I. Quality Assurance

The University has established the Centre for Internal Quality Assurance (CIQA) in the University campus. The CIQA will monitor and maintain the quality of the ODL programmes. It has the following objectives in making the compliances of quality implementations.

Objectives

The objective of Centre for Internal Quality Assurance is to develop and put in place a comprehensive and dynamic internal quality assurance system to ensure that programmes of higher education in the Open and Distance Learning mode and Online mode being implemented by the Higher Educational Institution are of acceptable quality and further improved on continuous basis.

Functions of CIQA

The functions of Centre for Internal Quality Assurance would be following:

1) To maintain quality in the services provided to the learners.
2) To undertake self-evaluative and reflective exercises for continual quality improvement in all the systems and processes of the Higher Educational Institution.
3) To contribute in the identification of the key areas in which Higher Educational Institution should maintain quality.
4) To devise mechanism to ensure that the quality of Open and Distance Learning programmes and Online programmes matches with the quality of relevant programmes in conventional mode.
5) To devise mechanisms for interaction with and obtaining feedback from all stakeholders namely, learners, teachers, staff, parents, society, employers, and Government for quality improvement.
6) To suggest measures to the authorities of Higher Educational Institution for qualitative improvement.
7) To facilitate the implementation of its recommendations through periodic reviews.
8) To organize workshops/seminars/symposium on quality related themes, ensure participation of all stakeholders, and disseminate the reports of such activities among all the stakeholders in Higher Educational Institution.

9) To develop and collate best practices in all areas leading to quality enhancement in services to the learners and disseminate the same all concerned in Higher Educational Institution.
10) To collect, collate and disseminate accurate, complete and reliable statistics about the quality of the programme(s).
11) To ensure that Programme Project Report for each programme is according to the norms and guidelines prescribed by the Commission and wherever necessary by the appropriate regulatory authority having control over the programme;
12) To put in place a mechanism to ensure the proper implementation of Programme Project Reports.
13) To maintain a record of Annual Plans and Annual Reports of Higher Educational Institution, review them periodically and generate actionable reports.
14) To provide inputs to the Higher Educational Institution for restructuring of programmes in order to make them relevant to the job market.
15) To facilitate system based research on ways of creating learner centric environment and to bring about qualitative change in the entire system.
16) To act as a nodal coordinating unit for seeking assessment and accreditation from a designated body for accreditation such as NAAC etc.
17) To adopt measures to ensure internalization and institutionalization of quality enhancement practices through periodic accreditation and audit.
18) To coordinate between Higher Educational Institution and the Commission for various qualities related initiatives or guidelines.
19) To obtain information from other Higher Educational Institutions on various quality benchmarks or parameters and best practices.
20) To record activities undertaken on quality assurance in the form of an annual report of Centre for Internal Quality Assurance.
21) It will be mandatory for Centre for Internal Quality Assurance to submit Annual Reports to the Statutory Authorities or Bodies of the Higher Educational Institution about its activities at the end of each academic session. A copy of report in the format as specified by the Commission, duly approved by the statutory authorities of the Higher Educational Institution shall be submitted annually to the Commission.

After enrolling in M.Sc. (Mathematics) programme of Mangalayatan University in ODL mode, student will exhibit knowledge, skill and general competence with scientific aptitude and innovation. After completion of M.Sc. (Mathematics) programme, student will pursue further studies in mathematics for roles in academia, research, industry, finance, technology and government.