DR. RAMMANOHAR LOHIA AVADH UNIVERSITY, AYODHYA

Structure of Syllabus for the
Program: M.A./M.Sc. I, II Year (I, II, III and IV Semester),
Subject: MATHEMATICS
Effective from Academic Year 2024-25

Structure of Syllabus Developed by			
Name of BoS Convener/ BoS Member	**Designation**	**Department**	**College/University**
Prof. Sant Sharan Mishra	Dean	Science	Dr. R M L A University, Ayodhya
Prof. Sanjay Kumar Pandey	Convenor	Mathematics	Shri Lal Bahadur Shastri Degree College, Gonda
Prof. Pankaj Mathur	Member	Mathematics	Dept of Mathematics, Lucknow University
Prof. V K Mishra	Member	Mathematics	M M M University of Technology, Gorakhpur
Prof. Sheela Mishra	Member	Mathematics	Dept of Mathematics, Lucknow University

DR. RAMMANOHAR LOHIA AVADH UNIVERSITY, AYODHYA

Structure of Syllabus for the Programme

M. Sc. I, II Year, Subject: Mathematics

Effective from Academic Year 2024-25

Course Code		Course Title	Credits	T/P	Evaluation	
A	B	C	D	E	F	G
SEMESTER-I (YEAR-I)						
B030701T	CORE	Advanced Abstract Algebra	5	T	25	75
B030702T	CORE	Advanced Real Analysis	5	T	25	75
B030703T	CORE	Topology	5	T	25	75
B030704T	FIRST ELECTIVE (Select any one)	Mathematical Modeling	5	T	25	75
B030705T		Riemannian Geometry	5	T	25	75
B030706T		Fuzzy Sets	5	T	25	75
B030707P	SECOND ELECTIVE (Select any one)	Programming in Python	5	P	50	50
B030708P		Computational Techniques using C	5	P	50	50
SEMESTER-II (YEAR-I)						
B030801T	CORE	Analytical Dynamics	5	T	25	75
B030802T	CORE	Theory of Differential Equation and Boundary Value Problems	5	T	25	75
B030803T	CORE	Measure and Integration	5	T	25	75
B030804T	THIRD ELECTIVE (Select any one)	History of Mathematics	5	T	25	75
B030805T		Indian Contribution in Mathematics	5	T	25	75
B030806T		Elementary Statistics	5	T	25	75
B030807P	FOURTH ELECTIVE (Select any one	Project Presentation on any core/elective paper	5	P	50	50
B030808P		Project Presentation on a Mathematical Problem using Python	5	P	50	50

Course Code		Course Title	Credits	T/P	Evaluation	
					CIE	ETE
A	B	C	D	E	F	G
SEMESTER-III (YEAR-II)						
B030901T	CORE	Functional Analysis	5	T	25	75
B030902T	CORE	Integral Equations	5	T	25	75
B030903T	CORE	Machine Learning	5	T	25	75
B030904T	FIFTH ELECTIVE (Select any one)	General Relativity	5	T	25	75
B030905T		Finsler Geometry	5	T	25	75
B030906T		Advanced Discrete Mathematics	5	T	25	75
B030907P	SIXTH ELECTIVE (Select any one)	Introduction to SCILAB /MATLAB	5	P	50	50
B030908P		Introduction to LaTex	5	P	50	50
SEMESTER- IV (YEAR-II)						
B031001T	CORE	Advanced Operations Research	5	T	25	75
B031002T	CORE	Fluid dynamics	5	T	25	75
B031003T	SEVENTH ELECTIVE (Select any one)	Special Functions	5	T	25	75
B031004T		Differential Geometry of Manifolds	5	T	25	75
B031005T		Advanced Numerical Methods	5	T	25	75
B031006P	RESEARCH PROJECT / DISSERTATION	Research Project / Dissertation	10	P	50	50

M.A./M.Sc. I (SEMESTER-I), PAPER-I

ADVANCED ABSTRACT ALGEBRA

Course Code: B030701T	Credit-5 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Advanced Abstract Algebra	

Course outcomes:

CO1: The students will be well-awarded to biography of Indian mathematicians and their notable contribution in Mathematics.

CO2: The students will be able to know about solvable groups, cauchy's theorem for finite abelian group and finite groups, Maximal subgroups, simple groups, composition series, normal and subnormal series, Jordan-Holder theorem, modules, Schur's leema, Jordan canonical and rational canonical forms.

CO3: The students will be able to define Field extensions, splitting or decomposition field, normal and seperable field extension, perfect field.

CO4: The students are able to analyse Galois group, fundamental theorem of Galois group.

CO5: The student is equipped with standard concepts and tools at advance level that will serve him/her well towards pursuing research in algebra.

Unit	Topics	No. of Lectures
I	The brief introduction of Indian mathematicians and their notable contributions: Aryabhata, Bhaskar-I, Bhaskar-II, Brahmagupta-Bhaskara Equation, Lemmas of Brahmagupta	15
II	Solvable groups, cauchy's theorem for finite abelian group and finite groups, Maximal subgroups, simple groups, composition series, normal and subnormal series, Jordan-Holder theorem, modules, sub-modules, cyclic module, module homomorphism and isomorphism, Schur's lemma, Invariant subspaces, Jordan canonical and rational canonical forms.	20
III	Field extensions, finite field extensions, simple field extensions, algebraic field extension, splitting or decomposition field, normal and separable field extension, perfect field.	20
IV	Galois group, fundamental theorem of Galois group, Galois group of seperable polynomial, Galois field, construction of Galois field and its subfields.	20

Suggested Readings:

1. A modern Introduction to Ancient Indian Mathematics: T.S.Bhanu Murthy, New Age International Pub

2. Absract algebra: David S.Dummit, Richard M. Foote–Wiley India Pvt. Ltd.

3. Topic in algebra: I. N. Herstein–Wiley India Pvt. Ltd

4. Modern algebra: A. R. Vasishtha, A.k. Vasishtha -Krishna publications.

5. भारतीय गणितज्ञ - प्रो॰ अनंत व्यवहारे, शारदा प्रकाशन, संस्कृत संस्थान, वाराणसी

M.A./M.Sc. I (SEMESTER-I), PAPER-II

ADVANCED REAL ANALYSIS

Course Code: B030702T	Credit-5 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Advanced Real Analysis	

Course outcomes:

CO1: The students will be able to analyse Sequence and series of functions of real numbers, Uniform convergence.

CO2: The students will be able to analyse Riemann-Stieltjes integration and their properties, Relation between Riemann and R-S integrals.

CO3: The students will be able to analyse Functions of several variables, Taylor's theorem, Young's Theorem and Schwarz's theorem.

CO4: The students will be able to analyse Functions of bounded variation and their properties, Absolutely continuous functions and their properties, Relation between absolute continuity and function of bounded variation.

Unit	Topics	No. of Lectures
I	Sequence and series of functions of real numbers, Point wise convergence and Uniform convergence, Cauchy's criterion of uniform convergence, Weierstrass test for uniform convergence of series, Uniform convergence and continuity, Uniform convergence and Uniform integration convergence and differentiation.	20
II	Riemann-Stieltjes integration and their properties, Riemann-Stieltjes integration with respect to arbitrary integrator, Existence of Riemann-Stieltjes integrals, Integration by parts theorem, Properties of R-S integrable functions, Relation between Riemann and R-S integrals.	20
III	Functions of several variables, limit, continuity and differentiability of several variables, Directional derivatives, Derivative of functions in an open subset of R^n to R^m. Taylor's theorem, Young's Theorem, Schwarz's theorem.	20
IV	Functions of bounded variation and their properties, Absolutely continuous functions and their properties, Relation between absolute continuity and function of bounded variation.	15

Suggested Readings:

1. Walter, R. *Principles of Mathematical Analysis*. 3rd edition, McGraw-Hill, 2017.

2. Terence T. *Analysis II*. Hindustan Book Agency, 2009.

3. Malik, S. C. and Arora, S. *Mathematical Analysis*. 2nd edition reprint. New Age International Publishers 2005.

4. Apostol, T. M. *Mathematical Analysis*. 2nd edition. *Wesley Publishing Co.* 2002.

5. Somasundram, D. and Chaudhary, B. *A First Course in Mathematical Analysis*. Narosa Publishing House, 1996.

6. Royden, H. L. *Real Analysis,* Macmillan Pub. Co., Inc. 4th edition, New York, 1993.

M.A./M.Sc. I (SEMESTER-I), PAPER-III
TOPOLOGY

Course Code: B030703T	Credit-5 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Topology	

Course outcomes:

CO1: The students are able to analyse Topological space, open and closed sets in Topological space, neighborhoods, closure, interior, exterior, derived and dense sets, bases and sub-bases.

CO2: The students are able to analyse Continuous functions and Homeomorphism, first and second countable spaces and separability.

CO3: The students are able to understand various concepts like: T_0, T_1, T_2, T_3, T_4 spaces and basic properties.

CO4: The students are able to understand various concepts like: Compactness, Connectedness and Tychonoff product topology.

CO5: It provides the students useful tools for studying local properties of a space. Without the knowledge of topology, it is rather impossible even to conceive the idea of learning mathematics at higher level.

Unit	Topics	No. of Lectures
I	Definition and example of Topological space, open and closed sets in Topological space, neighborhoods, closure, interior, exterior, derived and dense sets, bases and sub-bases, sub-spaces.	20
II	Continuous functions and Homeomorphism, first (1^{st}) and second (2^{nd}) countable spaces, separability.	20
III	T_0, T_1, T_2, T_3, T_4 spaces and their basic properties.	20
IV	Connectedness and compactness, definition and some basic theorem.	15

Suggested Readings:

1. K. D.Joshi**:** Introduction to general topology—Wiley Eastern, New Delhi

2. J. L. Kelly **:** General Topology —Van Nostrand Reinhold company, Newyork

3. James R Munkres**:** Topology —Prentice Hall India Private Ltd, New Delhi

4. J. N. Sharma **:** Topology —Krishna publications, Meerut.

M.A./M.Sc. I (SEMESTER-I), PAPER-IV

MATHEMATICAL MODELLING

Course Code: B030704T	Credit-5 Max. Marks: 25+75	First Elective paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Mathematical Modelling	

Course outcomes:

CO1: The students will be able to convert a real-world problem into a mathematical model.

CO2: The students will be able to analyse mathematical modelling: need, classification, modelling process, Elementary mathematical models, Role of mathematics in problem solving and Single species population model.

CO3: The students will be able to do mathematical modelling through ordinary differential equations of first order and second order and Some applications in economics, ecology, Modelling in epidemiology (SIS, SIR, SIRS models) and basic reproduction number.

CO4: The students will be able to do mathematical modelling through difference equations, Some simple models, Basic theory of linear difference equations with constant coefficients.

CO5: The students will be able to do mathematical modelling through partial differential equations

Unit	Topics	No. of Lectures
I	Introduction to mathematical modelling: need, classification, modelling process, Elementary mathematical models; Role of mathematics in problem solving. Single species population model: The exponential model and the logistic model, Harvesting model and its critical value.	20
II	Modelling with ordinary differential equations: Overview of basic concepts in ODE and stability of solutions: steady state and their local and global stability, Linear and non-linear growth and decay models. Compartment models. Some applications in economics, ecology, Modelling in epidemiology (SIS, SIR, SIRS models) and basic reproduction number.	20
III	Mathematical models through difference equations, Some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modelling through difference equations in economics and finance, Mathematical modelling through difference equations in population dynamics.	20
IV	Mathematical modelling through partial differential equations, Situations giving rise to of partial differential equation models. The one-dimensional heat equation: derivation and solution. Wave equation: derivation and solution.	15

Suggested Readings:

1. D. N. P. Murthy, N. W. Page and E. Y. Rodin, Mathematical Modelling, Pergamon Press.
2. J. N. Kapoor, Mathematical Modelling, Wiley Estern Ltd.
3. J.N. Kapur, Mathematical Models in Biology and Medicine, East-West Press.
4. F. Charlton, Ordinary Differential and Differential equation, Van Nostarnd.
5. Fred Brauer and Carlos Castillo-Chavez, Mathematical Models in Population Biology and Epidemiology, Springer.
6. Frank R. Giordano, William Price Fox, Maurice D. Weir, A First Course in Mathematical Modelling, 4th Ed.,

Charlie Van Wagner.
7. Walter J. Meyer, Concept of Mathematical Modelling, McGraw-Hill.
8. Zafar Ahsan: Differential Equations and Their Applications, PHI learning Private Limited, New Delhi.
9. Steven H. Strogatz, Nonlinear dynamics and chaos, With Applications to Physics, Biology, Chemistry, and Engineering.

M.A./M.Sc. I (SEMESTER-I), PAPER-IV

RIEMANNIAN GEOMETRY

Course Code: B030705T	**Credit-5** **Max. Marks: 25+75**	**First Elective paper**
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	**COURSE TITLE: Riemannian Geometry**	

Course outcomes:

CO1: Students will be able to define Riemannian space, metric, Curvature of a curve, curvature of curve and Geodesic and its applications.

CO2: Students will be able to define Congruences of curves, Ricci coefficient of rotation, Curvature of a congruence, Geodesic congruence, normal and irrotational congruence.

CO3: Students will be able to define congruences and orthogonal ennuples and Ricci's coefficients of rotation, curvature of congruence.

CO4: Students will be able to analyse Curvature tensor and Ricci tensor, Bianchi's Identity, Theorem of schur, Projective and Conformal transformation, Weyl's Curvature tensor and Conformal curvature tensor with their fundamental properties.

CO5: Students will be able to analyse Hypersurfaces, Meusnier's theorem, Line of curvature

Unit	**Topics**	**No. of Lectures**
I	Riemannian space, metric, length of a curve, magnitude of vector, unit tangent vector, Gradient of a scalar function, Angle between two curve, Curvature of a curve, Principal normal, First curvature and geodesic curvature, Equation of geodesic and it's fundamental properties, Parallelism of vectors of constant and variable magnitude, Definition of a subspace of a Riemannian space.	20
II	Congruences of curves and orthogonalennuple, Ricci coefficient of rotation, Curvature of a congruence, Geodesic congruence, normal and irrotational congruence.	20
III	Curvature tensor and Ricci tensor, Covariant curvature tensor, Bianchi's Identity, Theorem of schur, Projective and Conformal transformation, Weyl's Curvature tensor and Conformal curvature tensor with their fundamental properties.	20
IV	Hypersurfaces : Definition of Hypersurface, Gauss formula for a Hypersurface, Curvature of a curve in a Hypersurface, Meusnier's theorem, Line of curvature.	15

Suggested Readings:

1. L.P. Ersenhart : Riemannian Geometry – Princeton University Press.
2. C.E. Weatherburn: An Introduction to Riemannian Geometry and the Tensor Calculus —Cambridge University Press.

M.A./M.Sc. I (SEMESTER-I), PAPER-IV

FUZZY SETS

Course Code: B030706T	Credit-5 Max. Marks: 25+75	First Elective paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	**Course Title: Fuzzy Sets**	

Course outcomes:

CO1: The students will be able to define Fuzzy sets and representations of Membership functions and types of Fuzzy sets.

CO2: The students will be able to define Fuzzy numbers, Fuzzy cardinality, Fuzzy arithmetic operations on intervals and Fuzzy equations.

CO3: Students will be able to analyse Fuzzy relations.

CO4: Students will be able to define Fuzziness, Shannon Entropy, Fuzzy linear programming problems**.**

Unit	Topics	No. of Lectures
I	Fuzzy sets and representations of Membership functions, types of Fuzzy sets,α-cut, strong α-cut, level set, support core and height of Fuzzy sets, Normal, equal and equivalent Fuzzy set, containments, union, intersection of Fuzzy sets, degree of sub-set hood, hamming distance, convex fuzzy sets and algebra of convex fuzzy sets.	20
II	Fuzzy numbers, Fuzzy cardinality, Fuzzy arithmetic operations on intervals, arithmetic operations on Fuzzy numbers, Fuzzy equations A+X=B, AX=B.	20
III	Fuzzy relations, union and intersection of Fuzzy relations, Binary Fuzzy relations, domain, range, height, inverse and matrix representations of binary Fuzzy relations, standard composition of Fuzzy relations, Fuzzy equivalence relations.	20
IV	Fuzziness, Shannon Entropy, Fuzzy linear programming problems.	15

Suggested Readings:

1.Fuzzy set theory **:**Michael Smithson, Jay Verkuilen— Sage Publications

2.Fuzzy sets, Fuzzy logic and Fuzzy systems **:**George J.Klir, Boyuan —World Scientific, Singapore

3.Fuzzy sets and Fuzzy logic **:** M Ganesh — PHI Publications

4.Fuzzy set theory :Shiv Raj Singh —Krishna publications, Meerut

M.A./M.Sc. I (SEMESTER-I), PAPER-V

PROGRAMMING IN PYTHON

Course Code: B030707P	**Max. Marks: 50 + 50**	**Second Elective Paper**
Total No. of Lectures-Practicals (in hours per week) : 4 + 2	**Course Title: PROGRAMMING IN PYTHON**	

Course outcomes:

CO1: The students will be able to describe the basic principles of Python programming language.
CO2: The students will be able to implement object-oriented concepts.
CO3: The students will be able to making use of software easily right out of the box.
CO4: The students will be able to experience with an interpreted language.

Basics of Python programming

Introduction to Python, Python Identifiers, Key words, Variables & Operators, Data Types, Strings, Lists and Tuples, Dictionary & Sets, Input-Output, Conditional Statements and Expressions, Loops, Control Flow statements, Functions, Modules & Recursions, introduction to Classes and Inheritance, Working with files

1. Getting started, Anaconda Installation, Python notebooks and Editors. Github
2. Calculate the distance between two points in three dimensions
3. Write a program to calculate average of two numbers and print their deviation.
4. Write a program to calculate factorial of a number.
5. Write a program to find GCD of two numbers.
6. Write a program greatest number from three numbers.
7. Write a program to print the reverse of a number.
8. Write a program to classify a given number as prime or composite
9. Write a program that computes permutations P(n,r) and combinations C(n,r)
10. Write a program that computes displays all leap years from 1900-2101
11. Write a program to print Fibonacci series up to a given number
12. Write a program to convert binary number to decimal number and vice versa
13. Opening, closing, editing, deleting and creating files in python
14. Create a simple function and call it from the main program
15. Loops in python: examples

Suggested readings:

1. S. Gowrishankar and A. Veena A, Introduction to Python Programming, CRC Press (2019).
2. Adam Stewart -Python Programming (2016).
3. Kenneth A. Lambert, Fundamentals of Python First Programs with Mindtap, Cengage Learning India (2011).

M.A./M.Sc. I (SEMESTER-I), PAPER-V

Computational Techniques using C

Course Code: B030708P	Credit-5 Max. Marks: 50 + 50	Second Elective Paper
Total No. of Lectures-Practicals (in hours per week): 4 + 2	**Course Title: Computational Techniques using C**	

Course outcomes:

CO1: The students will be able to learn and use basic principles of C programming language.

CO2: The students will be able to define and manage various type of data and data- structures based on problems subject domain.

CO3: The students will be able to have ability to handle possible errors during program execution.

CO4: The students will be able to define various types of functions and able to apply various types of decision making, statements/loops.

CO5: The students will be able to able to apply in various fields of Mathematics.

Basics of C programming

Overview of C: History and importance of C. Sample Programs. Programming Style. Executing a 'C' Programme, Constants, Variables, and Data Type. Operators: Arithmetic, Relational, Logical, Assignment, Increment and Decrement, Conditional, Bitwise, Special. Expressions: Arithmetic expressions, evaluation of expressions. Input and output operators. Decision Making and Branching: Decision making with if statement, simple if statement, the if-else statement, Nesting of if-else statements, The else if Ladder, The Switch statement, The Goto statement. Decision Making and Looping: The while statement, The do statement, The for statement. Jump in Loop. Arrays: One and Two– Dimensional Arrays. Deceleration of One and Two–Dimensional Arrays. Initializing of One and Two–Dimensional Arrays. Multi–dimensional Arrays, Dynamic Arrays, Character Arrays and Strings. User-defined Functions: Need for user-defined functions. A multi-function program. Elements of user-defined functions. Definition of functions. Functions Call, Functions Deceleration. Category of function, Nesting of functions.

Practical: Programming in C (with ANSI features)

1. To print the prime numbers between 1 and 100.
2. Write a program to add, subtract, multiply and divide common fractions.
3. To find the average of between n and 12n where n is an integer.
4. Write a program to check a number is Armstrong or not ?
5. Write a program to display table from 11 to 20.
6. To find the roots of a cubic equation.
7. To sum and difference of any two matrices and hence find the row sum and column sum of a given matrix. .
8. To find inverse of a given 3x3 matrices.
9. Write a program to find the transpose, trace and norm of a matrix.
10. To sort all the elements of a 4x4 matrix.
11. Program to accept a matrix and determine whether it is a symmetric matrix, skew-symmetric or not.
12. Write a program to print Fibonacci numbers.
13. Program to find the sum of the series: $\mathbf{1} + \boldsymbol{x} + \boldsymbol{x^2} + \cdots + \boldsymbol{x^n}$.

Suggested Readings:

1. Balagurusamy: Programming in ANSI C, MacGraw Hill Education (India) Pvt. Ltd., New Delhi.

2. Kernigham and Ritche: C Programming Language, Pearson Education India,

M.A./M.Sc. I (SEMESTER-II), PAPER-I

Analytical Dynamics

Course Code: B030801T	Credit-5 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Analytical Dynamics	

Course outcomes:

CO1: The students will be able to classify dynamical systems, and define generalized coordinates, Classification of Dynamical System and D'Alembert's Principle, Lagrange's equations.

CO2: The students will be able to define Hamilton's canonical equations, Hamilton's principle and principle of least action**.**

CO3: The students will be able to define two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations and examples.

CO4: The students will be able to define Lagrange Bracket, Poisson Bracket, Canonical Transformation, Jacobi Identity, Hamilton Jacobi Theorem and Poisson's Theorem

Unit	Topics	No. of Lectures
I	Introduction of Analytical Dynamics, Generalized coordinates, Degree of Freedom, Classification of Dynamical System, Conservative and Non Conservative System, generalized Forces, D'Alembert's Principle, Lagrange's equations	20
II	Hamilton's canonical equations, Hamilton's principle and principle of least action, Conservation of Momentum and Displacement of the System, Hamiltonian Function and total Energy, Cyclic or Ignorable Coordinate.	20
III	Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations and examples.	20
IV	Lagrange Bracket, Poisson Bracket, Canonical Transformation, Jacobi Identity, Hamilton Jacobi Theorem, Poisson's Theorem	15

Suggested Readings:

1 Classical Mechanics : Goldestein, H, Pearson Education, 2011

2 Classical Mechanics : Rana and Jog, McGraw Hill Education, 2017

3 Classical Mechanics : J.C. Upadhyaya, Himalaya publication, 2014

4 Analytical Dynamics: A New Approach, Udwadia and Robert, Cambridge University Press, 2007

M.A./M.Sc. I (SEMESTER-II), PAPER-II

Theory of Differential Equation and Boundary Value Problem

Course Code: B030802T	Credit-5 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Theory of Differential Equation and Boundary Value Problem	

Course outcomes:

CO1: The students will be able to analyse Laplace's Equation, Harmonic functions, Heat and Wave equations and their Fundamental solutions.

CO2: The students will be able to analyse Existence and uniqueness theorem, initial value problems and picardes theorem, Peano's existence theorem and corollaries.

CO3: The students will be able to analyse Ordinary Differential Equations of Sturm-Liouville boundary value problem, Green's function, Poisson representation formula.

CO4: The students will be able to analyse Application of Laplace transform to solve differential equations and Fourier transforms to boundary value Problems

Unit	Topics	No. of Lectures
I	Method of separation of variables for Laplace, Fundamental solution of Laplace's Equation, Harmonic functions and properties, The maximum principle, Energy methods, Heat and Wave equations, Mean value Method, Solution of Wave equation with initial values, Fundamental solutions of Heat Equation.	20
II	Existence and uniqueness theorem for first order ODE, initial value problem and picardes theorem, convergence of solution of initial value problems, Peano's existence theorem (statement only) and corollaries.	20
III	Ordinary Differential Equations of Sturm-Liouville boundary value problem, Eigen values and Eigen functions, Orthogonality theorem, Expansion theorem, Green's function.	20
IV	Application of Laplace transform to solve differential equations, Application of Fourier transforms to boundary value Problems.	15

Suggested Readings:

1. G. F. Simmons, *Differential Equations with Applications and Historical Notes*, McGrawHillEducation.
2. Coddington, E. A. and Levinson, N. (1955) *Theory of Ordinary Differential equations*, TMHEducation.
3. M. D. Raisinghania, Advanced Differential Equations, S. Chand, 2016.
4. D.P. Choudhary and H. I. Freedman: A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi,2002.

M.A./M.Sc. I (SEMESTER-II), PAPER-III

MEASURE AND INTEGRATION

Course Code: B030803T	**Credit-5** **Max. Marks: 25+75**	**Core paper**
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	**Course Title: Measure and Integration**	

Course outcomes:

CO1 : Students will be efficient to know the measurability of a set calculating meter and inner measure only meter measure gives the measurability of a set. Student will easily classify some measurable and non -measurable sets.

CO2 : Students will enable themselves to know measurable and non-measurable functions. Countability and measurability of a set is clearly known to students with Boral.

CO3 : Students will be defined Lebesgue integral, Relation between Riemann integral and Lebesgue integral, Lebesgue integral of bounded measurable function and it's properties.

CO4 : The students will be able to analyse L^p-space, some basic definitions and theorem, Holder's inequality, Minikowski inequality, Schwarz's and Jensen Inequality.

Unit	**Topics**	**No. of Lectures**
I	Measurable sets, outer and inner measure of a bounded set. Union and intersection of a Measurable sets. Lebesgue measurable sets. Sets of measure zero. Boral sets, measure of countable and uncountable sets.	20
II	Measurable functions, algebra of measurable functions, Boral measurable function, measurability of a continuous function, non-measurable function.	20
III	Lebesgue integral, Relation between Riemann integral and Lebesgue integral, criterion theorem for Lebesgue integral, Lebesgue integral of bounded measurable function and it's properties, Lebesgue integral of unbounded functions.	20
IV	L^p-space, some basic definitions and theorem, Holder's inequality, Minikowski inequality, Schwarz's and Jensen Inequality.	15

Suggested Readings:

1 – Measure theory : Krishna B. Athreya, Soumendra N.Lahiri – Trim Hindustan book Agency

2 – Measure theory and Integration : G. DE Barra – New Age international Publisher

3 – Measure theory and Integratism : A K Malik, S C Malik, S K Gupta – willy Eastern Publisher

M.A./M.Sc. I (SEMESTER-II), PAPER-IV

HISTORY OF MATHEMATICS

Course Code:B030804T	Credit-5 Max. Marks: 25+75	Third Elective Paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: HISTORY OF MATHEMATICS	

Course outcomes:

CO1: The students will be able to know that how the concepts have been developed in Mathematics

Unit	Topics	No. of Lectures
I	Ancient Mathematics: The Babylonians. The Egyptians. The Greeks. The Romans, The Maya, The Chinese, The Japanese. The Hindus. The Arabs	20
II	Mathematics in Europe during the middle age.	20
III	Mathematics during the sixteenth, seventeenth, eighteenth, nineteenth, and twentieth centuries.	20
IV	Evolution of Mathematics from the Renaissance contributions of Vieta and Descartes to the groundbreaking advancements by Newton, Euler, Lagrange, Laplace, Hardy, and Ramanujan.	15

Suggested Readings:

1. F. Cajon: A History of Mathematics, 1894.
2. J. Stillwell: Mathematics and its History, Springer International Edition, 4th Indian **Reprint, 2005.**

M.A./M.Sc. I (SEMESTER-II), PAPER-IV

Indian Contribution in Mathematic

Course Code:B030805T	Credit-5 Max. Marks: 25+75	Third Elective Paper
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	Course Title: Indian Contribution in Mathematics	

Course outcomes:

CO1: The students will be able to know Vedic period and some Indian contribution in Mathematics

Unit	Topics	No. of Lectures
I	**Vedic period:** Yajurveda samhita in which collection of large number is used, mantra in asvamedha, solution of partial fraction in purush sukta, value of virtual geometric constructions in satpatha Brahmma. Rules for construction of sacrificial five altars in sulbha sutra, verbal expression of Pythagorean theorem and square root of two in Baudhayana Sulba Sutra. Peninis grammer for use of Boolean logic and Null operator.	20
II	**Post Vedic Period:** Chhandas shastra of pingla for enumeration of syllabic combination; Pascal's triangle, bionomial coefficients, basic ideas of fibonacci numbers and combinatorial identity in work of Katyayana. Jain	20

	philosopher Mahavira's classified number as enumerable, innumerable and infinite. He used beejganita samikaran and shunya (zero) with Anuyoga dwara sutra including factorials. Astronomical work of Bhadrabahu.	
III	**Classical Period:** Aryabhatiya and Arya- Siddhanta of aryabhatta, his work includes Place value system and position of a planet along with number of days in a year. Bhramhagupta who introduced concept and computing method of zero. Works of Varahamihira, Bhaskara l, Bhaskara ll, Mahavira, Madhava of sangamgrama and nilakantha somayaji. Works of shridhara, manjula, shripati mishra.	20
IV	**Modern Period:** Contribution of Bharati krishna tirtha, Contribution of Ramanujan, Mahalanobis, C R Rao, Kaprekar, Harish Chandra, Satyendra Nath Bose, Narendra Karmakar and Shakuntala Devi, Shankaracharya.	15

Suggested Readings:

1. Gerard G. Emch, M.D. Srinivas, R. Sridharan (2005), Contributions to the History of Indian Mathematics, Hindustan Book Agency.

2. Gaurav Tekriwal (2021), The Great Indian Mathematics, Penguin Random house India Private Limited.

3. Jayant V Narlikar (2003), The Scientific Edge, The Indian Scientist from Vedic to Modern Times, Penguin Books Limited**.**

M.A./M.Sc. I (SEMESTER-II), PAPER-IV

Elementary Statistics

Course Code: B030806T	**Credit-5** **Max. Marks: 25+75**	**Third Elective paper**
Total No. of Lectures-Tutorials (in hours per week): 5+1=6	**Course Title: Elementary Statistics**	

Course outcomes:

CO1: Students will learn basic concepts of statistics used in various disciplines

CO2: Students will be able to study various measures of dispersion like range, mean deviation, quartile deviation and standard deviation.

CO3: Students will be able to analyze and solve various concepts related to probability and probability distributions.

CO4: Students will be able to learn and use concepts confidence intervals, hypothesis testing, linear regression

Unit	Topics	No. of Lectures
I	Introduction to Statistics, Branches of Statistics, Population versus Sample, Basic Terminology, Types of Variables, Summation Notation, Sources of Data, and Sampling Techniques, Frequency Distributions, Relative Frequency.	15
II	Pie Charts, Frequency Histogram, and Cumulative Frequency. Measures of Center: Mean, Median and Mode. Intro to Measures of Dispersion (Ungrouped Data), Measures of Variability: Range, variance and standard deviation.	15
III	Random variables, Discrete and continuous Random Variables. Mean and Standard Deviation, Probability, probability distributions, Intro to Normal Distribution, Applications of Normal Distribution sampling	20

	distributions, binomial distribution, the student's t distribution, the Chi-square distribution	
IV	Estimation using confidence intervals, hypothesis testing, linear regression, correlation	25

Suggested Readings:

1. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Mathematical Statistics, 11th Edn., (Reprint), Sultan Chand and Sons.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Spiegel and Stephens: Schaum's outlines Statistics, McGraw Hill Education

M.A./M.Sc. I (SEMESTER-II), PAPER-V

Project Presentation on any core/elective paper

Course Code: B030807P	**Credit-5** **Max. Marks: 50 + 50**	**Fourth Elective Paper**
Total No. of Lectures-Practicals (in hours per week): 4 + 2	**Course Title: Project Presentation on any core/elective paper**	

Course outcomes:

CO1. Deepened Subject Mastery: Achieve comprehensive understanding of selected mathematical concepts, showcasing expertise in a specific area of mathematics.

CO2.Research and Analytical Skills: Enhance research techniques and critical evaluation skills, enabling the application of theoretical concepts to practical scenarios.

CO3.Effective Communication: Develop the ability to succinctly convey complex mathematical ideas in written reports and oral presentations to a varied audience.

Students are tasked with conducting a thorough study and survey of a core or elective paper of their choosing, selected from the curriculum offered in either the 7th or 8th semester of Bachelors (1^{st} and 2^{nd} semester of Masters) in Mathematics program. The evaluation of the project will primarily focus on the presentation of critical, innovative ideas, results, and applications stemming from the chosen paper. Each student is required to articulate these insights effectively during their presentation. Additionally, students must submit their project reports in both hard and soft copy formats, ensuring comprehensive documentation of their research and findings

Guidelines for Post Graduate M.Sc. Mathematics Project

1. Any student registering for doing project is required to inform the In-charge , Mathematicsthe name of his/her project supervisor(s) at the time of pre-registration.
2. The student must submit the "Project Registration Form'' to the In-charge, Mathematics. Sample of Project Registration Form is given below:

Project Registration Form

Name of the college:	
Department	
Name of the student:	
Roll No. :	
e-mail :	
Name of the supervisor(s):	
Title of the Project:	
Signature of the Student:	
Signature of supervisor(s):	
Signature of HOD, Mathematics	

3. The student will be required to submit hard copy and an electronic version of the final Project Report / Dissertation to the Department of Mathematics. The final Project Report / Dissertation should not be longer than 50 A4 size pages in 1.5 line spacing. The following sequence for the thesis organization should be followed:

   (i) **Preliminaries** (Title Page; Certificate; Abstract/Synopsis; Acknowledgement and/ or Dedication; Table of Contents; List of Figures ,Tables, Illustrations, Symbols, etc (wherever applicable))

   (ii) **Text of Thesis** (Introduction; The body of the thesis, summary and conclusions)

   (iii) **Reference Material** (List of References /Bibliography)

   (iv) **Appendices (if any)**

M.A./M.Sc. I (SEMESTER-II), PAPER-V

Project Presentation on a Mathematical Problem using Python

Course Code: B030807P	Max. Marks: 50 + 50	Fourth Elective Paper
Total No. of Lectures-Practicals (in hours per week) : 4 + 2	Course Title: Project Presentation on a Mathematical Problem using Python	

Course outcomes:

CO1. Data Visualization Mastery: Students will learn to adeptly choose and apply appropriate data visualization techniques, enhancing their ability to present data insights effectively.

CO2. Model Development Skills: Gain practical experience in constructing simple yet insightful models in Python, demonstrating an understanding of data summarization techniques.

CO3. Comprehensive Reporting: Develop the skill to articulate the research process, analysis, and findings in a well-structured report, showcasing the ability to communicate complex information clearly.

Students will be provided with select datasets for analysis. Their task is to determine the most effective schema for data visualization and presentation. Subsequently, they are required to develop a straightforward model to encapsulate the data's essence, utilizing Python. A comprehensive report detailing their methodology, findings, and model summary must be compiled and submitted to the department in both hard and soft copy formats prior to their presentation.

Tools which may be used which may be used for data visualization are

1. Scatter plots
2. Bar charts
3. Histograms
4. Pie Charts
5. Interactive plots -1 : modifying display.
6. Interactive plots – 2 : editing data and plots.
7. How to make a simple animation in python

Suggested readings:

1 S. Gowrishankar and A. Veena A, Introduction to Python Programming, CRC Press (2019).

2 Adam Stewart -Python Programming (2016).

3 Kenneth A. Lambert, Fundamentals of Python First Programs with Mindtap, Cengage Learning India (2011)

4 John V. Guttag, Introduction to Computation and Programming using Python, MIT Press (2021)

Guidelines for Post Graduate M.Sc. Mathematics Project

1. Any student registering for doing project is required to inform the In-charge , Mathematics the name of his/her project supervisor(s) at the time of pre-registration.

2. The student must submit the "Project Registration Form'' to the In-charge, Mathematics. Sample of Project Registration Form is given below:

Project Registration Form

Name of the college:	
Department	
Name of the student:	
Roll No. :	
e-mail :	
Name of the supervisor(s):	
Title of the Project:	
Signature of the Student:	
Signature of supervisor(s):	
Signature of HOD, Mathematics	

3. The student will be required to submit hard copy and an electronic version of the final Project Report / Dissertation to the Department of Mathematics. The final Project Report / Dissertation should not be longer than 50 A4 size pages in 1.5 line spacing. The following sequence for the thesis organization should be followed:

(i)Preliminaries (Title Page; Certificate; Abstract/Synopsis; Acknowledgement and/ or Dedication; Table of Contents; List of Figures ,Tables, Illustrations, Symbols, etc (wherever applicable))

(ii)Text of Thesis (Introduction; The body of the thesis, summary and conclusions)

(iii)Reference Material (List of References /Bibliography)

(iv)Appendices (if any)

M.A./M.Sc. II (SEMESTER-III), PAPER-I

FUNCTIONAL ANALYSIS

Course Code: B030901T	**Credit-5** **Max. Marks: 25+75**	**Core Paper**
Total No. of Lectures-Tutorials (in hours per week): 4+1=5	**Course Title: Functional Analysis**	

Course outcomes:

CO1: The students will be able to analyse Normed linear space, Banach space.

CO2: The students will be able to analyse l_p^n , l_p, l_2 *and* l_∞ Banach spaces, Banach space C(X) , Riesz– Fisher theorem , Continous and Bounded linear Transformation.

CO3: The students will be able to analyse Isometric Isomarphism, Topological Isomarphism, Equivalent norm, Riesz- Lemma, Convexity, Hahn- Banach Theorem, Open mapping Theorem, Closed Graph Theorem.

CO4: The students will be able to analyse Hilbert space, Riesz representation theorem

Unit	Topics	No. of Lectures
I	Normed linear space, Banach space, Summability in Normed linear space, continuity and joint continuity.	15
II	l_p^n, l_p, l_2 *and* l_∞ Banach spaces, Riesz – Fisher theorem, Subspaces and Quotient spaces of Banach space, Continous and Bounded linear Transformation.	15
III	Isometric Isomarphism, Topological Isomarphism, Equivalent norm, Riesz- Lemma, Convexity, Hahn- Banach Theorem, Open mapping Theorem , Closed Graph Theorem.	20
IV	Hilbert space, The adjoint of an operators T in Hilbert space, Self adjoint, Normal and Unitary operators, Riesz representation theorem.	25

Suggested Readings:

Walter Rudin : Functional Analysis - TATA McGraw Hill New Delhi

Lusternik and sobolev : Elements of Functional Analysis - Hindustan Publishing corporation New Delhi

E.C. Titchmarsh : A Theory of Functions - Oxford University Press New Delhi

J.N. Sharma & A.R.Vasishtha : Functional Analysis - Krishna Publications Meerut

M.A./M.Sc. II (SEMESTER-III), PAPER-II

INTEGRAL EQUATIONS

Course Code:B030902T	**Credit-4** **Max. Marks: 25+75**	**Core paper**
Total No. of Lectures-Tutorials (in hours per week): 4	**Course Title: INTEGRAL EQUATIONS**	

Course outcomes:

CO1 Understand the methods to reduce Initial value problems associated with linear differential equations to various integral equations.

CO2 Categories and solve different integral equations using various techniques.

CO3 The **s**tudents will be able to analyze Fredholm and Volterra integral equations, Solution by the successive approximations, Neumann series and resolvent kernel, equations with convolution type kernels.

CO4 The **s**tudents will be able to analyze and solve the solution of integral equations by transform methods

Unit	Topics	No. of Lectures
I	**Integral Equations:** Definition and classification of linear integral equations. Conversion of initial and boundary value problems into integral equations. Conversion of integral equations into differential equations.	20
II	**Fredholm Integral Equations:** Solution of integral equations with separable kernels, Eigen values and Eigen functions. Solution by the successive approximations, Neumann series and resolvent kernel. Solution of integral equations with symmetric kernels, Hilbert-Schmidt theorem.	20
III	**Volterra Integral Equations:** Successive approximations, Neumann series and resolvent kernel. Equations with convolution type kernels.	20
IV	**Solution of integral equations by transform methods:** Singular integral equations, Hilbert transform and solutions by Laplace transformation.	15

Suggested Readings:

Kanwal, R.P.: Linear Integral Equation. Theory and Techniques. Academic Press, 2014.

Raisinghania M. D.: Integral Equation & Boundary Value Problem. S. Chand Publishing, 2007.

Jerri, A. :Introduction to Integral Equations with Applications, John Wiley & Sons, 1999.

Hildebrand, F. B.: Method of Applied Mathematics, Courier Corporation, 2012.

Wazwaz, A. M.: A First Course in Integral Equations. World Scientific Publishing Co Inc, 1997

M.A./M.Sc. II (SEMESTER-III) PAPER-III

MACHINE LEARNING

Course Code: B030903T	Credits-4 Marks:25+75	Core paper
Total No. of Lectures (in hours per week) –4	Course Title: MACHINE LEARNING	

Course outcomes:

CO1: The students will be able to understand the need for machine learning for various problem solving.

CO2: The students will be able to understand a wide variety of learning algorithms and know how to evaluate models generated from data.

CO3: The students will be able to understand the latest trends in machine learning.

CO4: The students will be able to identify appropriate machine learning algorithms for general real-world problems and apply these algorithms to solve these problems.

Unit	Topics	No. of Lectures
I	Introduction to Machine Learning (ML), Applications of ML, Recent trends in Machine Learning, Learning, Types of Learning, Introduction to Machine Learning Approaches Understanding of Data and Datasets, Preparation of Data for Analysis and Machine Learning, Dataset cleaning Train, Test and Validation Datasets, Imbalanced data, Outliers, Data Science vs Machine Learning.	20
II	Regression: Linear Regression, Cost Function, Multiple Linear Regressions, Logistic Regression. Decision Trees, Overfitting and Underfitting, Confusion Matrix, Performance Metrics: Accuracy, Precision, Recall	20
III	k-Nearest Neighbor (KNN) Classification, Decision Trees for classification, Logistic Regression Advanced Machine Learning Methods: Neural Networks and Polynomial Fits , over and under fitting.	20
IV	Statistical Inference and Bayes Theorem, Frequentist vs. Bayesian Approaches, Introduction to Bayesian Methods: Estimation, Likelihood, Posterior and Priors, Model comparison, Maximum Likelihood.	15

Suggested readings:

1. Coryn A. L., Bailer, Jones, Practical Bayesian Inference: A Primer for Physical Scientists, CUP
2. S.S.Malu and S.K.Pandey, Machine Learning with Python: A Hands-On Introduction, S.Chand Pub, 2024
3. Srinivasaraghavan, A. and Joseph, V: Machine Learning, Wiley India Pvt Ltd. 2019
4. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar: Foundations of Machine Learning, MIT Press, 2012.
5. Siman Haykin: Neural Netowrks, Pearson Education.

M.A./M.Sc. II (SEMESTER-III) PAPER-IV
GENERAL RELATIVITY

Course Code: B030904T	Max. Marks: 25+75	Fifth Elective paper
Total No. of Lectures (in hours per week) – 4	Course Title: GENERAL RELATIVITY	

Course outcomes:

CO1: The students will be able to understand metric tensor and Riemannian space.

CO2: The students will be able to learn Ricci tensor, Bianchi Identities, examples of symmetric space time.

CO3: The students will be able to understand Einstein's field equation, gravitational waves in empty space.

Unit	Topics	No. of Lectures
I	Transformation of coordinates, transformation law of tensor, Product of two tensor, Contraction, Quotient law, Metric tensor and Riemannian space, Conjugate tensor, symmetric and anti–tensor, Levi-Civita tensor, Christoffel symbol, Covariant derivative, Riemannian metric,	15
II	Tensor form of gradient, divergence and curls, Parallel transport, Riemannian curvature tensor, Ricci tensor, Bianchi identities, Geodesic, Null geodesic, Geodesic deviation	20
III	Introduction to General Relativity, Principle of Equivalence, Principle of General covariance, Mach's Principle, geodesic postulate, Energy momentum tensor, Newtonian approximation of equation of motion, Search for Einstein's field equation, Einstein's field equation reduces to Poisson's equations, deviation of Einstien's field equation from vibrational principle,	20
IV	Gravitational field in empty space, Schwarzschild exterior solution, Singularities in Schwarzschild line element, Isotropic form of Schwarzschild exterior line element, Planetary orbits, Three Crucial tests in General relativity, Birkhoff's theorem.	20

Suggested readings:

1. J.V.Narlikar:An Introductions to Relativity; Cambridge University Press, 2010.
2. James Hartle: Gravity, Pearson Education, 2003
3. S Dhurandhar and Sanjit Mitra: General Relativity and Gravitational Waves, Springer 2022
4. S. P. Puri: General Theory of Relativity; Pearson, 2013.
5. I.B. Khriplovich: General Relativity; Springer Science& Business media, 2005.
6. Ta-Pei Cheng: Relativity, Gravitation and Cosmology, Oxford. 2012

M.A./M.Sc. II (SEMESTER-III) PAPER-IV

FINSLER GEOMETRY

Course Code: B030905T	Max. Marks: 25+75	Fifth Elective paper
Total No. of Lectures (in hours per week) – 4	Course Title: Finsler Space	

Course outcomes:

CO1: The students will be able to analyse Finsler space and homogeneity properties of g_{ij} and C_{ijk}, Geodesics.

CO2: The students will be able to analyse Fundamental postulates of Cartan, Cartan covariant derivatives, Properties of Cartan covariant derivatives, Berwald's connection, Covariant derivatives of Berwald's and it's properties, Relation between connection coefficients of Cartan and Berwald.

CO3: The students will be able to find Commutation formulae, The three Curvature tensors of Cartan, Identities satisfied by the Curvature tensors and Bianchi identities.

CO4: The students will be able to analyse Curvature tensor of Berwald, The Lie-derivatives in a Finsler space and Motion in a Finsler space.

Unit	Topics	No. of Lectures
I	Curve line element, Fundamental function, Finsler metric, Finsler space, Tengent space, Indicatrix, Minkowskian space, magnitude of a vector, homogeneity properties of g_{ij} and C_{ijk}, Geodesics.	20
II	Fundamental postulates of Cartan, Cartan covariant derivatives, Properties of Cartan covariant derivatives, Berwald's connection, Covariant derivatives of Berwald's and it's properties, Relation between connection coefficients of Cartan and Berwald.	20
III	Commutation formulae, The three Curvature tensors of Cartan, Identities satisfied by the Curvature tensors, Bianchi identities.	20
IV	Curvature tensor of Berwald, The Lie-derivatives in a Finsler space, Motion in a Finsler space.	15

Suggested readings:

1. Hanno Rund**:** The Differential Geometry of Finsler spaces – Springer publication
2. Matsumoto**:** Foundations of Finsler Geometry and special Finsler spaces— Kaiseisha press

M.A./M.Sc. II (SEMESTER-III), PAPER-IV

Advanced Discrete Mathematics

Course Code: B030906T	**Credit-5** **Max. Marks: 25+75**	**Fifth Elective paper**
Total No. of Lectures-Tutorials (in hours per week): 4+1=5	**Course Title: Advanced Discrete Mathematics**	

Course outcomes:

CO1: Understand the basics of combinatorics, and be able to apply the methods from these subjects in problem solving.

CO2: Be able to use effectively algebraic techniques to analyse basic discrete structures and algorithms.

CO3: To provide a formal connection between algorithmic problem solving and the theory of languages and automata and develop them into a mathematical (abstract) view towards algorithmic design and in general
computation itself.

Unit	Topics	No. of Lectures
I	Basic counting principles, Permutations and Combinations (with and without repetitions),Binomial theorem, Multinomial theorem, Counting subsets, Set- partitions, Stirling numbers Principle of Inclusion and Exclusion, Derangements, Inversion formulae	15
II	Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.	20
III	**Generating functions:** Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions. **Recurrence relations:** Recurrence relation models, Divide and conquer relations, Solution ofrecurrence relations, Solutions by generating functions.	20
IV	**Languages :** Alphabets, string, language, Basic Operations on language, Concatenation, KleeneStar **Finite Automata and Regular Languages:** Regular Expressions, Transition Graphs, Deterministics and non-deterministic finite automata, NFA to DFA Conversion, Regular languages and their relationship with finite automata, Pumping lemma and closure properties of regular languages.	20

Suggested Readings:

c. L. Liu: Elements of discrete mathematics, Tata McGraw Hill Education, 2008.

Ram Babu: Disrete Mathematics, Pearson Edition India, 2011.

J.H. van Lint and R.M. Wilson, *A Course in Combinatorics*, 2nd Ed., Cambridge University Press, 2001

S.S. Sane, *Combinatorial Techniques*, Hindustan Book Agency, 2013

J. E. Hopcroft, R. Motwani and J. D. Ullman, *Introduction to Automata Theory, Languages, and Computation,* 2nd Ed., Addison-Wesley, 2001.
P. Linz, An Introduction to Formal Language and Automata 4th edition Publication Jones Bartlett, 2006

M.A./M.Sc. II (SEMESTER-III), PAPER- V

Introduction to SCILAB /MATLAB

Course Code: B030907P	**Credit-5** **Max. Marks: 50 + 50**	**Sixth Elective paper**
Total No. of Lectures-Practicals (in hours per week): 2+6	**Course Title: Introduction to SCILAB /MATLAB**	

Course outcomes:

CO1: The students will be able to use SciLab/MATLAB in their mathematical problem solving.

CO2: The students will be able to use these software in working problems related to polynomials and Linear Algebra

Introduction to SciLab/ MATLAB, Installation of SciLab/ MATLAB, Basic elements of the language, Looping and Branching: If, select, for, break, continue, Functions, return, Contour plots, tiles, axes, legends.

Matrices: Creating matrices, sum, product of matrices, inverse, rank determinant, comparing matrices, system of equations, working with polynomials, defining a function and output arguments.

Practicals:

1. To print the prime numbers between 1 and 100.
2. Write a program to add, subtract, multiply and divide common fractions.
3. To find the average of between n and 12n where n is an integer.
4. Write a program to check a number is Armstrong or not ?
5. Write a program to display table from 11 to 20.
6. To find the roots of a cubic equation.
7. To sum and difference of any two matrices and hence find the row sum and column sum of a given matrix. .
8. To find inverse of a given 3x3 matrices.
9. Write a program to find the transpose, trace and norm of a matrix.
10. To sort all the elements of a 4x4 matrix.
11. Program to accept a matrix and determine whether it is a symmetric matrix, skew-symmetric or not.
12. Write a program to print Fibonacci numbers.

Suggested Readings:

1. Gilat, A. : MATLAB: An Introduction with Applications, Wiley , 2012 2.Pratap, R : Getting Started with MATLAB, Oxford Univ Press, 2019
3. Nagar, S. : Introduction to Scilab, Apress , 2017

MA./M.Sc. II (SEMESTER-III), PAPER- V

Introduction to LaTex

Course Code: B030908P	**Credit-5** **Max. Marks: 50+50**	**Sixth Elective paper**
Total No. of Lectures-Practicals (in hours per week): 2+6	**Course Title: Introduction to LaTex**	

Course outcomes:

CO1: The students will be able to know that how the concepts have been developed in Mathematics

CO2: The students will be able to different typesetting Mathematical formulae and equations.

CO3: The students will be able to typeset in different formats including research paper, report and thesis

Topics

Introduction to LaTeX, Installation of LaTeX, Layout Design, LaTeX input files, Input file structure. Document classes, packages, environments, page styles, Typesetting texts, Fancy Header, tables, Inline math formulas and displayed equations, Math symbols and fonts, delimiters, matrices, arrays, Typesetting Mathematical formulae: fractions, Integrals, sums, products, etc.

Producing Mathematical Graphics.

Document classes for paper writing, thesis, books, etc. Table of contents, index, bibliography management. Hypertext, pdf pages, geometry, fancy header and footer, Verbatim, itemize, enumerate, boxes, equation number.

Practicals:

Practicals based on above .

Suggested Readings:

Kortwitz: Latex A beginner guide, Packt Publishing Ltd, 2021

Karmali: A Short Introduction to Latex, Greatespace Independent Pub Plateform, 2019

Lamport: Latex: A Document Preparation System, Addison Wisley,1994

Swapan Kumar: Latex A beginner guide, Lakxmi Pub Pvt Ltd, 2019

M.A./M.Sc. II (SEMESTER-IV), PAPER-I

ADVANCED OPERATION RESEARCH

Course Code: B031001T	Credit-4 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 4	Course Title: Advanced Operation Research	

Course outcomes:

CO1: Student will be able to define Inventory theory and Models.

CO2: Student will be able to define Quening theory and its characteristics, stochastic Processes under steady and transient states. Study of M/M/1 and M/M/s quening models and Parametric Linear Programming

CO3: Student will be able to analyse Network analysis, CPM and PERT.

CO4: Student will be able to define Game theory and Solution of rectangular game with saddle point, Solution of 2×2 game without saddle point. Graphical method of solution for 2×n and m×2 games.

CO5: Student will be able to solve Integer Programming problem and Branch and Bound technique.

Unit	Topics	No. of Lectures
I	Game theory, Zero- Sum Game, Solution of rectangular game with saddle point, Solution of 2×2 game without saddle point. Graphical method of solution for 2×n and m×2 games. Integer Programming, Branch and Bound technique.	20
II	Network analysis, CPM and PERT, Network components and general procedure forconstruction of networks and numbering of events (Fulkerson's rule). CPM computation and determination of critical path.	20
III	Inventory theory, economic order Quantity Models under various demands having shortages and no shortages, Probabilistic Inventory models with discrete or continuous demand. Simple replacement model for Equipments that deteriorates with time in descreteand continuous form.	20
IV	Quening theory and its characteristics, stochastic Processes under steady and transient states. Study of M/M/1 and M/M/s quening models, Parametric Linear Programming.	15

Suggested Readings:

Operations Research – kantiswarup, P.K.gupta, Man Mohan–Sultan Chand & sons, New Delhi

Operations Research (An Introduction) – Hamdy A. Taha – Pearson

Operations Research– R.K.Gupta–Krishna Prakasan

Operations Research –K.Nagrajan - New Age International Publications

M.A./M.Sc. II (SEMESTER-IV), PAPER- II

FLUID DYNAMICS

Course Code: B031002T	Credit-4 Max. Marks: 25+75	Core paper
Total No. of Lectures-Tutorials (in hours per week): 4	Course Title: FLUID DYNAMICS	

Course outcomes:

CO1: The Students will be able to identify the fundamental concepts of Fluid dynamics and their role in modern mathematics and applied contexts.

CO2: The Students will be able to apply the Fluid dynamics concepts to diverse situations in physics, engineering, and other mathematical contexts.

Unit	Topics	No. of Lectures
I	Lagrangian and Eulerian methods to describe the fluid motion, Equation of continuity, Boundary conditions, Stream Lines. Pathlines and streak lines, Velocity potential. Irrotational and rotational motions.	20
II	Euler's equations of motion, Pressure equation, Bernoulli's theorem, Impulsive actions, Flow and circulation, The permanence of irrotational motion. Stream function. Irrotational motion in two dimensions. Complex velocity potential. Sources, sinks, doublets, and their images.	20
III	The two-dimensional irrotational motion is produced by the motion of circular and elliptic cylinders in a liquid, Kinetic energy of liquid, Milne-Thomson circle theorem. The theorem of Blasius, Stoke's stream function.	20
IV	Wave motion in gas, speed of sound, equation of motion of a gas, subsonic, sonic, super- sonic flow of a gas, isentropic of a gas, shock formation	15

Suggested Readings:

F. Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi,1985.

W.H. Besaint and A.S. Ramsey: A Treatise on Hydrodynamics, Part II, C.B.S. Publishers, Delhi,1988.

B.G.Verma: Hydrodynamics, Pragati Prakashan, Meerut, 1995.

M.D. Raisinghania: Fluid Dynamics, S.Chand and Co, 2003

M.A./M.Sc. II (SEMESTER-IV), PAPER-III

Special Functions

Course Code: B031003T	Credit-5 Max. Marks:25+75	Seventh Elective paper
Total No. of Lectures-Tutorials (in hours per week): 4+1=5	Course Title: Special Functions	

Course outcomes:

CO1: Student will be able to define Fundamental System of Integrals, Singularity of a Linear Differential Equation. Series solution to Legendre, Bessel differential equations by Frobenius method.

CO2: Student will be able to define Hermite equation and its solution, Generating function, Rodrigue's formula, Recurrence relations, Orthogonal Properties of Hermite Polynomials.

CO3: Student will be able to define Lagurre equation and its solution.

CO4: Student will be able to define Hypergeometric Functions and Series Solution.

Unit	Topics	No. of Lectures
I	**Singularities:** Fundamental System of Integrals, Singularity of a Linear Differential Equation. Solution in the neighbourhood of a singularity, Regular Integral, Series solution to Legendre, Bessel differential equations by Frobenius method.	15
II	**Hermite Polynomial:** Hermite equation and its solution, Generating function, Rodrigue's formula, Recurrence relations, Orthogonal Properties of Hermite Polynomials	20
III	**Lagurre polynomial:** Lagurre equation and its solution, Generating function, Recurrence relations, Orthogonal Properties of Hermite Polynomials.	20
IV	**Hypergeometric Function:** Hypergeometric Functions, Series Solution near zero, one and infinity. Integral Formula, Confluent Hypergeometric function, Integral representation of Hypergeometric function, Differentiation of Hypergeometric Function.	20

Suggested Readings:

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

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

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

M.A./M.Sc. II (SEMESTER-IV), PAPER-III
DIFFERENTIAL GEOMETRY OF MANIFOLDS

Course Code: B031004T	**Credit-5** **Max.Marks:25+75**	**Seventh Elective paper**
Total No. of Lectures-Tutorials (in hours per week): 4+1=5	**Course Title: Differential Geometry of Manifolds**	

Course outcomes:

CO1: Students will be able to explain the concept of a manifold and give examples.

CO2: Students will be able to define Connections.

CO3: Students will be able to define Lie – bracket, Lie – derivative.

CO4: Students will be able to analyse Riemannian manifold, Riemannian connection, Riemannian curvature tensor, Ricci tensor, scalar curvature, Bianchi identities, constant curvature, definition of Einstein manifold, Geodesic in Riemannian manifold, Projective curvature tensor.

Unit	Topics	No. of Lectures
I	Definition and examples of differentiable manifold, differentiable function, Tangent space, vector field.	20
II	Connections, Affine connection and Covariant derivative, torsion and curvature tensors, difference tensor of two connections.	20
III	Lie – bracket, Lie – derivative, exterior product of two vectors, Exterior algebra, Exterior derivative.	20
IV	Definition of Riemannian manifold and examples, Riemannian connection, Riemannian curvature tensor and Ricci tensor, scalar curvature, Bianchi identities, constant curvature, definition of Einstein manifold, Geodesic in Riemannian manifold, Projective curvature tensor.	15

Suggested Readings:

1. Quddus Khan : Differential Geometry of manifolds — PHI Publications
2. H. S. Shukla & B. N. Prasad: Differential Geometry of manifolds — Vandana Prakashan.

M.A./M.Sc. II (SEMESTER-IV), PAPER-III

Advanced Numerical Methods

Course Code: B031005T	**Credit-5** **Max. Marks: 25+75**	**Seventh Elective Paper**
Total No. of Lectures-Tutorials (in hours per week): 4+1=5	**Course Title: Advanced Numerical Methods**	

Course outcomes:

CO1: Student will be able to solve System of Linear Algebraic Equations, ordinary differential equations, and Partial differential equations.

CO2: The students will be able to understand and apply various iterative techniques for solving system of algebraic equations.

CO3: The students will be able to analyze the consistency and convergence of a given numerical scheme.

CO4: The students will be able to explain what kind of numerical schemes are best suited for each type of PDEs (hyperbolic, parabolic and elliptic) and the reasons behind these choices.

CO5: The students will be able to demonstrate familiarity with the basics of finite difference methods for the numerical solution of partial differential equations.

Unit	Topics	No. of Lectures
I	**Numerical Solution of System of Linear Equations:** Gauss Elimination Method with Partial and Complete Pivoting. Triangular factorisation methods. Iterative methods: Jacobi method, Gauss-Seidel method and Gauss Jacobi method and their convergence, diagonal dominance, Successive-Over Relaxation (SOR) method, Ill- conditioned matrix.	20
II	**Numerical Solution of ordinary Differential equations:** Numerical solution of ODE by Picard's, Euler's and Runge-Kutta methods, Boundary value problems: Finite difference method, Shooting method.	20
III	**Numerical Solution of Partial Differential equations:** Classification of second order general PDE, Difference method. Difference methods for Parabolic PDE. Heat conduction equation and its numerical solutions with finite difference methods (Two and three level difference methods).	20
IV	Difference methods for Hyperbolic PDE. Wave equation and its numerical solutions with finite difference methods (First order only). Difference methods for Elliptical PDE. Dirichlet problem for Laplace equation and its numerical solutions with finite difference methods.	15

Suggested Readings:

M. K. Jain, S. R. K. Iyengar – R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, 6th Edition 2012.

S.D. Conte and C. DeBoor, Elementary Numerical Analysis: An Algorithmic Approach, McGraw Hill, N.Y., 1980.

C. F. Gerald and P. O. Wheatly – Applied Numerical Analysis, Pearson Education, Inc., 1999

A. Ralston and P. Rabinowitz – A First Course in Numerical Analysis, 2nd Edition, McGraw - Hill, New York, 1978

K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons, 1989.
F.B.Hilderbrand, Introduction to Numerical Analysis, Dover Publication.
W.F. Ames, Numerical Methods for PDEs, Academic Press, N.Y., 1977.

M.A./M.Sc. II (SEMESTER-IV), PAPER-IV

Research Project/ Dissertation

Course Code: B031006P	**Max. Marks: 50+50** **Min. Passing Marks: 33**	**Core Compulsory**
Credit: 10	**Course Title: Research Project/ Dissertation**	

Course Outcomes: This course will provide an opportunity to the students to acquire necessary research skills aspart of the academic activity.

Guidelines for Post Graduate M.Sc. Mathematics Project

1. Any student registering for doing project is required to inform the In-charge , Mathematics the name of his/her project supervisor(s) at the time of pre-registration.
2. Topic of such research project should be relevant to Mathematics programme on the whole.
3. The topic of such research project shall be finalized only after the Department/ College approves the same.
4. The student has to submit soft copy along with a hard copy of Research Dissertation to the Head of the Department/ College Principal on or before the last working day of the semester.
5. Each student shall be compulsorily supervised in the research project by a faculty member. The Supervisorwill guide the student in methodology and the course of the study.
6. Periodic individual conference, related to research project of each student, shall be conducted by the supervisor.
7. The student's performance in such assignments is considered in assigning the internal assessment marksallocated for research project.
8. The student must submit the "Project Registration Form'' to the In-charge, Mathematics. Sample of Project Registration Form is given below:

Project Registration Form

1- Name of the college:	
2- Department	
3- Name of the student:	
4- Roll No. :	
5- e-mail :	
6- Name of the supervisor(s):	
7- Title of the Project:	
8- Signature of the Student:	
9- Signature of supervisor(s):	
10- Signature of HOD, Mathematics	