

POST GRADUATE PROGRAMME

MASTER OF SCIENCE (M.Sc.)

IN

MATHEMATICS AND SCIENTIFIC COMPUTING



DEPARTMENT OF MATHEMATICS

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

PRAYAGRAJ-211004, INDIA

M. Sc. Program in Mathematics and Scientific Computing

Program Structure

First Semester:

S. No.	Course code	Name of the Course	Credit	L+T+P
1.	MA51101	Programming Languages	4	4+0+0
2.	MA 51201	Programming Languages (Lab)	4	0+0+6
3.	MA 51102	Real Analysis and General Topology	4	3+1+0
4.	MA 51103	Algebra	4	3+1+0
5.	MA 51104	Advanced Differential Equations	4	3+1+0

Second Semester:

S. No.	Course code	Name of the Course	Credit	L+T+P
1.	MA 52101	Fluid Dynamics	4	3+1+0
2.	MA 52102	Principles of Numerical Computations	4	3+1+0
3.	CS 52103	Data structure	4	4+0+0
4.	CS 52201	Data Structure (Lab)	4	0+0+6
5.	MA 52104	Probability and Statistics	4	3+1+0
6.	HS 52105	Communication Skill and Personality Development	4	3+1+0

Third Semester:

S. No.	Course code	Name of the Course	Credit	L+T+P
1.	MA 53101	Mathematical Modeling	4	3+1+0
2.	MA 53102	Complex Analysis	4	3+1+0
3.	MA 53103	Optimization	4	3+1+0
4.	MA 53104	Mathematical Methods	4	3+1+0
5.		Elective 1	4	

List of Electives for Third Semester

Students can choose a course from the following as an elective:

Elective 1

MA 53301 Coding Theory

MA 53302 Computational Fluid Dynamics

MA 53303 Number Theory

MA 53304 Analytical Dynamics and Generalized Coordinates
 MA 53305 Advanced Topology
 MA 53306 Operating System
 CS 53307 Design and Analysis of Algorithm

Note: Before going to winter vacation each student will choose a project for IVth semester under a teacher in the department. At the end of IV semester student will submit a thesis/report of the project and will make presentation in the department for the evaluation for grade.

Fourth Semester:

S. No.	Course Code	Name of the Course	Credit	L+T+P
1.	MA 54101	Discrete Structures and Fuzzy Theory	4	3+1+0
2	MA 54102	Differential Geometry and Tensor Analysis	4	3+1+0
3		Elective- 2	4	
4.		Elective-3	4	
5.	MA 54601	Project	4	

List of Electives for Fourth Semester

Elective –2

- MA 54301 Statistical Simulation and Data Analysis
- MA 54302 Commutative Algebra
- MA 54303 Computational Algebraic Geometry
- MA 54304 Cryptography
- MA 54305 Symmetry Analysis of Differential Equation
- MA 54306 Magnetogasdynamics and Hyperbolic Systems

Elective-3

- MA 54307 Graph Theory
- MA 54308 Functional Analysis
- MA 54309 Financial Mathematics
- MA 54310 Special Functions
- MA 54311 Wavelet Analysis
- MA 54312 Image Processing

गणित विभाग
मोतीलाल नेहरु राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
Mathematics Department
Motilal Nehru National Institute of Technology Allahabad
M.Sc. in Mathematics and Scientific Computing

MA-51101: Programming Languages

L	T	P	Credit
3	1	0	4

Unit I- Introduction to the C Language: (6 Lectures)

Writing a Simple C Program: Learning the format of a C program, declaring variables, designing program flow and control, defining and using functions, datatypes, using standard terminal I/O functions. Conditional Program Execution: Applying if and switch statements, nesting if and else, restrictions on switch values, use of break and default with switch. Program Loops and Iteration: Uses of while, do and for loops, multiple loop variables, assignment operators, using break and continue.

Unit II- Modular Programming, Arrays and Structures: (5 Lectures)

Passing arguments by value, scope rules and global variables, separate compilation, and linkage, building your own modules. Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size. Structures: Purpose and usage of structures, declaring structures, assigning of structures. Unions: Components in overlapping memory, declaring and using unions. .h vs. private .c files, hiding private variables and functions.

Unit III- Functions and Pointers to Objects: (8 Lectures)

Simple C-functions, passing arguments to functions, returning values from functions, reference arguments, overloaded functions, recursion, inline functions, default arguments, scope and storage class, returning by reference, const function arguments, runtime memory management. Pointer and address arithmetic, pointer operations and declarations, using pointers as function arguments, Dynamic memory allocation.

Unit IV- Object oriented paradigm & C++ at a glance: (6 Lectures):

Introduction, Classes and objects: A simple class, C++ objects as physical objects, C++ objects as data types, structures and classes, classes, objects and memory, static class data, constant member functions and constant objects, friend function and class, class design steps, class revisited, constructors, parameterized constructors, destructor, order of construction and destruction, constructors with default arguments, nameless objects, dynamic initialization through constructors, constructors with dynamic operations, copy constructor, constructors for two-dimensional arrays, constant objects and constructor, static data members with constructors and destructors, nested classes.

Unit-V Dynamic objects and Operator overloading: (8 Lectures)

Array fundamentals, arrays as class member data, array of objects, address and Pointers, the address of operator, pointers and arrays, pointers and functions, pointers and C-type Strings, memory management, pointers to objects, pointers to pointers, the this pointer, dynamic type information, overloading unary operators, overloading binary operators, data conversion, explicit and mutable keywords, tracing memory links.

Unit-VI Inheritance and Polymorphism: (7 Lectures)

Introduction, class revised, derived class declaration, forms of inheritance, inheritance and member accessibility, constructors and destructors in derived classes, constructors invocation and data members initialization, overloaded member functions, abstract classes, types of inheritance, virtual functions and base class, pointer to derived class objects, array of pointers to base class objects, pure virtual functions, abstract classes, virtual destructors, kinds of polymorphism, inclusion polymorphism, virtual methods, polymorphic objects.

Reference Books:

1. Herbert Schildt, Complete Reference in C,” TMH
2. Yashwant Kanetkar,” Let us C”, BPB
3. Balaguruswamy, “Programming in ANSI C,” TMH
4. Yashwant Kanetkar “Pointers in C”
5. Budd,”Object Oriented Programming “, Addison Wesley.
6. Mastering C++ K.R Venugopal Rajkumar, TMH.
7. C++ Primer , “Lip man and Lajole”, Addison Wesley.
8. Balaguruswami, “Object oriented with C++”, TMH .
9. Maria litvin , Gary litvin,“Programming in C++”,Vikas.
10. D Samantha, “Object oriented Programming in C++ and Java “, PHI.

MA51201: Programming Languages (Lab)

L	T	P	Credit
0	0	6	4

Lab Course Outline:

1. Writing a simple C-program: Learning the form of a C-program, declaring variables, designing program flow and control, using standard terminal I/O functions and datatypes. Control-Flow statements: Use of if-else, Loops: While, do-while, do, for and nested loops, break, continue, switch, etc. (8L)
2. Use of C-functions, Unions. (6L)
3. Arrays, Structures, Unions in C. (7L)
4. Writing a C++-program, Classes and Objects. (6L)
5. Constructors, destructors, pointers to objects. (7L)
6. Inheritance. (6L)

Reference Books:

1. Herbert Schildt, Complete Reference in C,” TMH
2. Yashwant Kanetkar,” Let us C”, BPB
3. Balaguruswamy, “Programming in ANSI C,” TMH

4. Yashwant Kanetkar “Pointers in C”
5. Budd,”Object Oriented Programming “, Addison Wesley.
6. Mastering C++ K.R Venugopal Rajkumar, TMH.
7. C++ Primer , “Lip man and Lajole”, Addison Wesley.
8. Balaguruswami, “Object oriented with C++”, TMH .
9. Maria litvin , Gary litvin,“Programming in C++”,Vikas.
10. D Samantha, “Object oriented Programming in C++ and Java “, PHI.

MA 51102: Real Analysis and General Topology

L	T	P	Credit
3	1	0	4

Unit I- (6 Lectures)

Riemann-Stieltjes Integral: Definition and Existence of Integral, Properties of Integral, Integration and Differentiation, Integration of Vector-valued functions.

Unit II- (7 Lectures)

Function of Several Variables: Linear transformation, Differentiation, The contraction principal, The inverse Function Theorem, The Implicit Function Theorem, Derivative of Higher orders, Langrage’s Multiplier Method.

Unit III- (8 Lectures)

Measure Theory: Set functions, Measurable Sets, Construction of Lebesgue Measure, Measure Spaces, Measurable Funtions, Simple Functions, Lebesgue Integration, Lebesgue’s Monotone Convergence Theorem, Fatou’s theorem, Lebesgue Dominated Convergence Theorem, Comparison with Riemann Integral, Function of class L2.

General Topology-

Unit IV- (5 Lectures)

Topological Spaces: Open sets, closed sets, neighbourhoods, bases, subbases, limit points, closures, interiors, continuous functions, homeomorphisms. Subspace topology, product topology, metric topology, order topology, Quotient Topology

Unit V- (6 Lectures)

Connectedness and Compactness: Connected spaces, Connected subspaces of the real line, Components and local connectedness, Compact spaces, Heine-Borel Theorem, Local-compactness.

Unit VI- (9 Lectures)

Separation Axioms: Hausdorff spaces, Regularity, Complete Regularity, Normality, Urysohn Lemma, Tychonoff embedding and Urysohn Metrization Theorem, Tietze Extension Theorem. Tychonoff Theorem, One-point Compactification.

Reference Books:

1. T. Apostol, Mathematical Analysis, 2nd ed., Narosa Publishers, 2002.
2. W. Rudin, Principles of Mathematical Analysis, 3rd ed., McGraw-Hill, 1983.
3. H.L. Royden, Real Analysis, 3rd ed., Macmillan, 1988.
4. S. C. Malik, S. Arora, Mathematical Analysis, New Age International (P) Ltd. Second Edition, 2004.
5. J.R. Munkres, Topology : A First Course, Prentice –Hall, New Delhi.
6. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill.
7. K.D. Joshi, Introduction to General Topology, New Age International Pvt. Ltd.

MA 51103: Algebra

L	T	P	Credit
3	1	0	4

Unit I (Lectures 6)

An overview of Groups, Rings and Fields, group action, Sylows theorem, Principal Ideal Domains, Euclidean domains, Polynomial Rings.

Unit II (Lectures 6)

Field extensions, finite extensions, algebraic extensions, irreducible polynomial of an algebraic element, splitting fields and their uniqueness, Finite fields their existence and characterization, extensions and subfields of finite fields. Construction and representation of finite fields using polynomials over \mathbb{Z}_p .

Unit III (Lectures 6)

Modules, Short exact sequence, Projective Modules. Linear Operators on Finite Dimensional Vector Spaces, Eigenvalues and eigenvectors,

Unit IV (Lectures 8)

Annihilating polynomials, Invariant subspaces, Direct Sum Decomposition, Invariant direct sums, Primary Decomposition. Cyclic subspaces, Annihilators, Cyclic Decomposition, Rational Canonical Form, Jordan Canonical Form, Computation of Invariant Factors.

Unit V (Lectures 8)

Polynomials and Affine spaces, Affine Varieties, Parametrization, Monomial Orders, Division Algorithm in several variables, Monomial Ideals and Dickson's lemma, Hilbert basis Theorem, Hilbert's Nullstellensatz, Radical Ideals and Varieties, Operations on Ideals, Irreducible Varieties and Irreducible Decompositions.

Unit VI (Lectures 8)

Groebner Bases, Properties, Buchberger's Algorithm, Applications, Solving systems of Polynomial equations, Elimination and Extensions, Implicitization, Unique Factorization and Resultants, Extension Theorems,

Texts / References:

1. Lidl and Niederreiter, Finite Fields and Applications.

2. Hoffman and Kunze, Linear Algebra.
3. Henry Helson, Linear Algebra.
4. Cox, Little and O'Shea, Ideals and Algorithms.
5. Algebra Vol I & II, Ramji Lal
6. Derek J.S. Robinson: An Introduction to Abstract Algebra
7. P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul: Basic Abstract Algebra

MA 51104: Advanced Differential Equations

L	T	P	Credit
3	1	0	4

Unit I (Lecture 7)

Review of First order and Second order ODE, Green's Function, Series Solutions, Special Functions (Hyper Geometric, Legendre and Bessel's Function) First order P.D.E.: Curves and Surfaces, Genesis of First order P.D.E., Classification of Integrals,

Unit II (Lecture 8)

Linear Equations of the First order, Pfaffian Differential equations, Compatible Systems, Charpit's Method, Jacobi's Method, Characteristic Method, Integral Surfaces Through a Given Curve, Quasi-Linear Equations, Non-Linear First Order P.D.E.

Second order P.D.E. : Genesis of Second order P.D.E., Classification of second order PDE. One dimensional Wave Equation, Vibrations of an Infinite String, Vibrations of a Semi-Infinite String, Vibrations of a String of Finite length, Riemann Method.

Unit III (Lecture 8)

Laplace's Equation, Boundary Value Problems (Homogeneous and non-Homogeneous), Maximum Minimum Principles, Cauchy Problem, The Dirichlet problem for Upper Half Plane, The Neumann problem for Upper Half Plane The Dirichlet problem for a circle, The Dirichlet Exterior problem for a Circle, Method of Superposition, The Neumann problem for a circle, The Dirichlet problem for a rectangle.

Unit IV (Lecture 7)

Harnack's Theorem, Laplace equation- Green's Function, The Dirichlet problem for a Half Plane, Solution of Poisson Equation, Vibrating Membrane, Solution of Wave equations in the presence of External force by Eigen-Function Method in one dimension, two Dimensions and three Dimensions,

Unit V (Lecture 7)

Solution of Circular Membrane in terms of Bessel's Function, D' Alembert's solution of the Wave equation Heat Conduction Problems, Heat Conduction-Infinite bar, Heat Conduction-Finite bar,

Unit VI (Lecture 8)

Duhamel's Principle: Wave Equations, Heat Conduction equations, solution of Heat Equation in two and three dimensions (cartesian, polar and spherical coordinate system) in terms of Bessel's and Legendre's Functions, Classification in case of n-variables, Families of Equipotential Surfaces, Kelvin's Inversion Theorem.

References:

1. G.F. Simmons, Differential equations with Applications an historical Notes, Tata McGraw Hill, Second Edition-2003.
2. I. N. Sneddon, Elements of partial differential equations, McGraw-Hill, Newyork (1957).
3. Tyn Myint U, Partial differential equations of Mathematical Physics, Elsevier(1973).
4. Phoolan Prasad, Partial Differential Equations, New Age International Publishers(1985).
5. T. Amaranath, An elementary course in partial differential equations, Narosa Publication (1997).
6. K. Sankar Rao, Introduction to Partial Differential Equation, PHI, 2011.

MA 52101: Fluid Dynamics

L	T	P	Credit
3	1	0	4

Unit-I (Lecture 6)

Kinematics of Fluid- Classification of Fluids, Fluid Properties, Lagrangian and Eulerian Methods of Fluid Motion. Stream Lines, Path Lines and Streak Lines, Velocity Potential, Vorticity, Irrotational and rotational motions.

Unit-II (Lecture 7)

Stresses and Strains: Stress components in a real fluid. Transformation of Stress Components, Rate of Strain, Transformation of Rate of Strain, Relations between stress and rate of strain.

Unit-III (Lecture 8)

Fundamental Equations of Fluid Flows: Equation of Continuity, Navier-Stokes Equations- Conservation of Momentum, Equation of Energy, Fundamental Equations in Cylindrical and Spherical Coordinates.

Unit-VI (Lecture 7)

Dynamic Similarity and Dimensional Analysis: Types of Similarity, Non-Dimensionalizing of Basic Equations of Fluid Flow, Non-Dimensional Parameters, Dimensional Analysis and Buckingham Pi Theorem.

Unit-V (Lecture 8)

Boundary Layer Theory: Properties Navier-Stokes Equations - Boundary Layer Concepts, Boundary Layer Equations in Two-Dimensional Flow, Boundary Layer Along a Flat Plate, Blasius Solution, Boundary Layer on a Surface with Pressure Gradient, Karman's Integral Relation.

Unit-II (Lecture 7)

Gas Dynamics: Wave Motion in a Gas, Speed of Sound, Equation of Motion of a Gas, Subsonic, Sonic and Supersonic flows of a gas, Isentropic gas flows. Flow through nozzle. Shock formation. Normal and Oblique Shock Waves

Texts/References:

1. F. Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.
2. S.W. Yuan, Foundation of Fluid Mechanics, Prentice-Hall of India Pvt Ltd, 1976.

3. G. K. Batchelor, Introduction to Fluid Mechanics, Foundation Book, New Delhi, 1994.
4. L. I. Sedov, Similarity and Dimensional Methods in Mechanics, Academic Press, New York, 1959.
5. P.K Kundu, Fluid Mechanics, I M Cohen Academic Press, 2010.

MA 52102: Principles of Numerical Computations

L	T	P	Credit
3	1	0	4

Unit I (Lecture 7)

Linear Equations and Eigen-value Problems: Direct and iterative methods for solution of linear system and their error analysis, Solution of tri-diagonal systems, Methods for ill-conditioned linear system, Eigen value and eigen vectors, Jacobi, Given's and Householder transformations for eigen value problems.

Unit II (Lecture 6)

Interpolation: Errors in polynomial interpolation, Finite differences, Symbolic relations and separation of variables, Newton, Lagrange, Stirling, Bessel and Everett's interpolating polynomials, Spline interpolation.

Unit III (Lecture 6)

Curve Fitting, B-spline and Approximation: Linear and non-linear curve fitting by least squares method, Cubic spline fitting, Representation of B-splines, Approximations of functions, Chebychev Polynomials, Economization of power series.

Unit IV (Lecture 7)

Numerical Differentiation and Integration: Numerical differentiation by interpolating polynomials and error analysis, Numerical integration by Trapezoidal and Simpson's rule, Cubic spline method, Romberg integration

Unit V (Lecture 7)

Numerical solution of Ordinary Differential Equations: Taylor series method, Modified Euler method, Runge-Kutta methods, Predictors-corrector methods, Cubic spline method, Boundary value problems, Stability and Convergence criteria, Error analysis.

Unit VI (Lecture 6)

Numerical Solution of Partial Differential Equations: Classification of partial differential equations of second order, Numerical Solution of elliptic, parabolic and hyperbolic partial differential equations- specially Laplace, Poisson, heat conduction and wave equations by finite difference and cubic spline methods.

Texts/References:

1. C.F.Gerald and P.O.Wheatley, Applied Numerical Analysis, Pearson Education
2. M.K.Jain, S.R.K.Iyenger and R.K.Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Ltd.
3. S.S Sastry, Introductory Methods of Numerical Analysis, Prentice Hall..
4. S. Rajasekharan, Numerical Methods for Science and Engineering, S.C hand.

5. James I. Buchman and Peter R. Turner, Numerical Methods and Analysis, McGraw-Hills Inc.

CS 52103: Data Structures

L	T	P	Credit
3	1	0	4

Unit I- Introduction to Data Structures and Arrays: (7Lectures)

Introduction: Basic Terminology: Elementary Data Organization, Data Structure Operations, Algorithms Complexity, Time-Space Trade off. Array Definition and Analysis, Representation of Linear Arrays in Memory, Traversing of Linear Arrays, Insertion And Deletion, Single Dimensional Arrays, Two Dimensional Arrays, Bubble Sorting, Selection Sorting, Linear Search, Binary Search, Multidimensional Arrays, Function Associated with Arrays, Character String in C, Character String Operations, Arrays as parameters, Implementing One Dimensional Array.

Unit II- Stacks and Queues: (6Lectures)

Introduction to Operations Associated with Stacks Push & Pop, Array representation of stacks, Operation associated with stacks: Create, Add, Delete, Application of stacks recursion polish expression and their compilation conversion of infix expression to prefix and postfix expression, Tower of Hanoi problem, Representation of Queues, Operations of queues: Create, Add, Delete, Front, Empty, Priority of Queues, Dequeues.

Unit III- Sorting: (6 Lectures)

Insertion Sort, Quick sort, two-way Merge sort, Heap sort, Sorting on different keys, External sorting.

Unit IV- Linked Lists and Trees: (9 Lectures)

Singly linked lists: Representation of linked lists in memory, Traversing, Searching, Insertion into, Deletion from linked list, Polynomial Addition, More on linked list, Header nodes, Doubly linked list, Generalized list.

Trees: Basic Terminology, Binary Trees and their representation, expression evaluation, Complete Binary trees, Extended binary trees, Traversing binary trees, Searching, Insertion and Deletion in binary search trees, Complexity of searching algorithm, Path length, Huffman's algorithm, General trees, AVL trees, Threaded trees, B trees.

Unit V- Graphs: (6 Lectures)

Terminology and Representations, Graphs & Multigraphs, Directed Graphs, Sequential representation of graphs, Adjacency matrices, Transversal Connected Component and Spanning trees, Shortest path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.

Unit VI- File Structure: (6 Lectures)

The Standard C Library: Input/Output : fopen, fread, etc. String handling functions, Math functions: log, sin, etc, Other Standard C functions. Physical storage media, File Organization,

Organization records into blocks, Sequential blocks, Indexing & Hashing, Primary Indices, Secondary Indices, B+ tree Index files, B tree index files, Static Hash functions, Indexing & hashing comparisons.

Reference Books:

1. Horowitz and Sahani, "Fundamentals of Data structures", Galgotia publications
2. An introduction to data structures and application by Jean Paul Tremblay & Pal G. Sorenson (McGraw Hill)
3. Tannenbaum, "Data Structures", PHI
4. R.L. Kruse, B.P. Leary, C.L. Tondo, "Data structure and program design in C" , PHI

CS 52201: Data Structure (Lab)

L	T	P	Credit
0	0	6	4

Data Structure Lab Outline:

1. Writing programs based on implementation of operations on queues (6P)
2. Linked lists: Traversing, searching, Insertion, deletion from linked list (6P)
3. Sorting: Insertion Sort, Quick sort, two-way Merge sort (6P)
4. Heap sort, Sorting on different keys, External sorting (6P)
5. Trees: Binary search tree traversing, searching, insertion, deletion, AVL Tree (8P)
6. Graphs: Adjacency matrices, Transversal, Spanning trees, Shortest path, Topological Sort (8P)

Reference Books:

1. Horowitz and Sahani, "Fundamentals of Data structures", Galgotia publications
2. An introduction to data structures and application by Jean Paul Tremblay & Pal G. Sorenson (McGraw Hill)
3. Tannenbaum, "Data Structures", PHI
4. R.L. Kruse, B.P. Leary, C.L. Tondo, "Data structure and program design in C" , PHI

L	T	P	Credit
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MA 52104 : Probability and Statistics

3	1	0	4
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Unit I. (Lecture 8)

Probability: - Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events. Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality.

Unit II. (Lecture 7)

Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Uniform, Exponential, Gamma, Normal joint distributions, Marginal and conditional distributions, Moments, Independence of random variables, Covariance, Correlation.

Unit III. (Lecture 7)

Functions of random variables. Weak law of large numbers, P. Levy's central limit theorem (finite variance case), Normal and Poisson approximations to binomial.

Unit IV. (Lecture 7)

Statistics: - Population, Sample, Parameters. Point Estimation: Method of moments, MLE, Unbiasedness, Consistency, Comparing two estimators (Relative MSE). Confidence interval estimation for means, difference of means, variance, proportions, Sample size problem.

Unit V. (Lecture 6)

Test of Hypotheses:-N-P Lemma, Examples of MP and UMP tests, p-value, Likelihood ratio test, Tests for means, variance, two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-square goodness of fit tests, Contingency tables, SPRT

Unit VI. (Lecture 6)

Regression Problem:- Scatter diagram, Simple linear regression, Least squares estimation, Tests for slope and correlation, Prediction problem, Graphical residual analysis, Q-Q plot to test for normality of residuals, Multiple regression, Analysis of Variance: Completely randomized design and randomized block design, Quality Control: Shewhart control charts and Cusum charts.

Texts /References:

1. R. Murray, Probability and Statistics.
2. Frederick Mosteller, Probability and Statistics.
3. S. C. Gupta and V. K . Kapur, Probability

HS 52105: Communication Skill and Personality Development

L	T	P	Credit
3	1	0	4

Unit I (6 Lectures):

Human Communication: Nonverbal communication, Oral communication. Communication cycle. Business communication: Written communication and its historical development, Effective communication, Communication as academic discipline

Unit II (6 Lectures)

Barriers to effective human communication: .1 Physical barriers, .2 System design, .3 Attitudinal barriers, .4 Ambiguity of words/phrases, .5 Individual linguistic ability, .6 Physiological barriers, .7 Presentation of information
Communication noise : Environmental noise Physiological-impairment noise Semantic noise, Syntactical noise, Organizational noise, Cultural noise, Psychological noise.

Unit III. (7 Lectures)

Organizational Behaviour: introduction to organizational behaviour in management; Foundations of individual behaviour -personality; perception; learning; values, attitudes and job satisfaction; ability and motivation.

Unit IV (7 Lectures)

Group Dynamics and team building: Foundations of group behaviour; group decision making; Leadership: power and politics, conflict. Transactional Analysis and interpersonal skills
 Organization; Foundations of organization structure; Job stress; Organizational culture: Meaning, importance and characteristics of organization culture.

Unit V. (7 Lectures)

Organization Change and Development: Significance of change; Forces of change: Resistance to organizational change; Management of change, Organisation development: Concept, characteristics and assumptions; Goals, approaches and techniques of organization development.

Unit VI. (7 Lecture)

Counseling, concepts, nature, theories and application, role of counselor and counselee, methods of counseling, counseling and social work

Reference:

1. Ivancevich, John and Michael T. Matheson, Organisational Behaviour and Management, Business Publication Inc., Texas.
2. Koontz, Harold, Cyril 'O' Donnell, And Heinz Weihrich, Essentials of Management, Fourth Edition, McGraw-Hill, Singapore.
3. Luthans, Fred, Organizational Behaviour, 7 th ed., McGraw-Hill, New York.
4. Nelson, Debra L. and James Campbell Quick, Organizational Behaviour, West Publishing Company, St. Paul.
5. Robbins, S., Judge, T., Millett, B., & Boyle, M. (2011). Organisational Behaviour. 6th ed. Pearson, French's Forest, NSW p315-317.

MA-53101: Mathematical Modeling

L	T	P	Credit
3	1	0	4

Unit I (6 Lectures)

Mathematical Modeling: Mathematical Model, types of Mathematical models and properties, Elementary models, Models by nature of environment, Models by the Extent of generality, Principle of modeling, Solution method for models, Characteristics, Advantages and Limitations of a model,

Unit II (6 Lectures)

Discrete and continuous dynamical system modeling, Modeling from input/output data, Stochastic Modeling, Graphical method: Barterning model, Approaches to differential equation: Heun method, Local stability theory: Bernoulli Trials, Classical and continuous models.

Unit III (6 Lectures)

Queuing system modeling, Single server, Unlimited queue model, Service in random order, Single server, Finite queue model, Multi- channel queuing model. Case studies in problems of engineering and biological sciences

Unit IV (6 Lectures)

Simulation: Introduction to simulation, General concept in discrete event simulation, Random number generation, Nature of Simulation, Simulation models, Monte-Carlo simulation

Unit V (6 Lectures)

Event type simulation, Demand pattern Simulation, Simulation in inspection work, Simulation of queuing models, Simulation of job sequencing, Advantage of simulation, Limitations of simulation

Unit VI (6 Lectures)

General techniques for simulating continuous random variables, simulation from Normal and Gamma distributions, simulation from discrete probability distributions, simulating a non – homogeneous Poisson Process and queuing system

Reference Books:

1. Edward A. Bender, An Introduction to Mathematical Modeling.
2. A. C. Fowler, Mathematical Models in Applied Sciences, Cambridge University Press.
3. J. N. Kapoor, Mathematical Modeling, Wiley eastern Limited.
4. S.M. Ross Simulation, India Elsevier Publication.
5. A.M. Law and W.D. Kelton, Simulation Modeling and Analysis, T.M.H. Edition
6. Doebelin, E.O., System Modeling and Response, John Wiley & Sons, 1980.
7. Gata, K., Modern Control Engineering, Prentice Hall India, 1995
8. Narasingh Deo, System Simulation with Digital Computer, Prentice Hall India, 1997.
9. Rolfe. J.M., and Staples, K.J., Flight Simulation, Cambridge Aerospace Series, Cambridge University Press, 1986. Manuals of Analog Computer, MATLAB, SIMULINK and other software.

MA 53102: Complex Analysis

L	T	P	Credit
3	1	0	4

UNIT I: (6 Lectures)

Complex Integration, Cauchy-Goursat Theorem, Cauchy's integral formula, higher order derivatives, Morera's Theorem, Cauchy's inequality and Liouville's theorem.

UNIT II: (8 Lectures)

The fundamental theorem of algebra, Taylor's theorem, Maximum modulus principles, Schwarz lemma, Weierstrass Theorem, Taylor series, Laurent's series, Zeroes and poles, isolated singularities.

UNIT III: (6 Lectures)

Residues, Cauchy's residues theorem, evaluation of integrals, branches of many valued functions with special reference to $\arg z$, $\log z$ and z^a .

UNIT IV: (8 Lectures)

Meromorphic functions, The argument principle, Rouché's theorem, inverse function theorem. Bilinear transformations, their properties and classifications, definition and examples of conformal mappings, conformal mapping of polygons.

UNIT V: (7 Lectures)

Spaces of analytic functions, Hurwitz's theorem, Montel's theorem, Riemann Mapping theorem. Uniform convergence of sequences and series. Taylor and Laurent series.

UNIT VI: (6 Lectures)

Isolated singularities and residues, Evaluation of real integrals, Riemann Zeta function, Riemann mapping theorem, analytic continuation, Picard's Theorem.

Texts / References:

1. J.B. Conway, Functions of One Complex Variable, 2nd ed., Narosa, New Delhi.
2. L.V. Ahlfors, Complex Analysis, McGraw Hill book company.
3. T.W. Gamelin, Complex Analysis, Springer International Edition, 2001.
4. R. Remmert, Theory of Complex Functions, Springer Verlag.
5. A.R. Shastri, An Introduction to Complex Analysis, Macmillan India.
6. D Sarason, Complex Function Theory, PHI.

	L	T	P	Credit
MA 53103: Optimization	4	1	0	4

UNIT I: (5 Lectures)

Introduction: Nature and Scope of operations research. Linear Programming: Mathematical formulation of the problem, Graphical Solution methods, Mathematical solution of linear programming problem, Matrix formulation of general linear programming Problem.

UNIT II: (7 Lectures)

Simplex Method: Fundamental properties to solution corroboration of extreme points, Simplex algorithm, Computational procedures, Artificial variables, Two phase Simplex Method, Unrestricted variables, problems of degeneracy, Principle of duality in simplex method, Formation of dual with mixed type of constraints, Solution of primal and dual constraints, Integer Programming.

UNIT III: (6 Lectures)

Transportation models: Construction and solution of these Models, the transportation problem, matrix form of transportation problem, Initial basic feasible solution, Transportation algorithm,

Degeneracy in transportation Problem, Replacement problem, Assignment problem- Hungarian Method.

UNIT IV: (4 Lectures)

Game Theory: Introduction, Two persons zero sum games, The maxmin and minimax principles. Graphical Solution: Reduction of game problem to LPP.

UNIT V: (5 Lectures)

Non-Linear programming: Quadratic form, Lagrangian method, Kuhn Tucker Condition.

Queuing theory: Poission Process and Exponential Distribution, Classification of Queues, Queuing Models.

UNIT VI: (6 Lectures)

Network Analysis: Rules of Network Construction, Time Calculation in Network, Critical Path Method, Project Evaluation Review Technique.

Inventory control: Types of inventory, The Inventory Decisions, Economic Order Quantity, Deterministic Inventory Problem, Probabilistic Problem.

Texts/References:

1. An introductory Operation Research: K.D. Kumar
2. Operation Research, Theory and Application by J.K. Sharma, Macmillan India
3. Quantitative techniques in Management by N. D. Vohra, TMH
4. Linear Programming by N.P. Loomba
5. Operation Research: An Introduction by H.A. Taha,
6. Operation Research, Kanti Swarup, P K Gupta, Man Mohan, Sultanchand and Sons.
7. 'Introduction to Operations Research', Hillier, F.S. and G.J. Lieberman, , 9th Ed., 2010, McGraw Hill, New York

MA 53104: Mathematical Methods

L	T	P	Credit
3	1	0	4

UNIT I: (6 Lectures)

Laplace Transform, Integral transforms, Fourier integral, and Fourier transform, Fourier series, Sturm-Liouville Problem.

UNIT II: (7 Lectures)

Integral equations, Introduction, Abel,s Problem, Fredholm Integral Equations of first, second and third kinds, Homogeneous Fredholm Integral Equation, Volterra integral equations of first, second and third kinds, Homogeneous Volterra integral equation, Singular Integral Equations,

UNIT III: (5 Lectures)

Symmetric Kernals, Degenerate Kernals, Iterated Kernals, Resolvent Kernals, Eigen values and Eigen functions of Integral operator, Solution by Eigen values and eigen functions Method.

UNIT IV: (7 Lectures)

Solution of Fredholm Integral Equations of the second kinds with degenerate kernals, Method of Successive Approximations, Method of Successive Substitutions, Neumann series. Fredholm's First, second and third Fundamental Theorems, Green's Function. Modified Green's Function

UNIT V: (6 Lectures)

Calculus of variations: Introduction, Euler - Lagrange equations, Invariance of Euler's Equations, Field of Extremals, Natural boundary conditions, Transversality conditions, Simple applications of variational principle, Sufficient conditions for extremum of a functional.

UNIT VI: (6 Lectures)

Variational formulation of BVP, Moving Boundary problems, Euler's Finite Difference Method, Ritz Method, Variational methods for finding Eigenvalues and Eigenfunctions.

Texts / References:

1. F.B. Hildebrand, Methods of Applied Mathematics, Prentice-Hall, New York, (1952)
2. I.M. Gelfand, S. V. Fomin, The Calculus of variations. Nauka (1969).
3. M.L. Krashnov, G.I. MaKarenko, A.I. Kiselev Problem and exercises in the calculus of Variations. Mir Publishers Moscow. (1975).
4. M.D. Raisinghania, Integral Equations and Boundary value problems, S. Chand (2007).
5. R. Courant & D. Hilbert, Methods of Mathematical Physics, Vol. I & II, Wiley Eastern Pvt. Ltd. New Delhi, 1975.

MA 53301: Coding Theory

L	T	P	Credit
3	1	0	4

UNIT I: (6 Lectures)

Polynomial rings over fields, Extension of fields, computation in $GF(q)$, Root fields of polynomials.

UNIT II: (7 Lectures)

Vector space over finite fields, Binary group codes, Hamming codes, polynomial codes, Linear block codes.

UNIT III: (6 Lectures)

The structure of cyclic codes, Quadratic residue codes, Reed Mueller codes, Simplex codes.

UNIT IV: (7 Lectures)

Nonlinear codes, Golay, Hadamard, Justeen, Kerdock, Nordstorm-Robinson codes. First and Second order Reed-Mueller codes, t-designs, steiner systems.

UNIT V: (5 Lectures)

Weight distribution of codes. Generalized BCH codes.

UNIT VI: (6 Lectures)

Self dual codes and invariant theory. Covering radius problem, Convolutional codes. (6L)

Books and References:

1. Coding Theory : A First Course, Cambridge University Press, By Chaoping Xing, San Ling, 2013
2. A Student's Guide to Coding and information Theory, Cambridge University Press, By Stefan M Moser and Po-Ning Chen, 2012
3. Error-correcting codes, self-checking circuits and applications by Wakerly, J. North-Holland, New York 1978.
4. Algebra and Codes by Wan Zh. Wissenschaftsverlag, Peking, 1980.
5. Coding theorems of information theory by Wolfowitz, J., Springer, Berlin, 1978.
6. Principles of communication engineering by Wozencraft, M., Jacobs, I. John Wiley, New York.
7. Sequential Decoding by Wozencraft, M., Reiffen, B, M.I.T. Press, Cambridge/Mass.
8. Codes for error control and synchronization by Wiggert, D. Artech, Boston/Mass, 1988.

MA 53302: COMPUTATIONAL FLUID DYNAMICS

L	T	P	Credit
3	0	2	4

UNIT I: (6 Lectures)

Introduction: Basics of CFD, Advances of computational fluid dynamics, Partial Differential Equations Types, Governing equations and assumptions, Boundary conditions.

UNIT II: (6 Lectures)**Basics of Discretization Techniques:**

Explicit schemes, implicit schemes, Grid generation, Finite Difference Method, Finite Volume Method and Finite Element Method.

UNIT III: (5 Lectures)

Spectral Methods, comparison of the Discretization Techniques, Errors and Accuracy, Consistency, Stability Analysis and Convergence.

UNIT IV: (7 Lectures)**Solving the Fluid Dynamic Equations:**

Flows governed by reduced Navier-Stokes Equations, Convective-Diffusive equations, Internal and external flows, supersonic inviscid flows.

UNIT V: (6 Lectures)

Boundary layer flows:

Laminar boundary layer flow, unsteady boundary layers, finite difference methods for two dimensional or axisymmetric steady external flows.

UNIT VI: (6 Lectures)

Incompressible & compressible Viscous Flow: Upwind differencing and artificial vorticity, primitive variable formulation, Vorticity, stream function variables.

Texts and References:

1. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Volume 1 & 2, Springer Verlag, 1992.
2. C. Y. Chow, Introduction to Computational Fluid Dynamics, John Wiley, 1979.
3. M. Holt, Numerical Methods in Fluid Mechanics, Springer Verlag, 1977.
4. H. J. Wirz and J. J. Smolderen, Numerical Methods in Fluid Dynamics, Hemisphere, 1978.
5. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, Computational Fluid Dynamics and Heat Transfer, McGraw Hill, 1984.

MA 53303: Number Theory

L	T	P	Credit
3	1	0	4

Unit I (8 Lectures)

Divisibility and Distribution of prime numbers: division algorithm, Euclidean Algorithm, Primes, Fundamental theorem of arithmetic, distribution of primes, numbers of special forms

Unit II (7 Lectures)

Congruences: basic definitions and properties, linear congruences, Chinese Remainder Theorem, Fermat's theorem, Wilson's theorem, Euler's theorem.

Unit III (7 Lectures)

Number theoretic functions: Greatest integer function, Arithmetic Functions, divisor function, the Mobius Inversion formula, recurrence function

Unit IV (7 Lectures)

Primitive roots and Quadratic residues: primitive roots, theory of indices, quadratic residues, Quadratic residue, Euler's criterion, quadratic reciprocity, Legendre and Jacobi symbol, Binary Quadratic Forms

Unit V (7 Lectures)

Diophantine equations: linear Diophantine equations, Pythagorean triples, Fermat's last theorem, Elliptic Curves.

Unit VI (6 Lectures)

Continued Fraction: finite continued fraction, infinite continued fraction, Farey fraction, Pell's equation.

Texts / References:

1. David M Burton, Elementary Number Theory, McGraw Hill Companies, 7th Edition 2007.

2. K. Ireland and M. Rosen, A Classical Introduction to Modern Number Theory, 2nd ed., Springer-Verlag, Berlin, 1990.
3. S. Lang, Algebraic Number Theory, Addison- Wesley, 1970.
4. Ivan Niven, H. S. Zuckerman and Hugh L. Montgomery, An Introduction to the Theory of Numbers,
5. T M Apostal, Introduction to Analytic Number Theory, Springer

MA 53304 : Analytical Dynamics and Generalized Coordinates

	L	T	P	Credit
Unit-I (6 lectures)	3	1	0	4
Harmonic oscillators, Effect of disturbing force, Damped and forced oscillations. Motion of a rigid body in two dimensions under finite and impulsive forces				
Unit-II (7 lectures)				
Kinetic energy and moment of momentum in two dimensions, Rolling spheres and cylinders, Conservation of energy and momentum				
Unit-III (6 lectures)				
Classification of dynamical systems, Generalized coordinates, Holonomic and non-holonomic systems, Kinetic energy, Generalized components of momentum, Generalized Components of the effective and applied forces, Lagrange's equations				
Unit-IV (8 lectures)				
Examples, Energy equation from Lagrange's equation, Reciprocal relations, Lagrange's equation for impulsive motion, Ignorance of coordinates, The Routhian function, Euler's equation from Lagrange's equation, Hamilton's equations of motion, Application of Hamiltonian methods				
Unit-V (7 lectures)				
Natural motions, The space of events, Action, Hamilton's principle, Principle of least action, Hamilton-Jacobi equation, Hamilton characteristic function, Generating function, Canonical transformations, Phase space, Bilinear invariants				
Unit-VI (7 lectures)				
Poisson brackets, Lagrange brackets, Invariance of Lagrange brackets and Poisson brackets under canonical transformations, Small oscillations. Lagrange's equation of small oscillations, Lagrange's determinants, Normal modes and normal coordinates and their stationary properties				

Books Recommended:

1. S. L. Loney: An Elementary Treatise on the Dynamics of a Particle and a Rigid Body, Macmillan India Ltd., 1982.
2. A.S. Ramsey: Dynamics part-II, The English Language Book Society and Cambridge University Press, 1972.
3. J. L. Synge and B.A. Griffith: Principles of Mechanics, McGraw Hill International Book Company, 1982

MA 53305: Advanced Topology

L	T	P	Credit
3	1	0	4

Unit-1 (6 lectures)

Nets and filters, convergence in terms of nets and filters, ultrafilters and compactness.

Unit-2 (6 lectures)

Paracompactness, characterisation in regular spaces, metrization based on paracompactness.

Unit-3 (7 lectures)

Nagata-Smirnov theorem, Stone's theorem, Smirnov's metrization theorem.

Unit-4 (7 lectures)

Homotopy and the fundamental group, computation of the fundamental groups of circle.

Unit-5 (7 lectures)

Uniformities, uniform continuity, product uniformities, metrization, completeness and compactness in uniform spaces.

Unit-6 (7 lectures)

Topological groups, subgroups, quotient groups, homogeneous spaces, product groups, uniform structures in topological groups, complete groups, completion of topological groups.

Textbook(s)

1. Joshi, K. D. *Topology* (Wiley-Eastern, 1988).
2. Munkres, J. R. *Topology: A first course* (2/e) (Prentice-Hall, 2000).

Reference book(s)

1. Kelley, J. L. *General Topology* (Graduate texts in Mathematics, Vol. 27, Springer, 1991).
2. Willard, S. *General Topology* (Addison-Wesley, Reading, 1970).
3. Engelking, R. *General Topology* (Polish Scientific Publishers, Warsaw, 1977).
4. Bourbaki, N. *Elements of Mathematics: General Topology*, Vols. I & II, (Springer-Verlag, 1988).

MA 53306: Operating System

L	T	P	Credit
4	0	0	4

Unit I (6 lectures)

Introduction: Operating system and function, Evolution of operating system, Batch, Interactive, Time Sharing and Real Time System, System protection.

Unit II (6 lectures)

Operating System Structure: System Components, System structure, Operating System Services.

Unit III (6 lectures)

Concurrent Processes: Process concept, Principle of Concurrency, Producer Consumer Problem, Critical Section problem, Semaphores, Classical problems in Concurrency, Inter Process Communication, Process Generation, Process Scheduling.

Unit IV (7 lectures)

CPU Scheduling: Scheduling Concept, Performance Criteria Scheduling Algorithm, Evolution, Multiprocessor Scheduling. **Deadlock:** System Model, Deadlock Characterization, Prevention, Avoidance and Detection, Recovery from deadlock combined approach

Unit V (8 lectures)

Memory Management: Base machine, Resident monitor, Multiprogramming with fixed partition, Multiprogramming with variable partition, Multiple base register, Paging, Segmentation, Virtual memory concept, Demand paging, Performance, Paged replaced algorithm, Allocation of frames, Thrashing, Cache memory, Organization, Impact on performance. **I/O Management & Disk Scheduling:** I/O devices and organization of I/O function, I/O Buffering, DISK I/O, Operating System Design Issues.

Unit IV (7 lectures)

File System: File Concept, File Organization and Access Mechanism, File Directories, File Sharing, Implementation Issues.

Books & References:

- 1.Milenekovic, "Operating System Concepts", McGraw Hill
- 2.Silverschwatz, "Operating System Concepts", Willey
- 3.Dietel, "An introduction to operating system", Addison Wesley
- 4.Tannenbaum, "Operating system design and implementation", Phi

CS 53307: Design and Analysis of Algorithms

L	T	P	Credit
3	1	0	4

UNIT I: (6 Lectures)

Introduction, Review of basic concepts, advanced data structures like Binomial Heaps, Fibonacci Heaps.

UNIT II: (6 Lectures)

Divide and Conquer with examples such as Sorting, Matrix Multiplication, Convex hull etc.

UNIT III: (7 Lectures)

Dynamic programming with examples such as Kanpsack, All pair shortest paths etc.

UNIT IV: (7 Lectures)

Backtracking, Branch and Bound with examples such as Travelling Salesman Problem etc.

UNIT V: (7 Lectures)

Algorithms involving Computational Geometry.

UNIT VI: (7 Lectures)

Selected topics such as NP-completeness, Approximation algorithms, Randomized algorithms, String Matching.

Text/ Reference Books:

1. Thomas H. Coreman, Charles E. Leiserson and Ronald L. Rivest, "Introduction to Algorithms", Printice Hall of India
2. E. Horowitz & S Sahni, "Fundamentals of Computer Algorithms" Aho, Hopcraft, Ullman, "The Design and Analysis of Computer Algorithms" Pearson Education

MA 54101 : Discrete Structures and Fuzzy Theory

L	T	P	Credit
3	1	0	4

Unit 1 (Lectures 6)

Mathematical Logic: Statements, Connectives, Statement Variables and Formulas, Tautologies, Equivalences and Implications, Disjunctive and Conjunctive Normal Forms, Inference Theory in Statement Logic, Indirect Proofs.

Unit II. (Lectures 6)

Combinatorics: Permutations and Combinations, Permutations and Combinations with repetitions Ordered and Unordered Partitions, Sterling Numbers of First and Second Kind, Partition Functions, Linear Recurrence Relations (Difference Equations), Solution by Characteristic Roots, Generating Functions.

Unit III. (Lectures 6)

Lattices and Boolean Algebra: Boolean Matrices, Boolean Product, Directed Graphs, Digraph representations of Relations, Paths and Connectivity, Transitive Closures. Partially Ordered Sets, Lattices, Modular and Distributive Lattices, Complements, Boolean Algebra, Stone Representation Theorem for Finite Boolean Algebras, Boolean Functions, Free Boolean Algebras, Relationship with Statement Logic.

Unit IV. (Lectures 10)

Fuzzy Sets and Fuzzy Measures: Introduction, Background, Uncertainty and Imprecision, Statistics and Random Processes, Uncertainty in Information, Fuzzy Sets and Membership, Chance Versus Ambiguity. Crisp Versus Fuzzy Sets, Example 1 Fuzzy Sets versus Crisp Sets,

Fuzzy Set Operations, Properties Of Fuzzy Sets, Fuzzification Techniques, Alpha Cuts, Fuzzy Measures, Belief and Plausibility, Evidence Theory, Probability Measures Extension Principle

Unit V. (Lectures 8)

Fuzzy Relations and Fuzzy Graphs: Fuzzy Relations On Sets And Fuzzy Sets, Compositions Of Fuzzy Relations, Properties Of The Min-Max Composition, Reflexivity, Symmetry, Transitivity, Fuzzy Graphs, Special Fuzzy Relations. Fuzzy Functions On Fuzzy Sets, Extrema of Fuzzy Functions, Integration Of Fuzzy Functions

Unit VI. (Lectures 6)

Fuzzy Logic and Expert System: Approximate Reasoning, Fuzzy Tautologies, Contradictions, Equivalence, and Logical Proofs, Other Forms of the Implication Operation, Other Forms of the Composition Operation. Fuzzy Set and Expert Systems, Introduction to Expert Systems, Fuzzy Decisions, Fuzzy Linear Programming, Symmetric Fuzzy LP, Fuzzy Dynamic Programming, Fuzzy Multi Criteria Analysis.

Texts/References:

1. Fuzzy sets and fuzzy logic, theory and applications – George J. Klir, Yuan Prentice Hall 2006.
2. Analysis and management of uncertainty: Theory and applications: Ayyub, B. M., L.N. Kanal, North Holland, New York 1992.
3. Fuzzy data Analysis: Bandler, W. and W. Nather, Kluwer 1996.
4. Tremblay and Manohar, Discrete Mathematical Structures.
5. Kolman, Busby and Ross, Discrete Mathematical Structures
6. Mott, Kandel and Baker, Discrete Mathematical Structures
7. Chang and Lee, Symbolic Logic and Mechanical Theorem Proving.

MA 54102 Differential Geometry and Tensor Analysis	L	T	P	Credit
	3	1	0	4

Unit I. (Lectures 6)

Curves in space, Curvature of plane curves, arc length and line integrals, Graphs and level sets of functions on Euclidean spaces, vector fields, integral curves of vector fields, tangent, normal, binormal, tangent spaces, Helix.

Unit II. (Lectures 7)

Surfaces in Euclidean spaces, vector fields on surfaces, orientation, Gauss map. Surface theory: Fundamental forms, Curvature of curves in surface, Curves on a surface: Principle directions, lines of curvature, conjugate curves, asymptotic lines, isometric lines Geodesics, parallel transport, Weingarten map.

Unit III. (Lectures 6)

Curvature of plane curves, arc length and line integrals. Curvature of surfaces. Parametrized surfaces, local equivalence of surfaces. Gauss-Bonnet Theorem, Poincare-Hopf Index Theorem.

Unit IV. (Lectures 7)

Tensor Analysis and Applications: Space of N-dimensions, second order tensors, Higher order tensors, Tensor algebraic operations, Eigen value and eigen vectors of tensors, symmetric tensors, skew symmetric tensors, orthogonal tensors, Quotient law, relative tensor, Metric tensors

Unit V. (Lectures 6)

Principal directions for a symmetric covariant tensor, Permutations symbols and tensors, Christoffel symbols and covariant differentiation Ricci theorem, Curl, divergence gradient Intrinsic derivative, curvative tensor and Riemannian curvature, Tensor processing.

Unit VI. (Lectures 4)

Case studies with applications of tensor analysis in science and engineering.

Texts/References:

1. Differential Geometry of Curves and Surfaces by M. doCarmo, Prentice Hall, 1976.
2. Elementary Differential Geometry by B. O'Neill, Academic Press, New York, 1966.
3. Differential Geometry: T.J. Wilmore
4. Differential Geometry: B.B. Sinha
5. Differential Geometry by J.J. Stoker, Wiley-Inter science, 1969.
6. Elementary Topics in Differential Geometry by J.A. Thorpe, Springer (India), 2004
7. Vector and Tensor Analysis, Brand, L., John Wiley and Sons 1990.
8. Tensor Calculus, Theory and Problem, J.L. Bansel, Jaipur Publishing House, 2000

MA 54301 Statistical Simulation and Data Analysis

L	T	P	Credit
3	1	0	4

Unit-I (4 Lectures)

Introduction to Data Mining and its Virtuous Cycle:

Unit-II Cluster Analysis: (5 Lectures)

Hierarchical and Non-hierarchical techniques, Classification and Discriminant Analysis

Unit-III Tools: (6 Lectures)

CART, Random forests, Fisher's discriminant functions and other related rules, Bayesian classification and learning rules.

Unit-IV (8 Lectures)

Dimension Reduction and Visualization Techniques: Multidimensional scaling, Principal Component Analysis, Chernoff faces, Sun-ray charts

Unit-V (7 Lectures)

Algorithms for data-mining:

Data mining using multiple nonlinear and nonparametric regression algorithms

Unit-VI (10 Lectures)

Neural Networks: Multi-layer perceptron, predictive ANN model building using back-propagation algorithm, Exploratory data analysis using Neural Networks self organizing maps, Genetic Algorithms, Neuro-genetic model building, Discussion of Case Studies

Reference Books:

1. L. Breiman, J.H. Friedman, R.A. Olschen and C.J. Stone, Classification of Regression Trees, Wadsowrth Publisher, Belmont, CA, 1984.
2. D.J. Hand, H. Mannila and P. Smith, Principles of Data Mining, MIT Press, Cambridge, MA 2001.
3. M.H. Hassoun, Fundamentals of Artificial Neural Networks, Prentice-Hall of India, New Delhi 1998.
4. T. Hastie, R. Tibshirani & J. H. Friedman, The elements of Statistical Learning: Data Mining, Inference & Prediction, Springer Series in Statistics, Springer-Verlag, New York 2001.
5. R.A. Johnson and D.W. Wichern, Applied Multivariate Analysis, Upper Saddle River, Prentice-Hall, N.J. 1998.
6. S. James Press, Subjective and Objective Bayesian Statistics: Principles, Models, and Applications, 2nd Edition, Wiley, 2002.

MA 54302: Commutative Algebra

L	T	P	Credit
3	1	0	4

Unit I (6 Lectures)

Ring Theory Background, Basic concepts of rings, prime ideal and maximal ideals, Prime Avoidance, Jacobson Radicals, Local Rings, and Other Miscellaneous Results, Nakayama's Lemma.

Unit II (6 Lectures)

Primary Decomposition and Associated Primes, Primary Sub-modules and Ideals
 Primary Decomposition, Associated Primes, Associated Primes and Localization, The Support of a Module, Artinian Rings

Unit III (5 Lectures)

Integral Extensions. Integral Elements, Integrality and Localization, Going Down,

Unit IV (6 Lectures)

Valuation Rings, Extension Theorems, Properties of Valuation Rings, Discrete Valuation Rings
 Completion, Graded Rings and Modules, Completion of a Module, The Krull Intersection Theorem

Unit V (6 Lectures)

Dimension Theory, The Calculus of Finite Differences, Hilbert and Hilbert-Samuel Polynomials
 The Dimension Theorem, Consequences of the Dimension Theorem, Strengthening of Noether's
 Normalization Lemma, Properties of Affine A -Algebras

Unit VI (6 Lectures)

Depth Systems of Parameters, Regular Sequences, Homological Methods, Homological
 Dimension: Projective and Global, Injective Dimension, Tor and Dimension, Application Regular
 Local Rings, Basic Definitions and Examples

Texts/References:

1. Atiyah and Macdonald: Commutative Algebra.
2. Gopalakrishnan: Commutative Algebra.
3. N.Y. Sharpe : Commutative Algebra

MA 54303: Computational Algebraic Geometry

L	T	P	Credit
3	0	2	4

Unit I (5 Lectures)

Review of some basic commutative algebra. Noetherian ring, Hilbert basis theorem, Nakayama's Lemma. local rings, local global principle.

Unit II (7 Lectures)

Affine varieties: projective varieties, ideals and varieties, closed sets and Zariski topology, coordinate rings and morphisms,

Unit III (7 Lectures)

Regular functions and maps, rational maps, nonsingular varieties, projection and graphs, images of rational maps.

Unit IV (7 Lectures)

Syzygies, Resultants, irreducible varieties, primary decompositions, projective geometry, Hilbert polynomials and the Bezout Theorem. Nullstellensatz, classification of maximal ideals, transcendental basis,

Unit V (6 Lectures)

Primary decomposition, irreducible ideals, quotient ideals, primary ideals, uniqueness of primary decomposition

Unit VI: (7 Lectures)

Schemes: sheaves, schemes, first properties of schemes, separated and proper morphisms, sheaves of modules, divisors, projective morphisms, differentials, formal schemes.

Texts/References :

1. Shafarevich. Basic Algebraic Geometry 1, ISBN 0-387-54812-2,
2. Cox-Little-O'Shea "Ideals, varieties, and algorithms".
3. Robin Hartshorne, Algebraic Geometry, Springer.
4. Hal Schenck, Computational Algebraic Geometry, London Mathematical Society.
5. Brendan Hassett, Introduction to Algebraic Geometry, Cambridge University Press.

MA 54304- Cryptography,

L	T	P	Credit
3	1	0	4

Unit I. (6 Lectures)

The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream & Block ciphers.

Unit II. (7 Lectures)

Shannon's Theory of Perfect Secrecy, Vernam One Time Pad, Random Numbers, Mode of operations in block cipher, the Data Encryption Standard (DES), Feistel Ciphers, the Advanced Encryption Standard(AES), Prime Number Generation, Fermat Test, Miller Rabin Test.

Unit III. (8 Lectures)

Public Key Cryptography, *RSA Cryptosystem*, Factoring problem, *Rabin Cryptosystem*, Quadratic Residue Problem, Diffie-Hellman (DH) Key Exchange Protocol, Discrete Logarithm Problem (DLP), *ElGamal Cryptosystem*, Elliptic Curve, Elliptic Curve Cryptosystem (ECC),

Unit IV. (6 Lectures)

Hash and Compression Functions, Security of Hash Functions, Iterated Hash Functions, SHA-1, MD-5, Message Authentication Codes.

Unit V. (6 Lectures)

Digital Signature, RSA Signature, ElGamal Signature, Digital Signature Algorithm (DSA), ECDSA.

Unit VI. (7 Lectures)

Identification and Authentication, Passwords, Challenge-Response Identification, Zero-Knowledge Proofs, The Schnorr Identification Scheme, The Okamoto Identification Scheme, Identity-based Identification Schemes, Shamir Secret Sharing Protocol.

Books and References:

1. J Buchmann, Introduction to Cryptography, Springer (India) 2004
2. D R Stinson, Cryptography: Theory and Practice. CRC Press, 2000.
3. S. Padhye, R A Sahu, V Saraswat, Introduction to Cryptography, CRC Press, 2018
4. B Forouzan, Cryptography and Network security, Tata McGraw Hill, 2011
5. Wenbo Mao, Modern Cryptography: Theory and Practice. Pearson Education, 2004

MA 54305- Symmetry Analysis of Differential Equations,

L	T	P	Credit
3	1	0	4

Unit I: (7 Lecture Hours)

Dimensional Analysis: Application of dimensional analysis to ordinary and partial differential equations. Extended transformations: Extended group transformations for one dependent and one independent variable, Extended infinitesimal transformations for one dependent and one independent variable.

Unit II: (7 Lecture Hours)

Examples of one-parameter Lie groups of transformations, Infinitesimal transformations: First fundamental theorem of Lie, Infinitesimal generators, Invariant functions. Canonical coordinates, Invariant surfaces, Invariant curves, Invariant points.

Unit III: (7 Lecture Hours)

Generalization of dimensional analysis, Invariance of partial differential equations under scaling of variables, Lie Group of Transformations: Groups, Examples of groups, Groups of transformations, One-parameter Lie group of transformations.

Unit IV (7 Lecture Hours)

Extended transformations for one dependent and n independent variables, Multi-parameter Lie groups of transformations; Lie algebras, r-parameter Lie groups of transformations, Lie algebras, Examples of Lie algebras, Solvable Lie algebra.

Unit IV (7 Lecture Hours)

Lie symmetry analysis of Korteweg-de Vries equations, Symmetry reductions and invariant solutions of Korteweg-de Vries equations, Lie symmetry analysis of Gardner equation, Symmetry reductions and invariant solutions of Gardner equation.

Unit IV (7 Lecture Hours)

Lie symmetry analysis of breaking soliton equations, Lie symmetry analysis of Bogoyavlenskii equations, Symmetry reductions and invariant solutions of Bogoyavlenskii equations.

Recommended Books:

1. G. W. Bluman and A. C. Anco, Symmetry and Integration Methods for Differential Equations, Appl. Math. Sci., 154, Springer, New York, 2002.
2. G. W. Bluman and S. Kumei, Symmetries and Differential Equations, Appl. Math. Sci., Springer-Berlin, 1989.
3. P. J. Olver, Applications of Lie Groups to Differential Equations, Springer-Verlag, New York 1993.
4. L. V. Ovsiannikov, Group Properties of Differential Equations, Novosibirsk, Moscow, 1962.

MA 54306 : Magnetogasdynamics and Hyperbolic Systems

L	T	P	Credit
3	1	0	4

Unit I (7 Lectures)

Nature of Magnetohydrodynamics, Maxwell electromagnetic field equations, Equation of motion of a conducting fluid, MHD approximations, Rate of flow of charge, Simplification of the electromagnetic field equations

Unit II (7 Lectures)

Magnetic Reynolds number and Magnetic field equation, Alfvén's Theorem. Magnetic body force, Magnetohydrostatics, Pinch confinement of a plasma, Equilibrium of sunspots, Magnetohydrodynamic waves,

Unit III (7 Lectures)

More Detailed investigation of Alfvén waves, Reflection and transmission of Alfvén waves at a discontinuity in density. Magnetohydrodynamics shock waves.

Unit (7 Lectures)

Shock wave in conducting gas with finite viscosity and thermal conductivity, MHD effect in shock formation, Laminar flow of a viscous conducting liquid between parallel walls in a transverse magnetic field

Unit V (8 Lectures)

Waves and First Order Equations: Continuous solutions, Kinematic waves, Shock waves, Shock structure, Weak shock waves, Breaking condition, Note on conservation laws and weak solutions, More general Quasi-linear equations- Damped waves, Waves produced by a moving source, Nonlinear first order equations.

Unit (8 Lectures)

Hyperbolic Systems: Characteristic and classification, Example of classification, Riemann Invariants, Stepwise integration using characteristics, Discontinuous derivatives, Expansion near a

wave front, An example from river flow, Shock waves, System with more than two independent variables, Second order equation.

Texts/Reference Books:

1. Alan Jeffery: Magneto hydrodynamics, Oliver and Boyd Ltd, Edinburgh, 1966
2. F. Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
3. G.B. Whitham: Linear and Nonlinear waves, Jhon Wiley and Sons, INC New York, 1973

MA 54307: Graph Theory

L	T	P	Credit
3	1	0	4

UNIT I: (6 Lectures)

Fundamental concepts of graphs and digraphs, Tree and their properties, Binary tree, Spanning tree, connectivity, optimal graph traversals.

UNIT II: (7 Lectures)

Planarity of Graphs, Drawing graphs and maps, **Graph colouring-** colouring maps and planar graphs, colouring vertices, colouring edges, list colouring,

UNIT III: (7 Lectures)

Perfect graphs, Extremal graph theory-subgraphs, minors, hadwiger'sconjecture, szemerédi'sregularity lemma

UNIT IV: (7 Lectures)

Special digraph models, network flow and applications , Infinite graphs, homogeneous and universal graphs, connectivity and matching, The topological end space.

UNIT V: (7 Lectures)

Algebraic specifications of Graphs, Non planar layouts, Band width, Searching, Dynamic Graph algorithm

Unit VI. (6 Lectures)

Algorithm on recursively constructed graphs, Maximum flows, minimum cost flow matching and assignment network design model.

Text/ Reference Books:

- Introduction to Enumerate Combinatorics, M. Bona, Rudin Series
- Introduction to Graph Theory, D.B.West Prentice-Hall of India/Pearson
- Graph Theory and Applications J.A. Bondy and U.S.R.Murty: (Freely downloadable from Bondy's website; Google-Bondy)
- Graph Theory: Modeling, Applications, and Algorithms, by Geir Agnarsson and Raymond Greenlaw
- Introductory Combinatorics by R A Brualdi, Pearson Education

MA 54308 : Functional Analysis

L	T	P	Credit
3	1	0	4

Unit-I (7 Lectures)

Baires Category theorem: Complete Metric Space, Category, Baires Category Theorem, Fixed point theorem: Contraction Mapping, Banach Fixed Point Theorem.

Unit-II (7 Lectures)

Normed Linear Spaces: Linear Metric Space, Normed Linear Space, Basic Theorems on Normed Linear Spaces.

Unit-III (7 Lectures)

Banach Space, Hahn-Banach theorem, Open mapping and Closed graph theorems, Uniform boundedness principle.

Unit-IV (6 Lectures)

Operator Theory: Linear Operator, Self Adjoint Operators, Compact Operator, Normal and unitary operators.

Unit-V (7 Lectures)

Hilbert Spaces: Inner Product Spaces, Orthonormal Sets, Riesz Representation Theorem, Bounded Linear Operator on Hilbert Spaces.

Unit-VI (6 Lectures)

Banach Algebras: Normed Algebra, Spectrum, Self adjoint, normal and unitary operators; Commutative Banach Algebra.

Text/References:

1. G.F. Simmons: Topology and Modern Analysis
2. B. V. Limaye: Functional Analysis
3. K. Yoshida : Functional Analysis , Springer
4. S. Nanda and B Choudhari, Functional Analysis With Application, New Age International Ltd
5. S C Bose, Introduction to Functional Analysis, Macmillan India Ltd.

MA 54309: Financial Mathematics

L	T	P	Credit
3	1	0	4

Unit I: (4 Lectures)

Review Of probability, finite probability space.

Unit II: (6 Lectures)

Derivatives security, interest rates, other financial instruments, Arbitrage and pricing, risk less issue, yield curves, mean terms matching and immunization, interest rate models.

Unit III: (6 Lectures)

Dependent annual rates of return, random walk and Markov process, stochastic calculus,

Unit IV: (5 Lectures)

option pricing, portfolio optimization, Fokker-plank equation, distribution and green functions,

Unit V: (6 Lectures)

Feynman-kac formula options, dividends revisited. Exoticoptions,

Unit VI: (6 Lectures)

bond pricing, transaction costs, time series ,stochastic processes, Neural nets.

Textbooks/References:

1. Financial mathematics-Richard Brass, Springer(2003)
2. Mathematics of financial derivatives- Wilmott & Howison, Springer(2005)
3. Hand book of stochastic methods-Gardiner, Wiely (2000)
4. The Mathematics of Financial Derivatives: A Student Introduction, by Wilmott, Dewynne, and Howison (Cambridge University Press, 1995)
5. Futures, and Other Derivatives, 5th ed, by Hull (Prentice Hall, 200

MA 54310: Special Functions

L	T	P	Credit
3	1	0	4

Unit I: (6 Lectures)

Differential equations with three regular singularities hypergeometric differential equations Gauss hypergeometric functions elementary properties-contiguous relations, integral representation linear and quadratic transformation and summation formulae Analytic continuation. Barnes' contour integral representation.

Unit II: (6 Lectures)

Confluent hypergeometric function and its elementary properties Generalized hypergeometric function pFq and its elementary properties linear and quadratic transformations, summation formulae. Hermite, Laguerre, Jacobi Ultraspherical polynomials , Definition and elementary properties

Unit III: (7 Lectures)

Asymptotic Series : Definition, elementary properties-term by term differentiation, integration, theorem of uniqueness, Watson's lemma, Asymptotic expansions of $1F1$, $2F1$.

Unit IV: (6 Lectures)

Orthogonal polynomials : Definition their zeros expansion in term of orthogonal polynomials, three term recurrence relation, Christofel-Darboux formula, Bessel's inequality.

Unit V: (6 Lectures)

Characterization – Appell, Sheffes and o-type characterization of polynomial sets.

Weirstrass' Elliptic Functions : Jacobi's first and second question, irreducible zeros and poles of elliptic functions.Weierstrass' functions $p(z)$, (z) and $o(z)$, pseudo periodicity of (z) and $o(z)$.

Unit VI: (6 Lectures)

Differential equation, addition theorem for $p(z)$. Algebraic relation between two elliptic functions, expansion for elliptic functions in term of $o(z)$, (z) and $p(z)$. Evaluation of elliptic integrals.

References/Books

1. Theory of complex variables E. T. Copsom Wile limited 1997.
2. Resonance of Ramanujan Mathematics volume I, II, III, R. P. Agrawal Narosa publishing house 1996.
3. Theory of Hypergeometric functions and applications, Gasper and Rehman M. allied publishers 2000.

MA 54311: Wavelet Analysis

L	T	P	Credit
3	1	0	4

Unit I : (6 Lectures)

The Scalable Structure of Information: The New Mathematical Engineering, Good Approximations,

Unit II: (6 Lectures)

Wavelets: A Positional Notation for Functions, Review of linear algebra: Vector spaces, basis, dimension, linear transformations, matrices and digitalization, inner products and orthonormal bases.

Unit III: (7 Lectures)

Wavelet Theory: Algebra and Geometry of Wavelet: Matrices, One-Dimensional Wavelet Systems, Examples of One-Dimensional Wavelet Systems,

Unit IV: (6 Lectures)

Higher Dimensional, Wavelet Systems. Wavelets on Z , Z_n , $l^2(Z)$,

Unit V: (6 Lectures)

Fourier series, transform and convolution on l^2 .

Unit VI: (6 Lectures) Wavelet Approximation and Algorithms: The Mallat Algorithm.

Texts/References:

1. George J. Klir; Wavelet Analysis and its Applications.
2. Y. Y. Tang; Wavelet Analysis and its Applications.

MA 54312: Image Processing

L	T	P	Credit
3	0	2	4

Unit I. (7 Lectures)

Catalog Description: Discrete time signals, and systems. Sampling, reconstruction, and quantization.

Unit II. (7 Lectures)

Digital image representation. Digital image fundamentals. Image transforms. Image enhancement.

Unit III. (6 Lectures)

Image restoration. Image segmentation and description. The digitized image and its properties.

Unit IV. (7 Lectures)

Data structures for image analysis Image pre-processing , Segmentation, Shape representation and description.

Unit V. (7 Lectures)

Mathematical morphology, Linear discrete image transforms.

Unit VI. (7 Lectures)

Image data compression , Texture.

Text Book:

1. M. Sonka, V. Hlavac, R. Boyle, "Image Processing, Analysis, and Machine Vision".
Texts/References:
2. R. C. Gonzalez, R. E. Woods, "Digital Image Processing", Addison-Wesley.
3. A. K. Jain, "Fundamentals of digital Image Processing", Prentice-Hall.
4. K. R. Castleman, "Digital Image Processing".
5. M. Seul, "Practical Algorithms for Image Analysis: Descriptions, Examples, and Code".