Draft Syllabus
for
Four-Year (Eight-Semester)
Undergraduate Program
in
Mathematics (Major)
as per NEP 2020
(This contains Semester-VII to Semester-VIII Syllabus)

(Effective from Academic Session 2023-24)

Name of Major (Core) Papers

VII	MTMMJ-MC-16	Functional Analysis
	MTMMJ-MC-17	Topology
	MTMMJ-MC-18	Classical Mechanics
	MTMMJ-MC-19	Research Methodology
VIII (Honours)	MTMMJ-MC-20	Computer aided Laboratory
	MTMMJ-MC-21	Measure Theory
	MTMMJ-MC-22	Theory of Differential Equations
	MTMMJ-MC-23	Term paper
VIII (Honours with Research)	MTMMJ-MC-20	Computer aided Laboratory
	MTMMJ-MC-DRP	Dissertation/Research Project

Note: Each Major course from Semester VII to Semester VIII is of 4 credits (75 marks, out of which 25 marks is allotted for Continuous Assessment (**CA**) and 50 marks is allotted for Semester-End (**SE**) examination.)

SEMESTER VII

MTMMJ-MC-16

Functional Analysis
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:
The course aims to provide a rigorous foundation in Functional Analysis, focusing on the structure and properties of normed linear spaces, Banach spaces, and Hilbert spaces. It develops a deep understanding of bounded linear operators, fundamental theorems such as the Hahn–Banach Theorem, Uniform Boundedness Theorem, Open Mapping Theorem, Closed Graph Theorem, and the Riesz Representation Theorem. The course also emphasizes the geometry of inner product spaces, duality theory, and operator theory, enabling students to apply abstract analytical tools to advanced problems in mathematics and related disciplines.

Learning Outcomes:
On completion of the course, the students would

1. understand and explain the fundamental concepts of normed linear spaces, Banach spaces, equivalent norms, finite-dimensional normed spaces, local compactness, and apply results such as Riesz Lemma.

2. analyze bounded linear transformations and apply the Uniform Boundedness Theorem, Open Mapping Theorem, and Closed Graph Theorem in solving theoretical problems.

3. characterize linear functionals and determine necessary and sufficient conditions for bounded (continuous) and unbounded (discontinuous) linear functionals in terms of their kernels, and identify hyperplanes in normed spaces.

4. apply the Hahn–Banach Theorem to study dual spaces, examine examples of reflexive Banach spaces, and analyze the structure and properties of L^p-spaces.

5. demonstrate proficiency in real and complex inner product spaces by applying the Cauchy–Schwarz inequality, Parallelogram Law, Pythagorean Theorem, Bessel's inequality, and performing the Gram–Schmidt orthogonalization process.

6. analyze Hilbert spaces, orthonormal sets, complete orthonormal sets, Parseval's identity, orthogonal complements, projections, and apply the Riesz Representation Theorem and operator-theoretic concepts including adjoint operators.

Course Contents

Module-1

Normed Linear Spaces and its properties, Banach Spaces, Equivalent Norms, Finite dimensional normed linear spaces and local compactness, Riesz Lemma. Bounded Linear Transformations. Applications of Uniform Boundedness Theorem, Open Mapping Theorem, Closed Graph Theorem.

Module-2

Linear Functionals, Necessary and sufficient conditions for Bounded (Continuous) and Unbounded (Discontinuous) Linear functionals in terms of their kernel. Hyperplane, Necessary and sufficient conditions for a subspace to be hyperplane. Applications of Hahn-Banach Theorem, Dual Space,Examples of Reflexive Banach Spaces.

Module-3

Real Inner Product Spaces and its Complexification, Cauchy-Schwarz Inequality, Parallelogram law, Pythagorean Theorem, Bessel's Inequality, Gram-Schmidt Orthogonalization Process, Hilbert Spaces, Orthonormal Sets, Complete Orthonormal Sets and Parseval's Identity, Orthogonal Complement and Projections.

Module-4

Riesz Representation Theorem for Hilbert Spaces, Adjoint of an Operator on a Hilbert Space with examples, Reflexivity of Hilbert Spaces.

Reference Books

1. B.V. Limaye, Functional Analysis, Wiley Eastern Ltd, 1981.
2. E. Kreyszig, Introductory Functional Analysis and its Applications, John Wiley and Sons, New York, 1978.
3. A. Brown and C. Pearcy, Introduction to Operator Theory I: Elements of Functional Analysis, New York: Springer-Verlag, 1977.
4. E. S. Suhubi, Functional Analysis, New Delhi: Springer, 2009.
5. C. D. Aliprantis and O. Burkinshaw, Principles of Real Analysis, 3rd ed. Singapore: Harcourt Asia Pte Ltd., 1998.
6. S. Ponnusamy, Foundations of Functional Analysis, New Delhi: Narosa, 2011.
7. C. Goffman and G. Pedrick, First Course in Functional Analysis. New Delhi: Prentice Hall of India, 1987.
8. G. Bachman and L. Narici, Functional Analysis, New York: Academic Press, 1966.
9. A. E. Taylor, Introduction to Functional Analysis, New York: John Wiley and Sons, 1958.
10. G. F. Simmons, Introduction to Topology and Modern Analysis, New York: McGraw-Hill, 1963.
11. J. B. Conway, A Course in Functional Analysis, New York: Springer-Verlag, 1990.
12. W. Rudin, Functional Analysis, New Delhi: Tata McGraw Hill, 1992.
13. P.K.Jain and A.P.Ahuja, Functional Analysis-New Age International, 2010.

MTMMJ-MC-17

Topology
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The principal aim of this course is to introduce the fundamental concepts and structures of General Topology, including various types of topological spaces, continuous functions, connectedness, compactness, countability axioms, and separation axioms. The course is designed to develop a rigorous understanding of abstract topological ideas, their properties, and their interrelationships, thereby preparing students for advanced study in analysis and other branches of mathematics. .

Learning Outcomes:

On completion of the course, the students would

1. understand and construct various topologies on a set, compare finer and coarser topologies, and work with bases, subbases, product, and subspace topologies.
2. analyze interior, closure, boundary, and limit points of sets and determine their properties in different topological spaces.
3. examine continuous functions, open and closed maps, homeomorphisms, and apply standard techniques for constructing continuous mappings.
4. distinguish between connected and path-connected spaces and verify compactness through definitions and basic properties.
5. apply countability and separation axioms to classify topological spaces.
6. ecognize and analyze important classes of spaces such as metric, Lindelöf, regular, and normal spaces.

Course Contents

Module-1

Topology on a set, Examples of Topologies (Topological Spaces): Discrete Topology, Indiscrete Topology, Finite Complement Topology, Basis and Sub basis for a topology, Countable Complement Topology, Topologies on the Real Line: $\mathbb{R}$ with usual Topology, Lower Limit Topology, Upper Limit Topology etc., Finer and Coarser Topologies.

Module-2

Interior Points, Limit Points, Derived Set, Boundary of a set, Closed Sets, Closure and Interior of a set. Continuous Functions, Rules for Constructing Continuous Functions: Inclusion Map, Composition, by restricting the domain, by restricting/expanding the range, Pasting Lemma, Open maps, Closed maps and Homeomorphisms, Topological invariant, Metric topology and quotient topology.

Module-3

Connected and Path Connected Spaces: Definitions, Examples and its simple properties, Compact Spaces: Examples and its simple properties.

Module-4
Countability Axioms, Separation Axioms, Lindelöf spaces, Regular spaces, Normal spaces,application of Urysohn's lemma, Tietze extension theorem. Product topology, Subspace Topology.

Reference Books

1. J.R. Munkres, Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. J. Dugundji, Topology, Allyn and Bacon, 1966.
3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
4. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, 2010.
5. J.L. Kelley, General Topology, Van Nostrand Reinhold Co., New York, 1995.
6. J.G. Young, Topology, Addison-Wesley Reading, 1961.
7. S. Willard, General Topology, Dover, 2004.
8. R. Engelking, General Topology, 2nd ed., Polish Scientific Pub, 1977.
9. W. Sierpinski, Introduction to General Topology, The University of Toronto Press, Canada,1952.
10. K. Kuratowski, General Topology, Vol. I, Academic Press, New York and London, 1966.
11. J.MeCleary ,A First Course in Topology, American Mathematical Society.

MTMMJ-MC-18

Classical Mechanics
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:
The objective of this course is to introduce the fundamental concepts of analytical mechanics and dynamical systems. It aims to develop an understanding of constraints, generalized coordinates, and principles such as virtual work and D'Alembert's principle for formulating equations of motion. The course also focuses on Lagrangian and Hamiltonian formulations of mechanics and their applications in analyzing physical systems. It introduces canonical transformations, Hamilton–Jacobi theory, and conservation principles in dynamical systems. In addition, the course develops the mathematical foundation of the calculus of variations and its applications to problems involving extrema and constrained systems.

Learning Outcomes:
On completion of the course, the students would

1. Explain the concepts of dynamical systems, constraints, generalized coordinates, and apply the principle of virtual work and D'Alembert's principle to mechanical systems.

2. Derive and apply Lagrange's equations of motion for holonomic systems and systems with dissipative or impulsive forces.

3. Analyze physical systems using Hamiltonian formulation, including phase space description, Hamilton's canonical equations, and conservation principles.

4. Apply canonical transformations, generating functions, and evaluate Poisson and Lagrange brackets to study properties of dynamical systems.

5. Solve problems using the Hamilton–Jacobi equation and understand the role of separation of variables in analytical mechanics.

6. Develop advanced mathematical reasoning and computational skills for further studies and research in analytical mechanics, mathematical physics, and dynamical systems.

Course Contents

Module-1
Dynamical systems, Holonomic and non-holonomic system, Unilateral and bilateral constraints, Generalized coordinates, Degrees of freedom, Virtual work, Principle of virtual work, D'Alembert's principle.

Module-2
Lagrange's equations for holonomic systems, Lagrange's equation for impulsive forces and for systems involving dissipative forces, Cyclic co-ordinate, Conservation theorems, Invariance of Lagrange's equations under generalised co-ordinate transformation and Galilean transformation. Phase space, Legendre transformation, Hamiltonian function, Hamilton's canonical equations, Hamilton's principle, Principle of least action, Conservation laws, Routhian equations of motion.

Module-3
Canonical transformations, Generating functions, Lagrange and Poisson brackets and their properties, Condition for canonicality, Symmetry groups of Mechanical systems, Liouville's theorem, Hamilton-Jacobi equations and separation of variables. Hamilton's principal function, Action angle variable.

Module-4
Variation of functional, Fundamental lemma of calculus of variations, Necessary and sufficient conditions for extrema: Euler's equation for simplest problem, Functional depends on higher order derivatives, Functional depends on several independent variables. Variational problems with moving boundary: Natural boundary condition, Transversality condition.

Reference Books

1. H.Goldstein, Classical Mechanics, Dover, 1980.

2. V.I. Arnold (Translated by K. Vogtmann and A. Weinstein), Mathematical Methods of Classical Mechanics, Springer (GTM), 1989.

3. N.C. Rana and P.S. Jog,Classical Mechanics, Tata McGraw Hill, 2001.

4. L.N. Hand and J.D. Finch, Analytical Mechanics, Cambridge University Press, 1998.
5. I.M. Gelfand and S.V.Fomin (Translated and edited by R.A. Silverman), Calculus of Variations, Prentice Hall, 1963.
6. D. Lao and S. Zhao, Fundamental theories and their applications of the calculus of variations, Springer, 2021.
7. L. Elsgolts, Differential equations and the calculus of variations,MIR Publication, 1977.
8. O. Bolza, Lectures on the Calculus of Variations, Chelsea Publishing Company, 1904.
9. H. Sagan, Introduction to Calculus of Variations, Dover, 1967.

MTMMJ-MC-19

Research Methodology for Mathematics
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives: The course aims to provide students with a comprehensive understanding of research methodology, ethical practices, and scholarly communication in mathematics. It enables them to identify and formulate research problems, conduct literature reviews using modern web-based resources and databases, and evaluate research outputs using standard academic metrics. The course also develops proficiency in mathematical typesetting and presentation using LaTeXand Beamer, while equipping students with computational skills through MATLAB/Mathematica for mathematical modeling, visualization, and problem-solving. Overall, the course prepares students for independent mathematical research and effective dissemination of research findings.

Course Outcomes:
After successful completion of the course, the students will be able to:

1. explain the concepts, objectives, methodologies, and ethical standards of research, and identify instances of scientific misconduct and plagiarism.
2. formulate research problems, prepare research designs and synopses, and apply appropriate research methodologies to mathematical investigations.
3. conduct literature surveys using mathematical databases and web resources, evaluate journal quality using research metrics, and prepare scholarly references and citations.
4. prepare professional-quality mathematical documents, research articles, theses, dissertations, posters, and presentations using LaTeXand Beamer.
5. apply MATLAB/Mathematica tools to perform mathematical computations, solve algebraic and differential equations, and generate graphical visualizations.
6. integrate research methodology, ethical practices, mathematical writing, and computational techniques to undertake independent mathematical research and effectively communicate research findings.

Course Contents

Module I: Fundamentals of Research and Ethics

Research: Meaning, Objectives, and Motivation, Types of Research, Research Approaches - Basic, Pure, Applied, Interdisciplinary, Multidisciplinary, etc., Research Methods vs. Methodology. Research Problem: Definition, Necessity and Techniques of Defining Research Problem, Formulation of Research Problem, Objectives of Research Problem. Research Design: Meaning, Need and Features of Good Research Design, Types of Research Designs, Synopsis Design for Research Topic. Research Ethics: Definition, Moral Philosophy, Scientific Conduct, Intellectual Honesty, and Research Integrity, Scientific Misconducts-Falsification, Fabrication and Plagiarism, Redundant Publications-Duplication, Overlapping Publications.

Module II: Mathematical Research and Web Resources

Mathematical Research: What is Mathematical Research? Defining a Research Problem, Literature Review, Research Criteria, Citations, Keywords, Mathematics Subject Classification, Structuring a Mathematical Research Article/Project Report/Thesis/Dissertation (Title Page to References/Bibliography), Scientific Communications - Publishing Research Articles in Journals. Web Resources: AMS, MAA, SIAM, arXiv, ResearchGate, etc., Journal Metrics - Impact Factor of Journals according to JCR (Web of Science); CiteScore (Scopus), Quartiles (Q1 to Q4), SJR (SCImago Journal Rank), SNIP (Source Normalized Impact per Paper), Google Scholar Metric. Reviews/Databases - Indexing and Citation Databases: MathSciNet, zbMath, Web of Science, Scopus, etc.

Module III: Mathematical Typesetting and Presentation using LaTeX

Preparation and Compilation a Basic LaTeX File. Document Classes - Article, Report, Book, Beamer, etc. Structure: Titles, Abstract, Chapters, Sections, Subsections, Footnote, Paragraph, References/Bibliography, Citations, Appendix. Mathematical Representation: Inline Math, Equations, Fractions, Matrices, Determinants, Trigonometric, Logarithmic, Exponential Functions, Limits, Derivatives, Integrals, Scaling of Parentheses, Brackets, etc. Customization of Fonts: Bold, Emphasise, mathbb, mathbf, mathcal, mathfrak, etc., Sizes - normal, footnotesize, tiny, large, huge, etc. Creating Tables. Including and Placing Figures. Packages: amsmath, amssymb, amsthm, graphics, graphicx, geometry, algorithms, color,hyperref, etc. Preparation of Mathematical Reasearch Articles using LaTeX, Preparation of Mathematical Talk/Oral/Poster Presentations using Beamer.

Module IV: Computational Tools for Mathematical Research Basic Commands of Matlab or Mathematica: clc, help, clear, format, exit, line space, zeros, ones, meshgrid, eye, rand, real, imag, angle, conj, commands for trigonometric and inverse trigonometric function, abs, exp, sqrt, log, log2, log10, mod, plot, title, legend, hold on, axis, grid on, figure, clf, close all. Evaluation of Arithmetic Expression, Exponential and Logarithms, Trigonometric Functions, Computation of Complex Numbers. Solution of Algebraic Equation, System of Linear Equations. Parametrizing a Curve, Arc- length, Arc-length of Parametrized Curves, Area of Surface of Revolution. 2D and 3D Plotting. Solving Differential Equations and IVPs using Matlab or Mathematica.

Reference Books

1. N. J. Higham, Handbook of Writing for the Mathematical Sciences, SIAM, 3rd edition, 2019.

2. G. Grätzer, More Math Into LaTeX, Springer, 5th edition, 2016.

3. F. Vivaldi, Mathematical Writing, Springer, 2014.
4. K.B. Sinha and S. N. Maity, Research Methodology in Mathematics, Academic Publishers, 2015.
5. D. J. Hand, Statistics: A Very Short Introduction, Oxford University Press, 2008.
6. S. H. Strogatz, Nonlinear Dynamics and Chaos (for computational examples), Westview Press, 2015.
7. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer, 5th edition, 2016.
8. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 4th edition, 2019.
9. P. K. Mittal, Research Methodology, NCERT Publication (for NEP alignment), 2021.
10. M. J. Quinn, Ethics for the Information Age, Pearson, 8th edition, 2020 (relevant chapters on IPR and ethics).

SEMESTER VIII

MTMMJ-MC-20

Computer aided Laboratory
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Practical Components: (By using C)

1. Solution of transcendental and algebraic equations by
   - Bisection method
   - Secant method
   - Regula-Falsi method
   - Fixed point method
   - Newton Raphson method
2. Solution of system of linear equations
   - Gaussian elimination method
   - Gauss Jordan method
   - LU decomposition method
   - Gauss-Jacobi method
   - Gauss-Seidel method
3. Interpolation & approximation
   - Newton Interpolation
   - Lagrange Interpolation
   - Least square approximation
4. Numerical Integration
   - Newton Cotes formula
   - Trapezoidal Rule
   - Simpson's 1/3rd rule
   - Simpson's 3/8th rule
   - Weddle's Rule
   - Gauss Quadrature: Gauss-Legendre, Gauss-Chebyshev, Gauss-Laguerre, Gauss-Hermite
5. Method of finding Eigenvalue by Power method
6. Fitting a Polynomial Function
7. Solution of ordinary differential equations

- Euler method
- Modified Euler method
- Runge Kutta method of order 2 and 4

8. Programming in probability and statistics
    - Probability by using Empirical Definition
    - Mean
    - Median
    - Mode
    - Standard deviation
    - Coefficient of correlation

9. Matrices
    - Determinants
    - Transpose
    - Product
    - Addition/Substruction
    - Rank
    - Inverse

Reference Books & Resources

1. E. Balagurusamy, Programming In Ansi C.

2. Y. Kanetkar, Let Us C.

MTMMJ-MC-21

Measure Theory
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The objective of this course is to introduce the concepts of advanced integration and measure theory, including the Riemann–Stieltjes Integral and its properties, and to develop an understanding of the construction of Lebesgue Measure and measurable sets on the real line. The course aims to familiarize students with Measurable Function, sequences of measurable functions, and the development of the Lebesgue Integral along with integrable functions and Lp space. It also aims to help students apply important convergence results such as the Monotone Convergence Theorem, Fatou's Lemma, and Dominated Convergence Theorem, and to understand product measure spaces and the applications of Fubini's Theorem.

Learning Outcomes:

On completion of the course, the students would

1. Explain the concept and properties of the Riemann–Stieltjes Integral and apply techniques such as integration by parts and change of variables.
2. Construct and analyze Lebesgue Measure on the real line and identify measurable and non-measurable sets.
3. Determine whether a function is Measurable Function and analyze sequences of measurable functions using results like Egorov's Theorem and Lusin's Theorem.
4. Evaluate integrals using the Lebesgue Integral for simple, bounded, and general measurable functions.
5. Demonstrate the relationship between the Riemann Integral and the Lebesgue Integral.
6. Apply convergence theorems such as the Monotone Convergence Theorem, Fatou's Lemma, and Dominated Convergence Theorem to analyze integrals of sequences of functions.

Course Contents

Module-1
Riemann Stieltjes integrals and its properties. Integration by parts, Change of variables, Reduction to Riemann integral, Absolutely Continuous Functions.

Module-2
Lebesgue Measure: Lebesgue Outer measure and measure on $\mathbb{R}$, $\sigma-$algebra on Lebesgue measurable set, Borel sets, Borel $\sigma-$algebra, open sets, closed sets are measurable, Existence of a non-measurable set, Measure space, Measurable Function and its properties, Borel measurable functions, Concept of Almost Everywhere (a.e.), sets of measure zero, Steinhaus Theorem, Sequence of measurable functions, Egorov's Theorem, Lusin Theorem and its applications.

Module-3
Simple and Step Functions, Lebesgue integral of simple and step functions, Lebesgue integral of a bounded function over a set of finite measure, Lebesgue integral of non-negative function, The General Lebesgue integral: Lebesgue Integral of an arbitrary Measurable Function, Lebesgue Integrable functions. $\mathbf{L}^p$-Spaces. Riemann Integral as Lebesgue Integral.

Module-4
Bounded Convergence Theorem, Fatou's Lemma, Monotone Convergence Theorem. Dominated Convergence Theorem. Product measure spaces, Fubini's Theorem (applications only).

Reference Books

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, 2002.
2. H.L. Royden, Real Analysis, 3rd Edition, Macmillan, New York & London, 1988.
3. C.D. Aliprantis and O. Burkinshaw, Principles of Real Analysis, 3rd Edition, Harcourt Asia Pte Ltd.,1998.
4. P.R. Halmos, Measure Theory, Springer, 2007.
5. W. Rudin, Principles of Mathematical Analysis, Tata McGraw Hill, 2001.

6. W. Rudin, Real and Complex Analysis, McGraw-Hill Book Co., 1966.
7. T. Tao, An Introduction to Measure Theory, American Mathematical Society, 2011.
8. A.N. Kolmogorov and S.V. Fomin, Measures, Lebesgue Integrals and Hilbert Space, Academic Press, New York & London, 1961.
9. I.K. Rana, An introduction to Measure and Integration, 2nd Edition, Narosa, 1997.
10. G.D. Barra, Measure Theory and Integration, Woodhead Pub, 1981.
11. J.F.C. Kingman and S.J. Taylor, Introduction to Measure and Probability, Cambridge University Press, 1966.
12. D.L. Cohn, Measure Theory, Birkhäuser, 2013.
13. R. L. Wheeden and A. Zygmund, Measure and Integral: An Introduction to Real Analysis, Monographs and Textbooks in Pure and Applied Mathematics,Marcel Dekker, New York, 1977.
14. H. H. Sohrab, Basic Real Analysis, Birkhäuser, 2003.
15. J. Yeh, Lectures on Real Analysis, World Scientific, 2000.
16. B. K. Lahiri and K. C. Roy, Real Analysis, The World Press Pvt. Ltd., 2008.

MTMMJ-MC-22

Theory of Differential Equations
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:
The objective of this course is to develop a solid understanding of the theory of Ordinary Differential Equation with emphasis on existence and uniqueness of solutions for initial value problems using results such as the Peano Existence Theorem and the Picard–Lindelöf Theorem. It also aims to introduce systems of differential equations, linear systems, and stability analysis of dynamical systems using concepts like Lyapunov Function. The course further focuses on boundary value problems and eigenvalue problems using tools such as Green's Function and Sturm–Liouville Theory. Finally, it introduces fundamental concepts and properties of important Partial Differential Equation such as the Laplace's Equation, Heat Equation, and Wave Equation.

Learning Outcomes:
On completion of the course, the students would

1. Analyze first-order initial value problems and apply theorems such as the Peano Existence Theorem and Picard-Lindelöf Theorem to determine existence and uniqueness of solutions.

2. Solve and study systems of Ordinary Differential Equation, including linear homogeneous and nonhomogeneous systems, and construct fundamental matrices.

3. Examine stability of equilibrium points of dynamical systems using linearization techniques and Lyapunov Function.

4. Formulate and solve boundary value problems using Green's Function, eigenvalue methods, and concepts from Sturm–Liouville Theory.

5. Understand and analyze fundamental partial differential equations such as Laplace's Equation, Heat Equation, and Wave Equation, including their key properties and solution techniques.

Course Contents

Module-1

First order initial value problems: Gronwall inequality, $\epsilon-$approximate solution, $\epsilon-$approximate theorem. Existence of solutions: Peano existence theorem, Cauchy-Peano existence theorem, Picard's existence theorem. Uniqueness of solutions: Lipschitz condition, Lipschitz uniqueness theorem, Peano's uniqueness theorem. Picard's successive approximations, Picard-Lindelöf theorem. Existence of solutions in Large Interval.

Module-2

System of initial value problems: Existence and uniqueness of solution of systems, Local existence, Non-local existence, Approximation and uniqueness. Existence and uniqueness for linear systems, Linear homogeneous systems, Linear nonhomogeneous systems, Linear system with constant coefficients, linear system with periodic coefficients, Fundamental Matrix. Higher order linear initial value problems, fundamental solutions, Linear equations with analytic coefficients. Planar autonomous systems of ordinary differential equations: Stability of stationary points for linear systems with constant coefficients, Linearized stability, Lyapunov functions.

Module-3

Boundary Value Problems: Exact and adjoint equations, Lagrange's and Green's identity, Linear Boundary value problems, Green's function for boundary value problems, Green's function for initial value problems, Eigenvalues and Eigenfunctions, Maximum principle, Strum-Liouville problems, Orthogonality theorem, Expansion theorem.

Module-4

Laplace's equation: Fundamental solution, Mean value theorem, Properties of harmonic functions, Maximum principle, Green's function. Heat equation: Fundamental solution, Mean value theorem, Maximum principle. Wave equation: Spherical mean.

Reference Books

1. G.F.Simmons, Differential Equations, Tata McGraw Hill.

2. R.P.Agarwal and D. O' Regan, An Introduction to Ordinary Differential Equations, Springer, 2000.

3. E.A.Codington and N. Levinson, Theory of Ordinary Differential Equation, McGraw Hill.

4. E.L.Ince, Ordinary Differential Equation, Dover.

5. M.S.P. Estham, Theory of Ordinary Differential Equations, Van Nostrand Reinhold Compa.Ny,1970.
6. H.T.H. Piaggio, An Elementary Treatise on Differential Equations and Their Applications, G. BellAnd Sons, Ltd, 1949.
7. P. Hartman, Ordinary Differential Equations, SIAM, 2002.
8. D.G. Zill and M.R. Cullen, Differential Equations with Boundary Value Problems, Brooks/Cole, 2009.
9. I.N. Sneddon, Elements of Partial Differential Equations, McGraw Hill.
10. T. Amarnath, An Elementary course in Partial Differential Equations, Narosa, 2003.
11. L.C. Evans, Partial Differential Equations, AMS, 2010.
12. Q. Han, A Basic Course in Partial Differential Equations, AMS, 2011.
13. A.K. Nandakumaran and P.S.Datti, Partial Differential Equations: Classical theory with a Modern Touch, Cambridge University Press, 2020.
14. D. A. Sánchez, Ordinary Differential Equations and Stability Theory: An Introduction, Dover Publications,2019.
15. S.G. Deo,V. Raghavendra and Rasmita Kar, Textbook of Ordinary Differential Equations, McGraw Hill Education, 2017.
16. M.S.P. Eastham,Theory of ordinary differential equations,Van Nostrand Reinhold Inc.,U.S., 1970.

MTMMJ-MC-23

Term paper
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

For this Paper, Students of Mathematics Major (without Research) will opt for Literature Review/ Book Review Common guidelines for the paper for their preparation and examination are as follows

1. Students will choose a broad area of Mathematical sciences and allied (preferably based on the syllabus) for individual students.
2. Students must submit two Spiral Bond hard copies of the Review Paper for evaluation. The concerned teacher should endorse the hard copy before the examination.
3. Presentation of the Review work using beamer/ppt etc. should be evaluated in the presence of external examiner(s).
4. Viva will be conducted either at their home center or at an away center, as per the guidelines provided by the Controller of Examinations, University of Gour Banga.

5. Choice of the topic to be approved by the concerned department of the college.
6. Marks should be average marks provided by both internal and external examiner(s).
7. In Literature review, relevant topic should be preferred.
8. Marks distribution of the Review work may be as follows:

Component	**Description**	**Marks**
Topic Selection	Relevance and justification of the chosen topic for the literature review-based project.	05
Abstract	Concise, standalone summary of the study.	2
Introduction and preliminaries	Background of the topic, context and importance of the study.	10
Objectives	Clear statement of the aims and objectives of the review work.	05
Review of Literature	Systematic review with appropriate headings and subheadings highlighting previous research contributions.	15
Key Points and Outcome	Summary of important findings and outcomes derived from the review.	05
Conclusion and Future Prospect	Overall conclusion and possible future directions for further research.	05
References	Proper citation of books, journals, and other scholarly sources following standard referencing style.	03
	Total (Project Work)	**50**
Presentation using beamer/ppt	Presentation of the review paper highlighting objectives, methodology, and key outcomes.	10
Viva-voce	Oral examination to assess understanding of the topic and ability to answer related questions.	15
	Total (Presentation + Viva-voce)	**25**
	Full Marks	**75**

SEMESTER VIII

MTMMJ-MC-20

Computer aided Laboratory
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Practical Components: (By using C)

1. Solution of transcendental and algebraic equations by
   - Bisection method
   - Secant method
   - Regula-Falsi method
   - Fixed point method
   - Newton Raphson method
2. Solution of system of linear equations
   - Gaussian elimination method
   - Gauss Jordan method
   - LU decomposition method
   - Gauss-Jacobi method
   - Gauss-Seidel method
3. Interpolation & approximation
   - Newton Interpolation
   - Lagrange Interpolation
   - Least square approximation
4. Numerical Integration
   - Newton Cotes formula
   - Trapezoidal Rule
   - Simpson's 1/3rd rule
   - Simpson's 3/8th rule
   - Weddle's Rule
   - Gauss Quadrature: Gauss-Legendre, Gauss-Chebyshev, Gauss-Laguerre, Gauss-Hermite
5. Method of finding Eigenvalue by Power method
6. Fitting a Polynomial Function
7. Solution of ordinary differential equations

- Euler method
- Modified Euler method
- Runge Kutta method of order 2 and 4

8. Programming in probability and statistics
   - Probability by using Empirical Definition
   - Mean
   - Median
   - Mode
   - Standard deviation
   - Coefficient of correlation

9. Matrices
   - Determinants
   - Transpose
   - Product
   - Addition/Substruction
   - Rank
   - Inverse

Reference Books & Resources

1. E. Balagurusamy, Programming In Ansi C.
2. Y. Kanetkar, Let Us C.

MTMMJ-MC-DRP

Dissertation/Research/ Project
Credit: 12
Full Marks:

Learning Objectives:

1. To familiarize students with the fundamentals of mathematical research design and problem formulation.
2. To develop the ability to review scientific literature and identify relevant research gaps.
3. To enable students to prepare a systematic, well-structured dissertation/report following academic standards.
4. To strengthen students' capacity for critical thinking, scientific writing, and oral presentation through seminars and viva-voce.

5. To encourage application of mathematical knowledge for local, regional, and contemporary problem-solving.

Learning Outcomes:

On completion of the course, the students would

1. Define a clear research problem, develop research questions and a feasible plan.
2. Produce a structured dissertation report with literature review, methodology, results and discussion.
3. Present and defend findings in a departmental seminar and viva; identify future work / policy implications.

General Guidelines for the Report Preparation

1. Each student shall prepare an individual and original dissertation/research/project report under the direct supervision of an assigned faculty supervisor. Joint or group submissions are not permitted.
2. The entire report must be written in English, using clear, academic, and grammatically correct language.
3. Students must strictly adhere to the approved document format, referencing style, and plagiarism limits prescribed by the University.
4. Submission of the dissertation/research/project shall be subject to:
   - Supervisor's certification.
   - Plagiarism and AI similarity verification report is needed.
   - Completion of presentation and viva-voce.
5. Structure for Dissertation/Research/Project Preparation
   (a) **Preliminary Pages:** This will contain cover page, supervisor's certificate, acknowledgement,table of contents, list of figures and list of tables.
   (b) **Core content:** This contains literature review, research gap, objectives, Methodoloy for explaining the research problems, research outcomes and discussion.
6. Document Format and Technical Specifications:
   (a) **Length and copies:** Within 100 pages or 10,000 words and 3 Nos of printed copies
   (b) **Font:** Times New Roman, 12 pt
   (c) **Line spacing:** 1.5
   (d) **Figures, tables, and scientific notation/equations:** Properly labeled
   (e) **Referencing style:** Standard.
   (f) **Plagiarism threshold:** Plagiarism and AI similarity verification report is needed.

Method of Assessment, Measurement, & Evaluation

1. The evaluation of the Dissertation/Research Project shall be conducted in accordance with the approved assessment scheme prescribed by the University.
2. The assessment shall consider originality, relevance of the topic, methodological rigour, quality of analysis, interpretation of results, and overall academic presentation.
3. Marks awarded for the written report and presentation/viva-voce shall be clearly recorded, signed, and dated by the examiner(s).
4. The evaluation sheet and viva-voce report shall be preserved by the department for future reference and audit purposes.
5. Any case of academic misconduct or plagiarism detected during evaluation shall be dealt with strictly as per university regulations.
6. This course is carries a total of 12 credits, corresponding to 225 marks. The credit structure is distributed into two distinct components, namely
   (a) **Theory Component (Continuous Evaluation):** 150 Marks includes literature review, research design, methodology, and findings.
   (b) **Practical Component (Viva-Voce / Presentation):** 75 Marks includes seminar presentation and viva-voce examination

Table 1: Theory Component Assessment (150 Marks)

Component	**Marks**
Topic relevance, clarity of problem statement, and objectives	15
Review of literature and identification of research gap	25
Research methodology, identification of methods and advantage and disadvantage of these identifications	35
Results, observations and interpretation	35
Discussion, major findings, conclusions, and recommendations	25
Referencing, format, and overall presentation	15
Total	**150**

Table 2: Practical Component Assessment (75 Marks)

Component	**Marks**
Quality and clarity of presentation (structure, slides/poster, time management)	25
Understanding of the topic, methodology, and results	25
Ability to answer questions, critical thinking, and defence of the work	15
Communication skills and confidence	10
Total	**75**