# MAA PATESWARI UNIVERSITY, BALRAMPUR

**Structure of Syllabus for the**

**Program: M.A./M.Sc., Subject: MATHEMATICS**

| Structure of Syllabus Developed by | | | |
|---|---|---|---|
| **Name of BoS Convener/ BoS Member** | **Designation** | **Department** | **College/University** |
| Prof. Sanjay Kumar Pandey | Professor & Convener | Mathematics | Shri Lal Bahadur Shastri Degree College, Gonda |
| Prof. Sudhir Kumar Srivastava | Professor & Expert | Mathematics | DDU, University Gorakhpur |
| Prof. Shiv Kumar Tiwari | Professor & Expert | Mathematics | K.S. Saket P.G. College, Ayodhya |
| Prof. Veena Singh | Professor & Invited member | Mathematics | M.L.K.(P.G.) College, Balrampur |
| Dr. Jitendra Kumar Singh | Associate Professor & Expert | Mathematics | Siddharth University, Kapilvastu, Siddharthnagar |
| Shri. Ram Asrey Gautam | Assistant Professor & Member | Mathematics | M.L.K.(P.G.) College, Balrampur |
| Shri Manish Sharma | Assistant Professor & Member | Mathematics | Shri Lal Bahadur Shastri Degree College, Gonda |
| Dr. Shesh Kumar Pandey | Assistant Professor & Member | Mathematics | A.N.D. Kisan P. G. College, Babhnan, Gonda |

Shesh Manish Tiwari

| Course Code | | Course Title | Credits | T/P | Evaluation | |
|---|---|---|---|---|---|---|
| | | | | | CIE | ETE |
| A | B | C | D | E | F | G |
| **SEMESTER-I (YEAR-I)** | | | | | | |
| B030701T | CORE | Advanced Abstract Algebra | 4 | T | 25 | 75 |
| B030702T | CORE | Topology | 4 | T | 25 | 75 |
| B030703T | CORE | Theory of Differential Equations and Boundary value problems | 4 | T | 25 | 75 |
| B030704T | ELECTIVE (Select any one) | IV(a). Fuzzy Sets | 4 | T | 25 | 75 |
| B030705T | | IV(b). Mathematical Modeling | 4 | T | 25 | 75 |
| B030706T | | IV(c). Riemannian Geometry | 4 | T | 25 | 75 |
| B030707T | | IV(d). Advanced Numerical Methods | 4 | T | 25 | 75 |
| B030708P | ELECTIVE (Select any one) | V(a). Programming in Python-I | 4 | P | 50 | 50 |
| B030709P | | V(b). Computational Techniques using C | 4 | P | 50 | 50 |

| **SEMESTER- II (YEAR-I)** | | | | | | |
|---|---|---|---|---|---|---|
| B030801T | CORE | Advanced Analysis | 4 | T | 25 | 75 |
| B030802T | CORE | Analytical Dynamics | 4 | T | 25 | 75 |
| B030803T | CORE | Integral Equations & Calculus of Variations | 4 | T | 25 | 75 |
| B030804T | ELECTIVE (Select any one) | IV(a). Modules Theory and Group Actions | 4 | T | 25 | 75 |
| B030805T | | IV(b). Advanced Topology | 4 | T | 25 | 75 |
| B030806T | | IV(c). Finsler Geometry | 4 | T | 25 | 75 |
| B030807T | | IV(d). General Relativity | 4 | T | 25 | 75 |
| B030808P | ELECTIVE (Select any one) | V(a). Programming in Python-II | 4 | P | 50 | 50 |
| B030809P | | V(b). Advanced Numerical Techniques Using C | 4 | P | 50 | 50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **SEMESTER-III (YEAR-II)** | | | | | | |
| B030901T | CORE | Functional Analysis-I | 4 | T | 25 | 75 |
| B030902T | CORE | Machine Learning | 4 | T | 25 | 75 |
| B030903T | CORE | Advanced Operations Research | 4 | T | 25 | 75 |
| B030904T | ELECTIVE (Select any one) | IV(a). Probability and Statistics | 4 | T | 25 | 75 |
| B030905T | | IV(b). Indian Contribution in Mathematics | 4 | T | 25 | 75 |
| B030906T | | IV(c). Cryptography | 4 | T | 25 | 75 |
| B030907T | | IV(d). Cosmology | 4 | T | 25 | 75 |
| B030908R | Research Project | Research Project | 4 | R | 50 | 50 |
| **SEMESTER-IV(YEAR-II)** | | | | | | |
| B031001T | CORE | Measure and Integration | 4 | T | 25 | 75 |
| B031002T | CORE | Fluid dynamics | 4 | T | 25 | 75 |
| B031003T | CORE | Functional Analysis-2 | 4 | T | 25 | 75 |
| B031004T | ELECTIVE (Select any one) | IV(a). Special Functions | 4 | T | 25 | 75 |
| B031005T | | IV(b). Differential Geometry of Manifolds | 4 | T | 25 | 75 |
| B031006T | | IV(c). Financial Mathematics | 4 | T | 25 | 75 |
| B031007T | | IV(d). History of Mathematics | 4 | T | 25 | 75 |
| B031008D | DISSERTATION | Dissertation | 4 | D | 50 | 50 |

# M.A./M.Sc. I (SEMESTER-I), PAPER-I
## ADVANCED ABSTRACT ALGEBRA

| | | |
|---|---|---|
| **Course Code: B030701T** | **Credit-4**<br>**Max. Marks: 25+75** | **Core paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title: Advanced Abstract Algebra** | |

***Course outcomes:***

**CO1:** The students will be able to different kinds of canonical forms: Jordan canonical and rational canonical forms, Quadratic forms and Bilinear forms.

**CO2**: The students will be able to define field extensions and splitting fields, normal and separable field extension.

**CO3**: The students will be able to define perfect field, Cyclotomic extensions and finite fields.

**CO4:** Students can demonstrate the ability to analyze Sylow's Theorems and their applications. Students will also be familiar with 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 | 08 |
| **II** | **Group Theory:** Maximal subgroups, simple groups, composition series, normal and subnormal series, Jordan-Holder theorem p-groups, The Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Non-simplicity tests. Introduction to Galois theory, Definition and Examples of Galois groups, Fundamental theorem of Galois group (without proof). | 20 |
| **III** | **Field theory:** Finite field and its subfields. Field extensions, Finite field extensions, Algebraic and transcendental extensions, Splitting or decomposition field, Normal and separable field extension, Perfect field, Automorphisms of field extensions, Artin's theorem (without proof). Roots of unity, Cyclotomic polynomials and extensions. | 20 |
| **IV** | **Canonical forms:** Diagonal forms, Triangular forms, Invariant subspaces, The primary decomposition theorem, Jordan canonical and rational canonical forms. Recapitulation of Quadratic forms and Bilinear forms, reduction and classification of quadratic forms. | 12 |

**Suggested Readings:**

1. Absract algebra: David S. Dummit, Richard M. Foote–Wiley India Pvt. Ltd.
2. Topic in algebra: I. N. Herstein–Wiley India Pvt. Ltd
3. Modern algebra: A. R. Vasishtha, A.k. Vasishtha -Krishna publications.
4. Basic Abstract Algebra: P. B. Bhattacharya, S. K. Jainand, S. R. Nagpaul, Cambridge University Press, Indian Edition, 1997.

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

| | | |
|---|---|---|
| **Course Code: B030702T** | **Credit-4**<br>**Max. Marks: 25+75** | **Core paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title: Topology** | |

***Course outcomes:***

**CO1:** The students can analyse topological spaces along with certain well-known examples of neighbourhoods, closure, interior, exterior, derived and dense sets.

**CO2:** Students can demonstrate the ability to critically analyse and distinguish open and closed sets, bases and sub-bases in topological space and Continuous functions.

**CO3**: The students will be able to understand various concepts like: Homeomorphism, first and second countable spaces, $T_0$, $T_1$, $T_2$, $T_3$, $T_4$ spaces and their basic properties.

**CO4**: The students will be able to understand various concepts like: Compactness, Connectedness and Completeness on surface level.

**CO5:** It provides the students certain 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** | Topological space, Examples of topological space: Usual topology, lower limit and upper limit topologies on $\mathbb{R}$, the topology on metric spaces, co-finite and co-countable topologies, weak and strong topologies etc. Interior, closure, boundary and limit points of subsets of a topological space. | 15 |
| **II** | Open, Closed and dense sets, Basis and sub-basis for a topology, Order topology, Subspaces, Housdorff space, Continuous functions, Continuity in terms of open sets, Sequential continuity | 15 |
| **III** | Homeomorphism, Topological invariant properties, first and second countable spaces. $T_0$, $T_1$, $T_2$, $T_3$, $T_4$ spaces and basic properties. | 15 |
| **IV** | Definition and examples of Connectedness, Path-connectedness, compactness and completeness, Particular examples of these kinds of sets in $\mathbb{R}$ and $\mathbb{R}^n$ ,Certain basic results and properties: Continuous functions on compact and connected space and their particular cases on $\mathbb{R}$, Union of Connected and Compact sets, Closure of connected set. | 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.
5. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).
6. N. Bourbaki, Topology I and II, Springer Verlag, New Delhi.
7. L. A. Steen and J. A.Seebach, Counter Examples in Topology, Holt, Reinhart and Winston, Inc. New York, 1970.

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

## Theory of Differential Equation and Boundary Value Problem

| | | |
|---|---|---|
| **Course Code: B030703T** | **Credit-4**<br>**Max. Marks: 25+75** | **Core paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **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.
**CO2:** The students will be able to analyse Existence and uniqueness theorem, initial value problems and Picard’s 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, Application of Laplace transform to solve differential equations and Fourier transforms to boundary value Problems.
**CO4:** The students will be able to analyse systems of first order ordinary differential equations.

| **Unit** | **Topics** | **No. of Lectures** |
|---|---|---|
| **I** | Method of separation of variables for Laplace, Heat and Wave equations, Harmonic functions and properties, The maximum principle, Mean value Method, Solution of Wave equation with initial values, | 15 |
| **II** | Existence and uniqueness theorem for first order ODE, initial value problem and Picard’s theorem, convergence of solution of initial value problems, Peano's existence theorem (statement only) and corollaries. | 15 |
| **III** | Ordinary Differential Equations of Sturm-Liouville boundary value problem, Eigen values and Eigen functions, Orthogonality theorem, Expansion theorem, Green’s function. Recapitulation of Laplace transform and Fourier transforms to solve differential equations and boundary value Problems. | 15 |
| **IV** | **Systems Of First Order Ordinary differential equations:** Basic concepts, Solution of homogeneous & non-homogeneous linear systems of ODEs with constant coefficients by vector-matrix method (eigenvalue method). Existence & uniqueness theorem, Linear dependence and independence of solutions (Wronskian of solutions), fundamental matrix and fundamental set of solutions. | 15 |

**Suggested Readings:**


1. G. F. Simmons, *Differential Equations with Applications and Historical Notes*, McGraw Hill Education.
2. Coddington, E. A. and Levinson, N. (1955) *Theory of Ordinary Differential equations*, TMH Education.
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.
5. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.
6. Robert C Mcowen, Partial Differential Equations: Methods and Applications, Pearson Education Inc. 2003.
7. S.L. Ross, Differential equations, Third Edition John Wiley and Sons Inc., New York.
8. Tyn Myint-U Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers Fourth Edition, 2007, Birkhauser Boston
9. Martha L. Abell, James P. Braselton, Introductory Differential Equations with Boundary Value Problems , Fourth Edition, Elsevier , USA, 2014.

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

## FUZZY SETS

<table>
<tr><td colspan="2">Course Code: B030704T</td><td>Credit-5<br>Max. Marks: 25+75</td><td>Elective paper</td></tr>
<tr><td colspan="2">Total No. of Lectures-Tutorials (in hours per week): 4+1=5</td><td colspan="2">Course Title: FUZZY SETS</td></tr>
<tr><td colspan="4">Course outcomes:<br>CO1: The students will be able to define Fuzzy sets and representations of Membership functions and types of Fuzzy sets.<br>CO2: The students will be able to define Fuzzy numbers, Fuzzy cardinality, Fuzzy arithmetic operations on intervals and Fuzzy equations.<br>CO3: Students will be able to analyse Fuzzy relations.<br>CO4: Students will be able to define Fuzziness, Shannon Entropy, Fuzzy linear programming problems.</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td>I</td><td colspan="2">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.</td><td>15</td></tr>
<tr><td>II</td><td colspan="2">Fuzzy numbers, Fuzzy cardinality, Fuzzy arithmetic operations on intervals, arithmetic operations on Fuzzy numbers, Fuzzy equations A+X=B, AX=B.</td><td>15</td></tr>
<tr><td>III</td><td colspan="2">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.</td><td>15</td></tr>
<tr><td>IV</td><td colspan="2">Fuzziness, Shannon Entropy, Fuzzy linear programming problems.</td><td>15</td></tr>
</table>

**Suggested readings:**


1. Klir, G. J. and Bo Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India, New Delhi 1995
2. Zimmermann, H. J., Fuzzy Set Theory and Its Applications, Allied Publishers Ltd, New Delhi 1991
3. Ross, T. J., Fuzzy Logic with Engineering Applications, McGraw Hill Inc., New Delhi
4. Backzinski, M. and J Balasubramanian, Fuzzy Implications, Springer Verlag, Heidelberg 2008.

# M.A./M.Sc. I (SEMESTER-I), PAPER-IV(b)
## MATHEMATICAL MODELLING

| Course Code: B030705T | Credit-4<br>Max. Marks: 25+75 | Elective paper |
|---|---|---|
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **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. | 15 |
| 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. | 15 |
| 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. | 15 |
| 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. Zafar Ahsan: Differential Equations and Their Applications, PHI learning Private Limited, New Delhi.
8. Steven H. Strogatz, Nonlinear dynamics and chaos, With Applications to Physics, Biology, Chemistry, and Engineering.

# M.A./M.Sc. I (SEMESTER-I), Paper-IV(c)
## RIEMANNIAN GEOMETRY

| Course Code: B030706T | Credit-4<br>Max. Marks: 25+75 | Elective paper |
|---|---|---|
| Total No. of Lectures-Tutorials (in hours per week): 4+1=5 | 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 curves, 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. | 15 |
| II | Congruences of curves and orthogonal ennuple, Ricci coefficient of rotation, Curvature of a congruence, Geodesic congruence, normal and irrotational congruence. | 15 |
| 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. | 15 |
| 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(d)

## ADVANCED NUMERICAL METHODS

| Course Code: B030707T | Credit-4<br>Max. Marks: 25+75 | 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 and Gauss Jacobi methods and their convergence, diagonal dominance, Successive-Over Relaxation (SOR) method, Ill- conditioned matrix. | 15 |
| 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. | 15 |
| 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). | 15 |
| 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:**


1. M. K. Jain, S.R.K. Iyengar-R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, 6th Edition 2012.
2. S.D. Conte and C. DeBoor, Elementary Numerical Analysis: An Algorithmic Approach, McGraw Hill, N.Y., 1980.
3. C. F. Gerald and P. O. Wheatly- Applied Numerical Analysis, Pearson Education, Inc., 1999.
4. A. Ralston and P. Rabinowitz- A First Course in Numerical Analysis, 2nd Edition, McGraw Hill, N.Y., 1978.
5. K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons, 1989.
6. F. B. Hilderbrand, Introduction to Numerical Analysis, Dover Publication.
7. W.F. Ames, Numerical Methods for PDE's, Academic press, N.Y., 1977.


Tiwari

# M.A./M.Sc. I (SEMESTER-I), PAPER-V(a)
# PROGRAMMING IN PYTHON-I

| | | |
|---|---|---|
| **Course Code: B030708P** | **Credit-4**<br>**Max. Marks: 50 + 50** | **Elective Paper** |
| **Total No. of Lectures-Practicals (in hours per week) : 4 + 2** | **Course Title: PROGRAMMING IN PYTHON-I** | |

**Course outcomes:**
**CO1:** The **s**tudents 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

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

# M. A./M. Sc. I (SEMESTER-I), PAPER- V(b)
# Programming in C

| | | |
|---|---|---|
| **Course Code: B030709P** | **Credit-4**<br>**Max. Marks: 50 + 50** | **Elective Paper** |
| **Total No. of Lectures-Practicals (in hours per week): 4 + 2** | **Course Title:** Programming in C | |

***Course outcomes:***

**CO1:** The **s**tudents 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.

**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

## ADVANCED ANALYSIS

| Course Code: B030801T | Credit-4<br>Max. Marks: 25+75 | Core paper |
|---|---|---|
| Total No. of Lectures-Tutorials (in hours per week): 4+1=5 | Course Title: ADVANCED 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.

**CO5**: The students will be able to understand and have knowledge and skills to identify the fundamental concepts of complex analysis

| 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. | 15 |
| 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. | **15** |
| 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.<br>Functions of bounded variation and their properties, Absolutely continuous functions and their properties, Relation between absolute continuity and function of bounded variation. | 15 |
| IV | Maximum−modulus theorem, Schwarz's lemma, Vitali's convergence theorem. Hadamard's three−circles theorem, Mean values of $\|f(z)\|$, Borel−Caratheodory theorem, Pharagmen− Lindelof theorem. | 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. J.B. Conway, Complex Analysis (2nd Ed.), Narosa Publishing House, New Delhi
7. Ruel V. Churchill, Complex Variables and Applications (Eight Edition), Tata McGraw Hill,2009
8. H. A. Priestly, Introduction to Complex Analysis, Oxford University Press, Clarendon Press, 1990
9. Royden, H. L. *Real Analysis,* Macmillan Pub. Co., Inc. 4th edition, New York, 1993.

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

## ANALYTICAL DYNAMICS

| Course Code: B030802T | Credit-4<br>Max. Marks: 25+75 | Core paper |
|---|---|---|
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **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 | 15 |
| **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. | 15 |
| **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. | 15 |
| **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-III

## INTEGRAL EQUATIONS & CALCULUS OF VARIATIONS

| Course Code: B030803T | Credit-4<br>Max. Marks: 25+75 | Core paper |
|---|---|---|
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title: INTEGRAL EQUATIONS & CALCULUS OF VARIATIONS** | |

***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 students 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 students 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. | 15 |
| 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. | 15 |
| III | **Volterra Integral Equations:** Successive approximations, Neumann series and resolvent kernel. Equations with convolution type kernels. | 15 |
| IV | **Calculus of variations-** Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations. | 15 |

**Suggested Readings:**


1. Kanwal, R.P.: Linear Integral Equation. Theory and Techniques. Academic Press, 2014.
2. Raisinghania M. D.: Integral Equation & Boundary Value Problem. S. Chand Publishing, 2007.
3. Jerri, A.: Introduction to Integral Equations with Applications, John Wiley & Sons, 1999.
4. Hildebrand, F. B.: Method of Applied Mathematics, Courier Corporation, 2012.
5. Wazwaz, A. M.: A First Course in Integral Equations. World Scientific Publishing Co Inc, 1997.

# M.A./M.Sc. I (SEMESTER-II), PAPER-IV(a)
## Modules Theory and Group Actions

| | | |
|---|---|---|
| **Course Code: B030804T** | **Credits-4**<br>**Max Marks: 25+75** | **Elective paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | Course Title: | Modules Theory & Group Actions |

**Course outcomes:**
**CO1:** The students will be able to understand Modules, different types of modules and related concepts.
**CO2:** The students will be come across Direct sum and product of modules, Free modules, projective and injective modules.
**CO3:** The students will able to analyze solvable groups and related concepts, Galois groups and solvability by radicals.
**CO4:** The students learn group actions and related concepts.
**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 | Modules, Sub-modules, Cyclic modules, Simple modules, Semi−simple modules, Schur's lemma, Noetherian and Artinian modules, Hilbert basis theorem, Modules homomorphism and isomorphism, | 15 |
| II | Direct product and direct sum of modules, exact sequences and split exact sequences of modules. Free modules, projective and injective modules | 10 |
| III | Fundamental theorems on isomorphism of groups, Recapitulation of Galois theory, Galois group of separable polynomials, Galois field, construction of Galois field and its subfields. Construction with ruler and compass. Insolvability of the general equation of degree 5 by radicals, Solution of polynomial equations by radicals. | 20 |
| IV | Action of Group G on set, G-set, stabilizers and faithful action of G, Isotropy groups, solvable groups, Cauchy's theorem for finite abelian group and finite groups. | 15 |

Suggested Readings:


1. M.F. Atiyah and I.G. MacDonald, Introduction to Commutative Algebra, CRC Press, Taylor & Francis, 2018.
2. I. N. Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul: Basic Abstract Algebra (Second Edition), Cambridge University Press, Indian Edition, 1997.
4. Surjeet Singh and Qazi Zameeruddin: Modern Algebra, Vikas Publishing House Pvt. Ltd., 2005.
5. A. R. Vasishtha & A. K. Vasishtha: Modern Algebra, Krishna Prakashan Media(P) Ltd., Meerut.
6. Luther, I.S. and I.B.S. Passi, Algebra Volumes I and II, Narosa Publishing House, New Delhi 1999.
7. D.S. Dummit and R.M. Foote, Abstract Algebra, Third Edition, Wiley India Pvt. Ltd., 2011.
8. N. Jacobson, Basic Algebra, Volumes I & II, Second Edition, Dover Publications, 2009.

# M.A./M.Sc. I (SEMESTER-II), PAPER-IV(b)
# ADVANCED TOPOLOGY

| | | |
|---|---|---|
| **Course Code: B030805T** | **Credits-4**<br>**Max. Marks: 25+75** | **Elective paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title: ADVANCED TOPOLOGY** | |

**Course outcomes:**

**CO1:** The students are able to know sequential and countable compactness of topological space.

**CO2**: The students are able to know the importance of Urysohn's lemma and Tietze Extension theorem.

**CO3:** The students are able to know the need for generalization of concepts of sequences in topology and so are able to know the importance of convergence of nets and filters.

**CO4:** The students are able to form not only larger topological spaces from the given topological space(s) with the help of product topology, but also, they are able to know the product invariant properties.

| Unit | Topics | No. of Lectures |
|---|---|---|
| **I** | Countable compact spaces, Sequential compact spaces, Lindelof Spaces, Separable spaces, One point compactness, separation axioms, Urysohn's lemma, Tietze Extension theorem. | 15 |
| **II** | Inadequacy of sequential convergence, directed sets, nets and subnets and their examples Convergence of a net, characterization of open sets, closed sets, closure, cluster point and limit point of a set in terms of net convergence. Hausdorffness and continuity of a function in terms of nets. | 15 |
| **III** | Definition of filter and its examples, Neighbourhood filter, Comparison of filters. Filter base and Convergence of a filter, Ultrafilters, Continuous functions and filters, Net based on filter and filter based on net, Quotient topology. | 15 |
| **IV** | Finite product space, projection mapping, Tychonoff product topology in terms standard subbase and its characterizations in terms of projection maps, continuous functions, Product of $T_0$, $T_1$, $T_2$, spaces. Connectedness and compactness, first and second countability for product spaces. | 15 |

**Suggested Readings:**


1. R. Munkres, Topology, A First Course, Pearson, N. Delhi, 2000.
2. W. J. Pervin, Foundation of General Topology, Academic Press Inc., New York, 1964.
3. J. L. Kelley, General Topology, D Van Nostrand Reinhold Co. New York 1955 (Reprinted by Springer Verlag, New York.
4. K. D. Joshi, Introduction to General Topology, New Age International (p) Ltd, 1983.
5. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).
6. N. Bourbaki, Topology I and II, Springer Verlag, New Delhi.
7. S. Willard, General Topology, Addison-Wesley, Reading, 1970. Reprinted by Dover.
8. L. A. Steen and J. A. Seebach, Counter Examples in Topology, Holt, Reinhart and Winston, Inc. New York, 1970.


Tiwari

# M.A./M.Sc. I (SEMESTER-II), PAPER-IV(c)
# Finsler Geometry

| Course Code: B030806T | Credits-4<br>Max. Marks: 25+75 | Elective paper |
|---|---|---|
| **Total No. of Lectures (in hours per week): 4+1=5** | **Course Title: Finsler Geometry** | |

**Course outcomes:**

**CO1:** The students will be able to analyse basic concepts of a Finsler space.

**CO2**: The students will be able to analyse δ-derivatives, Cartan's postulates and covariant derivatives, Berwald's covariant derivatives and its properties, and the relation between Cartan and Berwald connection coefficients.

**CO3**: The students will be able to find commutation formulae, Cartan's curvature tensors, related identities including Bianchi identities, and study spaces of scalar and constant curvature along with Schur's theorem

**CO4**: The students will be able to analyse projective changes, invariants, Berwald's parameter transformations, projective curvature tensors, and applications of Lie derivatives.

| Unit | Topics | No. of Lectures |
|---|---|---|
| I | Development of Finsler geometry, Line elements, Finsler space, Tangent space, Indicatrix, Minkowskian space, Metric tensor, Dual tangent space, Hamiltonian function, Magnitude of a vector, definition of angle and orthogonality, Generalized Christoffel symbols, Geodesics, Definitions and properties (without proof) of Connections in $F_n$ (Finsler Connection, Rund Connection, Cartan's Connection, Berwald's Connection). | 15 |
| II | δ-derivative, Fundamental postulates of Cartan, Cartan covariant derivatives and it's properties, Berwald's covariant derivatives and its properties, Relation between connection coefficients of Cartan and Berwald. | 15 |
| III | Commutation formulae resulting from Cartan's covariant differentiation, Cartan curvature tensor, Commutation formulae resulting from Berwald's covariant differentiation, Berwald curvature tensor, Generalizations of Bianchi identities, Space of scalar curvature, Space of constant curvature, Generalization of Schur's theorem. | 15 |
| IV | Projective change, Projective invariants, Projective change of Berwald's connection parameters, Projective deviation tensor, Weyl's projective curvature tensor, Lie derivatives and their applications. | 15 |

**Suggested readings:**


1. H. Rund, The Differential Geometry of Finsler Spaces, Springer-Verlag, Berlin, 1959.
2. M. Matsumoto, Foundations of Finsler Geometry and Special Finsler Spaces, Kaisheisha Press, Otsu, 1986.
3. P. L. Antonelli (ed.), Handbook of Finsler Geometry, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2003.
4. Shen Y. B., Shen Z., Introduction to modern Finsler geometry, World scientific publishing.

# M.A./M. Sc. I (SEMESTER-II), PAPER-IV(d)
# GENERAL RELATIVITY

| Course Code: B030807T | Credit-4<br>Max. Marks: 25+75 | Elective paper |
|---|---|---|
| **Total No. of Lectures (in hours per week): 4+1=5** | **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 | 15 |
| 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 Einstein’s field equation. | 15 |
| 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. | 15 |

**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. I (SEMESTER-II), PAPER-V(a)
# PROGRAMMING IN PYTHON-II

| Course Code: B030808P | Max. Marks: 50 + 50 | Elective Paper |
|---|---|---|
| Total No. of Lectures-Practical (in hours per week: 4 + 2 | Course Title: PROGRAMMING IN PYTHON-II | |

**Course outcomes:**

**CO1:** The students will be able to analyze the data by plotting Bar chart/Pie chart/Histogram using Python programming.

**CO2**: The students will be able to solve simultaneous equations by using Python Programming.

**CO3:** The students will be able to solve ordinary and partial differential equations by using Python Programming.

**CO4:** The students will be able to find roots of equations by using different methods with Python programming.

Use of Matplotlib for plotting and data representation. Introduction to numpy, scipy, sympy, using these libraries for Fourier series and Fourier transform,

□**Practicals:**

**Practicals:**

**I Data Visualization - I**

1. Scatter plots
2. Bar charts
3. Histograms
4. Pie Charts

**II Data Visualization - II**

5. Interactive plots -1: modifying display.
6. Interactive plots – 2: editing data and plots.
7. How to make a simple animation in python

**III Numpy**

8. Array Arithmatic
9. Matrix Arithmatic
10. Numerical Methods through numpy

**IV Scipy**

11. Regression
12. Optimization
13. Root-Finding

**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)

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

## Advanced Numerical Techniques Using C

| Course Code: B030809P | Credit-4<br>Max. Marks: 50 + 50 | Elective Paper |
|---|---|---|
| Total No. of Lectures-practical (in hours per week): 4 + 2 | Course Title: Advanced Numerical Techniques Using C | |

*Course outcomes:*

**CO1:** The students will be able to find roots of equations by using different methods with C programming.

**CO2**: The students will be able to solve simultaneous equations by using different methods with C programming.

**CO3:** The students will be able to solve differential equations by using different methods with C programming.

Finite differences, Operators, Interpolation, Roots of a polynomial, Bisection Method, Newton-Raphson Method, Regula Falsi Method, Simultaneous linear Algebraic Equations, Gauss Elimination Method, Gauss-Seidal Method, L U Decomposition method, Numerical Quadrature, Simpson's rules, Trapezoidal Rule, Solving a ordinary differential equation using Euler's Method, Runge-Kutta Method, Eigen value problem,

**Practicals: Write Code for following**

1. Find roots of a polynomial using Bisection Method
2. Find roots of a polynomial using Newton-Raphson Method
3. Find roots of a polynomial using Regula-Falsi Method
4. Find the polynomial from a given data set using Lagrange's Interpolation formula.
5. Solve a system of linear equations using Gauss Elimination Method
6. Solve a system of linear equations using L U Decomposition method
7. Use Gauss-Seidal Method for system of linear equations.
8. Integrate a function using Simpson's 1/3rd rule and 3/8th rule for a given set of limits.
9. Integrate a function using Trapezoidal Rule and find the difference with above methods.
10. Find solution of ordinary differential equation using Euler's Method and Runge-Kutta Method
11. Solve a systems of ordinary differential equations using appropriate numerical methods.
12. Find eigenvalue and corresponding eigenvectors of a given matrix.

**Suggested Readings:**


1. E. Balagurusamy: Programming in ANSI C, MacGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Prahlad Tiwari, R.S. Chandel and A.K. Tripathi: Programming in C & Numerical Analysis, Ram Prasad & Sons, Agra.
3. S. S. Sastry: Introductory Methods of Numerical Analysis, PHI, New Delhi.
4. Madhumangal Pal, Numerical Analysis for Scientists and Engineers (Theory and C Programs), Narosa Publishing House, 2008.
5. B.S.Grewal, Numerical Methods in Engineering & Science with Programs in C, C++ & MATLAB, Khanna Publishers.

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

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

***Course outcomes:***

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

**CO2:** The students will be able to analyse $l^n$, $l_p$, $l_2$, $l_\infty$ and C [a, b] Banach spaces, Banach space C(X), Riesz – Fisher theorem, Continuous and Bounded linear Transformation.

**CO3:** The students will be able to analyse Isometric Isomorphism, Topological Isomorphism, Equivalent norm, Riesz- Lemma, 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 spaces, continuity and joint continuity. | 10 |
| II | $l^n$ $l_p$, $l_2$ , $l_\infty$ *and* C[a,b] Banach spaces, Riesz –Fischer theorem, Subspaces and Quotient space of a Banach space, Continuous and Bounded linear operator, Various forms of an operator norm. | 10 |
| III | Isometric Isomorphism, Topological Isomorphism, Equivalent norm, Riesz- Lemma, Convexity, Hahn- Banach Theorem, Open mapping Theorem, Closed Graph Theorem. | 20 |
| IV | Inner product spaces, Cauchy-Schwarz inequality, Norm induced by inner product, Continuity of inner product, Parallelogram equality, polarization identity, Characterization of inner product in terms of norm, Hilbert spaces and their examples. The adjoint of a bounded linear operator, Self adjoint operator, Riesz representation theorem, Normal and Unitary operators. | 20 |

**Suggested Readings:**

1. Walter Rudin, Functional Analysis - TATA McGraw Hill New Delhi
2. Lusternik and sobolev, Elements of Functional Analysis - Hindustan Publishing corporation New Delhi
3. E.C. Titchmarsh, A Theory of Functions - Oxford University Press New Delhi
4. J.N. Sharma & A.R. Vasishtha, Functional Analysis - Krishna Publications Meerut

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

| | | |
|---|---|---|
| **Course Code: B030902T** | **Credits-4**<br>**Marks: 25+75** | **Core paper** |
| **Total No. of Lectures+ Tutorials (in hours per week): 4+1=5** | **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. | 15 |
| II | SUPERVISED LEARNING (REGRESSION): Regression: Linear Regression, Cost Function, Multiple Linear Regressions, Logistic Regression. Decision Trees, Overfitting and Underfitting, Confusion Matrix, Performance Metrics: Accuracy, Precision, Recall | 15 |
| III | Unsupervised Learning: k-Nearest Neighbor (KNN) Classification, Decision Trees for classification, Logistic Regression<br>Advanced Machine Learning Methods: Neural Networks and Polynomial Fits - over and under fitting. | 15 |
| 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. Stone, James V., Bayes Rule: A tutorial introduction, Sebtel Press
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-III
## ADVANCED OPERATION RESEARCH

| | | |
|---|---|---|
| **Course Code: B030903T** | **Credit-4**<br>**Max. Marks: 25+75** | **Core paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **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 Queuing theory and its characteristics, stochastic Processes under steady and transient states. Study of M/M/1 and M/M/s queuing 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. | 15 |
| 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. | 15 |
| 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. | 15 |
| 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:**


1. Operations Research – kantiswarup, P.K.gupta, Man Mohan–Sultan Chand & sons, New Delhi
2. Operations Research (An Introduction) – Hamdy A. Taha – Pearson
3. Operations Research– R.K.Gupta–Krishna Prakasan

Operations Research –K.Nagrajan - New Age International

# M.A./M. Sc. II (SEMESTER-III), Paper-IV(a)

# Probability and Statistics

| | | |
|---|---|---|
| **Course Code: B030904T** | **Credits-4**<br>**Max. Marks: 25+75** | **Elective paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title: Probability and Statistics** | |

**Course outcomes:**

**CO1:** The students will be able to analyze and solve various concepts related to probability.

**CO2:** The students will be able to understand various concepts related to probability like conditional probability and Baye's Theorem.

**CO3:** The students will be able to study various measures of dispersion like range, mean deviation, quartile deviation and standard deviation.

**CO4:** The students will be able to fit various curves and different kinds of distributions.

**CO5:** The students will be able to apply concept of correlation to study the relationship between two or more variables.

**CO6:** The students will be able to find lines of regression of y on x and x on y which helps student to understand the use of forecasting.

| **Unit** | **Topics** | **No. of Lectures** |
|---|---|---|
| **I** | Counting principles and basic theory of Probability: Combinations and permutations, Random experiment, sample space, event, definition of probability, Laws of probability, Probability of pairwise independent events. Conditional probability, Bayes theorem and its applications. | 15 |
| **II** | Measures of Dispersion: Review of mean, median and mode, Various measures of dispersion, Minimal property of mean deviation, Root mean square deviation, Variance and standard deviation, Random variables, Discrete and continuous Random Variables. | 15 |
| **III** | Probability distributions, Normal Distribution, Applications of Normal Distribution Sampling distributions, Binomial distribution, The student's t distribution, the Chi-square distribution. Curve fitting: Moments about mean, origin, and any point, Skewness, Kurtosis, Pearson's β and γ – coefficients, Curve Fitting, Fitting of Straight lines, Fitting of second-degree parabola. | 15 |
| **IV** | Correlation and Regression Analysis: Significance of measuring correlation, Types of Correlation, Methods of measuring correlation, Regression Analysis, Lines of regression. | 15 |

**Suggested Readings:**


1. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Mathematical Statistics, 11th Edition, (Reprint), Sultan Chand and Sons.
2. Spiegel and Stephens: Schaum's outlines Statistics, McGraw Hill Education
3. Goon A.M., Gupta M.K. and Dasgupta B. (2005): Fundamentals of Statistics, Vol. I, 8th Edn.World Press, Kolkata.
4. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of statistics, 3rdEdn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
5. Rohatgi, V. K. and Saleh, A. K. Md. E. (2009): An Introduction to Probability and Statistics, 2ndEdn. (Reprint), John Wiley and Sons.
6. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
7. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1994): Discrete Univariate Distributions, John Wiley.
8. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

# M.A./M. Sc. II (SEMESTER-III), Paper-IV(b)
# Indian Contribution in Mathematics

| | | |
|---|---|---|
| **Course Code: B030905T** | **Credit-4**<br>**Max. Marks: 25+75** | **Elective Paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title:** Indian Contribution in Mathematics | |
| ***Course outcomes:***<br>**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. | 15 |
| **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 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. | 15 |
| **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. | 15 |
| **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. II (SEMESTER-III), PAPER-IV(c)
# CRYPTOGRAPHY

| Course Code: B030906T | Credits-4<br>Marks: 25+75 | Elective paper |
|---|---|---|
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title: CRYPTOGRAPHY** | |

Course outcomes:
CO1: The students will be able toknow the basic theory of Cryptography and Network Security.
CO2: The students will be able to secure a message over insecure channel by various means and also understand various protocols for network security to protect against the threats in the networks.

| Unit | Topics | No. of Lectures |
|---|---|---|
| I | Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques- Substitution and transposition ciphers, Caesar cipher, Play fair cipher, Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES). | 15 |
| II | Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem (statement only), Chinese Remainder theorem, Discrete logarithm. | 15 |
| III | Advanced Encryption Standard (AES), Stream ciphers, Introduction to public key cryptography, one-way functions, The discrete logarithm problem, Diffie-Hellman key exchange algorithm, RSA algorithm and security of RSA, The ElGamal public key cryptosystem, Introduction to elliptic curve cryptography. | 15 |
| IV | Information/Computer Security: Basic security objectives, security attacks,security services, Network security model, Cryptographic Hash functions, Secure Hash algorithm, SHA-3. Digital signature, Elgamal signature, Digital signature standards, Digital signature algorithm. | 15 |

**Suggested Readings:**

1. William Stallings, Cryptography and Network Security, Principles and Practice, 5th ed., Pearson Education, 2012.
2. Douglas R. Stinson, Cryptography: Theory and Practice, CRC Press, 3rd ed., 2005.
3. J.A. Buchmann, Introduction to Cryptography, 2nd ed., Springer 2003.
4. W. Trappe and L.C. Washington, Introduction to Cryptography with Coding Theory, Pearson, 2006.
5. J. Hoffstein, J. Pipher, and J. H. Silverman, An Introduction to Mathematical Cryptography, 2nd ed., Springer, 2014.

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

| | | |
|---|---|---|
| **Course Code: B030907T** | **Credits-4**<br>**Marks: 25+75** | **Elective paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **Course Title:** Cosmology | |

**Course outcomes:**

CO1: The students will be able to define cosmological equations.

CO2: The students will be able to define various types of cosmological models.

CO3: The students will be able to differentiate between Einstein universe and De-sitter universe.

CO4: The students will be able to explain geometrical features of FRW metric

| Unit | Topics | No. of Lectures |
|---|---|---|
| I | Review of General relativity, Maxwell's equation in vacuo, Propagation of electric and magnetic densities, Transformation equation for differential operator, Lorentz invariance of Maxwell's equations, Maxwell's equation in tensor form, energy-momentum tensor for electromagnetic field | 15 |
| II | Universe on large scales, Homogeneity and Isotropy, Cosmological Principle, Robertson−Walker metric, Hubble's Law, Red Shift, Static Cosmological models, Einstein Universe, De-Sitter Universe, Non-Static Cosmological Models, Geometrical features of Friedmann−Robertson−Walker (FRW) metric | 15 |
| III | The Einstein equations for the FRW metric, cosmological models, Exact solution for zero pressure, Solution for pure radiation, Exact solution connecting radiation and matter eras. | 15 |
| IV | Cosmologies with a non- zero Cosmological constant lambda. Origin and Evolution of Universe, The red-shift versus distance relation, Particles Horizon, Event Horizon, The Hubble constant and the deceleration parameter, | 15 |

**Suggested readings:**


1. General Theory of Relativity: S. P. Puri, Pearson, 2013
2. Introduction to Cosmology: Barbara Royden, Cambridge University Press, 2016
3. Cosmology: J.V.Narlikar; Cambridge University Press, 2010.
4. Theory of Relativity: S. R. Roy and Raj Bali, Jaipur Publishing House, 2008.

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

| | | |
|---|---|---|
| **Course Code: B030908R** | **Max. Marks: 50+50**<br>**Min. Passing Marks: 33** | **Core** |
| **Credit: 10** | **Course Title: Research Project** | |
| **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 project is required to inform the In-charge, Mathematicsthe 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 thelast working day of the semester.
5. Each student shall be compulsorily supervised in the research project by a faculty member. The Supervisor will 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 marks allocated 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 | |
| | | |

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

## MEASURE AND INTEGRATION

<table>
<tr><td>Course Code: B31001T</td><td>Credit-4<br>Max. Marks: 25+75</td><td>Core paper</td></tr>
<tr><td>Total No. of Lectures-Tutorials (in hours per week): 4+1=5</td><td colspan="2">Course Title: Measure and Integration</td></tr>
<tr><td colspan="3">Course outcomes:<br>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.<br>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.<br>CO3: Students will be defined Lebesgue integral, Relation between Riemann integral and Lebesgue integral, Lebesgue integral of bounded measurable function and it's properties.<br>CO4: The students will be able to analyse $L^p$-space, some basic definitions and theorem, Holder's inequality, Minikowski inequality, Jensen Inequality.</td></tr>
</table>

| Unit | Topics | No. of Lectures |
|---|---|---|
| I | **Algebra & Measurability of sets:** Algebra of sets, Axiom of choice, sigma algebras, Borel sets, Extended real number system, Outer measure, Lebesgue measure, Countable sub-additivity of Lebesgue outer measure, Sets of measure zero. The Cantor set and its Lebesgue outer measure, translation invariance. Lebesgue measurable sets: algebra of measurable sets, the class of measurable sets as algebra, the measure of the intersection of decreasing sequence of measurable sets. Non-measurable sets. | 15 |
| II | **Measurable functions:** Measurable space and measure space, Measurable functions; Scalar multiple, sum, difference and product & composition of measurable functions, Measurability of continuous functions, Sequential Pointwise Limits, Borel measurable functions, almost everywhere property, Characteristic functions, Simple functions. | 15 |
| III | **Lebesgue Integral and Convergence Theorems:** Lebesgue integral of a bounded function over a set of finite measure, Comparison with the Riemann integral, the Lebesgue integral of a non-negative measurable function, the general Lebesgue integral, convergence in measure., the Bounded convergence theorem, Fatou's Lemma, Monotone convergence theorem. | 15 |
| IV | **Differentiation and Integration:** Differentiability of Monotone functions- Vitali cover, Vitali covering lemma (without proof), Dini derivatives, Lebesgue differentiation theorem, Differentiability of an indefinite integral. Absolute continuity and indefinite integrals, Convex functions- definition & properties, Jensen's inequality and its geometrical interpretation. | 15 |

**Suggested readings/Reference Books**


1. Royden H.L., Real Analysis ,3e, Prentice-Hall Of India Pvt. Limited, 1988
2. James J. Yeh, Real Analysis: Theory of Measure and Integration, 2014
3. G. de Barra, Measure and Integration. New Age International (P) Ltd., New Delhi, 2006.
4. Berberian, S.K. Measure and Integration, McMillan N.Y.1965
5. E. Hewitt and K. Stromberg, Real and Abstract Analysis, Springer, Berlin, 1988.
6. Frank Burk, Lebesgue Measure and Integration: An Introduction, John Wiley & Sons, 1997
7. Harold Wodom: Lectures on Measure & Integration, Van Nostrand Reinhold Co., New York.
8. Gail Susan Nelson , User-friendly Introduction to Lebesgue Measure and Integration, AMS, American Mathematical Society, 2015
9. Measure theory : Krishna B.Athreya, Soumendra N.Lahiri – Trim Hindustan book Agency.

# M.A./M.Sc. II (SEMESTER-IV), PAPER-XXXII
# FLUID DYNAMICS

| | | |
|---|---|---|
| **Course Code: B031002T** | **Credit-4**<br>**Max. Marks: 25+75** | **Core paper** |
| **Total No. of Lectures-Tutorials (in hours per week): 4+1=5** | **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. | 15 |
| 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. | 15 |
| III | The two-dimensional irrotational motion, 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. | 15 |
| 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 waves and its formation, Rankine–Hugoniot (R-H) Conditions. | 15 |
| | **Suggested Readings:**<br>1 F. Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi,1985.<br>2 W.H. Besaint and A.S. Ramsey: A Treatise on Hydrodynamics, Part II, C.B.S. Publishers, Delhi,1988.<br>3 B.G.Verma: Hydrodynamics, Pragati Prakashan, Meerut, 1995.<br>4 M.D. Raisinghania: Fluid Dynamics, S.Chand and Co, 2003 | |

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

| | | |
|---|---|---|
| **Course Code: B031003T** | **Credits-4**<br>**Marks: 25+75** | **Core paper** |
| **Total No. of Lectures (in hours per week): 4+1=5** | **Course Title: Functional Analysis-II** | |

**Course outcomes:**

**CO1:** The students are able to find dual spaces of normed linear spaces.

**CO2:** The students will be able to know the importance of Banach-Steinhaus theorem.

**CO3:** The students will be able to know the need of Projection theorem.

**CO4**: The students will be able to know Bessel's generalized inequality.

**CO5:** The students are able to know special cases of Hilbert adjoint operators.

| Unit | Topics | No. of Lectures |
|---|---|---|
| I | Finite dimensional normed spaces and compactness, Riesz Theorem, Bounded linear functionals, Dual spaces, Form of dual spaces $R^n$, $C^n$, $c_0$, $\ell^p$ (n), $\ell^p$. | 10 |
| II | Simple consequences of Hahn– Banach theorem and Open Mapping Theorem, Product normed space, Uniform boundedness, Banach- Steinhaus theorem, Natural Embedding theorem and theorems based on Reflexivity. | 15 |
| III | Orthogonal vectors, Orthogonal Complement, Orthogonal sum, Projection Theorem, Orthogonal Projection operator and its properties, Orthogonal sets and their advantage over its linearly independent sets. Complete orthonormal sets, Bessel's generalized inequality, Parseval's Relation, Fourier series representation. Inner product structure of dual spaces, Reflexivity of Hilbert spaces. | 15 |
| IV | Hilbert adjoint operators, Shift operators, Special cases of Hilbert adjoint operators such as self-adjoint operators, positive operators, normal operators, unitary operators. Orthogonal projection operators, Eigenvalues and Eigen Vectors of an Operator, Spectrum of an operator, The Spectral Theorem on a Finite-Dimensional Hilbert Space. | 20 |

**Suggested Readings:**


1. E. Kreyszig: Introductory Functional Analysis with Applications, John Willey & sons, New York, 1978.
2. W. Rudin: Functional Analysis, Tata Mc Graw- Hill, New Delhi, 1977.
3. P.K. Jain, O.P. Ahuja and K. Ahmad: Functional Analysis, New Age International (P) Ltd. and Wiley Eastern Ltd., New Delhi, 1997.
4. F. B. Choudhary & S. Nanda: Functional Analysis with Applications, Wiley Eastern Ltd., 1989.
5. I.J Maddox: Functional Analysis, Cambridge University Press,1970.
6. G.F. Simmons: Introduction to Topology and Modern Analysis, McGraw–Hill Book Company, New York, 1963.
7. K. Chandrashekhara Rao: Functional Analysis, Narosa Publishing House, New Delhi.

# M.A./M.Sc. II (SEMESTER-IV), PAPER-IV(a)
## SPECIAL FUNCTIONS

| Course Code: B031004T | Credit-5<br>Max. Marks: 25+75 | 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:**<br>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:**<br>Hermite equation and its solution, Generating function, Rodrigue's formula, Recurrence relations, Orthogonal Properties of Hermite Polynomials | 15 |
| III | **Lagurre polynomial:**<br>Lagurre equation and its solution, Generating function, Recurrence relations, Orthogonal Properties of Hermite Polynomials. | 15 |
| IV | **Hypergeometric Function:**<br>Hypergeometric Functions, Series Solution near zero, one and infinity. Integral Formula, Confluent Hypergeometric function, Integral representation of Hypergeometric function, Differentiation of Hypergeometric Function. | 15 |

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

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

## DIFFERENTIAL GEOMETRY OF MANIFOLDS

| | | |
|---|---|---|
| **Course Code: B031005T** | **Credit-4**<br>**Max. Marks: 25+75** | **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. | 15 |
| II | Connections, Affine connection and Covariant derivative, torsion and curvature tensors, difference tensor of two connections. | 15 |
| III | Lie – bracket, Lie – derivative, exterior product of two vectors, Exterior algebra, Exterior derivative. | 15 |
| 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-IV(c)
## FINANCIAL MATHEMATICS

| Course Code: B031006T | Credit-4<br>Max. Marks: 25+75 | Elective paper |
|---|---|---|
| **Total No. of Lectures (in hours per week): 4+1=5** | **Course Title: Financial Mathematics** | |

**Course outcomes:**

**CO1:** The students will be able to learn the basics of Financial Management.

**CO2**: The students will be able to learn Time value of money.

**CO3**: The students will be able to understand the meaning of risk and financial derivatives.

| Unit | Topics | No. of Lectures |
|---|---|---|
| I | Financial Management: An overview, Nature and scope of financial management, Goals of financial management and main decision of financial management, Difference between risk, speculation and gambling. | 15 |
| II | Time Value of Money: Interest rate and discount rate, Present value and future value−discrete case as well as continuous compounding case, Annuities and its kinds. Meaning of returns: Return as Internal Rate of Return (IRR), Numerical methods Newton−Raphson to calculate IRR, Measurement of returns under uncertainty situations. | 15 |
| III | Meaning of risk: Difference between risk and uncertainty. Types of risks. Measurement of risk. Calculation of security and Portfolio Risk and Return−Morkowitz Model. Sharpe's Single Index Model, Systematic risk and Unsystematic Risk. Taylor Series and Bond Valuation. Calculation of Duration and Convexity of Bonds. | 15 |
| IV | Financial Derivative: Futures, Forwards, Swaps and Options. Call and Put Option. Call and Put Parity theorem. Pricing of contingent claims through Arbitrage and Arbitrage theorem. Pricing by Arbitrage: A Single Period Option Pricing Model. Multi Period Pricing Model−Cox−Ross−Rubinstein Model. Bounds on Option Prices. | 15 |

**Suggested readings:**


1. Aswath Damodaran: Corporate Finance−Theory and Practice, John Wiley & Sons, Inc.
2. John C.Hull: Options, Futures and Other Derivatives, Prentice−Hall of India Pvt. Limited.
3. Sheldom M. Ross: An Introduction to Mathematical Finance, Cambridge University Press.
4. Salih N. Neftci: An Introduction to Mathematics of Financial Derivatives, Academic Press Inc.
5. Robert J. Elliott and P. Ekkehard Kopp: Mathematics of Financial Markets, Springer−Verlag, New York Inc.

# M.A./M.Sc. II (SEMESTER-IV), PAPER-IV(d)
## HISTORY OF MATHEMATICS

<table>
<tr><td colspan="2">Course Code: B031007T</td><td>Credit-5<br>Max. Marks: 25+75</td><td colspan="2">Elective Paper</td></tr>
<tr><td colspan="2">Total No. of Lectures-Tutorials (in hours per week): 4+1=5</td><td colspan="3">Course Title: HISTORY OF MATHEMATICS</td></tr>
<tr><td colspan="5">Course outcomes:<br>CO1: The students will be able to know that how the concepts have been developed in Mathematics.</td></tr>
<tr><td>Unit</td><td colspan="3">Topics</td><td>No. of Lectures</td></tr>
<tr><td>I</td><td colspan="3">Ancient Mathematics: The Babylonians. The Egyptians. The Greeks. The Romans, The Maya, The Chinese, The Japanese. The Hindus. The Arabs</td><td>15</td></tr>
<tr><td>II</td><td colspan="3">Mathematics in Europe during the middle age.</td><td>15</td></tr>
<tr><td>III</td><td colspan="3">Mathematics during the sixteenth, seventeenth, eighteenth, nineteenth, and twentieth centuries.</td><td>15</td></tr>
<tr><td>IV</td><td colspan="3">There naissance Vieta and Descartes to Newton, Euler, Lagrange, Laplace, Hardy, and Ramanujan</td><td>15</td></tr>
<tr><td colspan="5">Suggested Readings:<br>1. F. Cajon: A History of Mathematics, 1894.<br>2. J. Stillwell: Mathematics and its History, Springer International Edition, 4th Indian Reprint, 2005.</td></tr>
</table>

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

| | | |
|---|---|---|
| **Course Code: B031008D** | **Max. Marks: 50+50**<br>**Min. Passing Marks: 33** | **Core Compulsory** |
| **Credit: 4** | **Course Title: 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 thelast 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

| | | |
|---|---|---|
| **11-** | Name of the college: | |
| **12-** | Department | |
| **13-** | Name of the student: | |
| **14-** | Roll No. : | |
| **15-** | e-mail : | |
| **16-** | Name of the supervisor(s): | |
| **17-** | Title of the Project: | |
| **18-** | Signature of the Student: | |
| **19-** | Signature of supervisor(s): | |
| **20-** | Signature of HOD, Mathematics | |
| | | |