DEPARTMENT OF MATHEMATICS

OSMANIA UNIVERSITY

M.Sc. Mathematics Syllabus

Semester – III & IV

(Choice Based Credit System)
(w.e.f. the academic year 2024-2025)

M.Sc. Mathematics Course Structure

(Choice Based Credit System)
(w.e.f. the academic year 2024-2025)

SEMESTER – III

Subjects	Code	Paper Title	THPW	T	Credits	IA	ESE	Total
Core	M 301	**Functional Analysis**	4	1	5	30	70	100
Core	M 302	**Elementary Number Theory**	4	1	5	30	70	100
Elective	M 303(A)	**Mathematical Statistics**	4	1	5	30	70	100
	M 303(B)	**Discrete Mathematics**						
	M 303(C)	**Mechanics**						
Elective	M 304(A)	**Operations Research**	4	1	5	30	70	100
	M 304(B)	**Graph Theory**						
	M 304(C)	**Finite Difference Methods**						
			16	4	20			400

SEMESTER – IV

Subjects	Code	Paper Title	THPW	T	Credits	IA	ESE	Total
Core	M 401	**Integral Equations and Calculus of Variations**	4	1	5	30	70	100
Core	M 402	**Partial Differential Equations**	4	1	5	30	70	100
Elective	M 403(A)	**Elementary Operator Theory**	4	1	5	30	70	100
	M 403(B)	**Analytical Number Theory**						
	M 403(C)	**Numerical Analysis**						
	M 403(D)	**Cryptography**						
Project	M 404	**Project**	5		5			100
			17	3	20			400

T – Tutorial class: Each batch consists of 20 students and will be allotted to a teacher (Demonstrating the theory through a numerical example and practicing through mathematical software)
THPW = Teaching Hours Per Week.
IA = Internal Assessment (IA Test 20 Marks + Assignment 10 Marks).
ESE = End-Semester Examination.
End-Semester Examination Duration - 3 Hrs.

M. Sc. Mathematics

M 301 **Semester-III**

Paper-I: Functional Analysis

Unit- I

Normed Spaces - Banach Spaces - Further properties of normed spaces - Finite dimensional normed spaces and sub spaces - compactness and finite dimension - linear operators - Bounded and continuous linear operators. [2.2, 2.3, 2.4, 2.5, 2.6 *and* 2.7].

Unit- II

Linear functional – normed spaces of operators – Dual space – Inner product space-Hilbert Space – Further Properties of Inner product Spaces – Orthogonal complements and direct sums – Orthogonal sets and sequences. [2.8, 2.10, 3.1, 3.2, 3.3 *and* 3.4]

Unit- III

Series related to Orthonormal Sequences and sets – Total Orthonormal sets and sequences – Representation of Functions on Hilbert spaces – Hilbert – Adjoint Operator-Self-Adjoint,unitary and normal operators. [3.5, 3.6, 3.8, 3.9 *and* 3.10]

Unit- IV

Hahn-Banach Theorem - Hahn-Banach Theorem for Complex Vector Spaces and Normed Spaces –Adjoint Operator- Reflexive Spaces- Category Theorem - Uniform Boundedness Theorem - Open Mapping Theorem - Closed Linear Operators – Closed Graph Theorem.
[4.2, 4.3, 4.5, 4.6, 4.7, 4.12 *and* 4.13]

Text Book:

- **Introductory Functional Analysis with Applications** by Erwin Kreyszig, John Wiley and sons, NewYork.

References:

1. **Functional Analysis** by B.V.Limaye 2nd Edition..
2. **Introduction to Topology and Modern Analysis** by G.F.Sinmmons. Mc.Graw-Hill International Edition.

M. Sc. Mathematics

M 302 **Semester-III**

Paper - II: Elementary Number Theory

Unit- I

The Fundamental Theorem of Arithmetic: Divisibility- GCD- Prime numbers, Fundamental theorem of arithmetic- the series of reciprocal of the primes- The Euclidean algorithm.
(Page No. 13 - 23)

Unit- II

Arithmetical Functions and Dirichlet Multiplication: The functions $\phi(n)$, $\mu(n)$ and a relation connecting them- Product formula for $\phi(n)$ - Dirichlet product- Dirichlet inverse and Mobius inversion formula -The Mangoldt function $\wedge(n)$- Multiplicative functions and Dirichlet multiplication- The inverse of a completely multiplicative function- Liouville's function $\lambda(n)$- The divisor functions $\sigma_\alpha(n)$.
(Page No. 24-39 & 46-51)

Unit- III

Congruences: Properties of congruences- Residue classes and complete residue system- Linear congruences-Reduced residue systems and Euler-Fermat theorem- Polynomial congruence modulo p - Lagrange's theorem- Application of Lagrange's theorem- Chinese remainder theorem and its applications.
(Page No. 106-120 & 126-128)

Unit- IV

Quadratic Residues and The Quadratic Reciprocity Law: Quadratic residues- Legendre's symbol and its properties- Evaluation of $(-1|p)$ and $(2|p)$ - Gauss' lemma- The quadratic reciprocity law and its applications-The Jacobi symbol.
(Page No. 178-190 & 201-203)

Text Book:

- **Introduction to Analytic Number Theory** by Tom M. Apostol. *Narosa publishing house*

References:

1. **Number Theory** by Joseph H. Silverman.
2. **Theory of Numbers** by K.Ramchandra.
3. **Elementary Number Theory** by James K Strayer.
4. **Elementary Number Theory** by James Tattusall.

M. Sc. Mathematics

M/AM 303(A) **Semester-III**

Paper-III(A): Mathematical Statistics

Unit- I

Probability: Sample space and events of an experiment, Properties of Probability experiments, Equally likely out comes, Conditional probability and independence, Bayes' Theorem. **Discrete Random Variables**: Random variables, Expected value, Properties of expected values, variance of random variables, Properties of variances, Binomial random variables and its Expected value and variance, Hyper-geometric random variables, Poisson random variables.[ch4, 5]

Unit- II

Normal Random Variables: Continuous random variables, Normal random variables, Probabilities associated with a standard Normal random variable, Finding Normal probabilities. Problems on related. **Distributions of Sampling Statistics**: Sample Mean, Central Limit Theorem, Distribution of the sample mean, Sample size needed, Sampling proportions from a finite population; Probabilities associated with sample proportions. **Estimation** : Point estimator of a population mean, population proportion, Estimating a population variance,.(Ch.6, 7, 8)

Unit- III

Testing Statistical Hypotheses: Hypothesis tests and Significance levels, Tests concerning the mean of a Normal population: Case of known variance, One-sided tests; the t-test for the mean of a Normal population: Case of unknown variance, Hypothesis Tests Concerning Population Proportions. Two-Sided Tests of p. **Hypothesis Tests Concerning Two Populations**:Testing equality of means of two Normal populations: Case of known and unknown variances and large Sample sizes, Testing equality of means: Small - sample tests when the unknown population variances are equal, Paired-sample t-test, Testing equality of population proportions. Problems on related.(Ch.9, 10)

Unit- IV

Chi-Squared Goodness of Fit Tests: Chi-Squared Goodness of fit Tests, Testing for independence in Populations classified according to two characteristics, Testing for independence in contingency tables with fixed marginal totals. Analysis of Variance: Introduction,One-factor and two factor Analysis of Variances, Parameter estimation, Degrees of freedom, Testing hypotheses.(ch11, 12)

Text Book:

- **Introductory Statistics** by Sheldon M.Ross(2010), Academic Press, Elsevier, 3rd Edition.(chapters 4 to 12).

References:

1. **Introduction to Probability Models** by Sheldon M.Ross(2010), Academic Press, Elsevier, 10th Edition. (chapters 4 to 13).

M/AM 303(B) **Semester-III**

Paper-III(B) : Discrete Mathematics

Unit- I

Propositional logic, Propositional Equivalences, Predicates and Quantifiers, Rules of Inference– Valid Arguments in Propositional Logic.Rules of Inference for Quantified Statements.Introduction to Proofs – Direct Proofs, Proofs by Contraposition, Proofs by Contradiction.NormalForms–Disjunctive Normal Form, Conjunctive Normal Forms, Principal Disjunctive Normal Form, Principal Conjunctive Normal Form. Boolean Algebra – Boolean Functions and Boolean Expressions, Identities of Boolean Algebra, Representing Boolean Functions. Logic Gates, Minimization of Circuits–K-maps. (1.1 *to* 1.3, 1.5 *to* 1.7, 10.1 *to* 10.4 *of* [1])

Unit- II

Elementary Combinatorics – Basics of Counting, Two Basic Counting Principles, Indirect ounting.Combinations and Permutations – Enumeration of Combinations and Permutations, Enumerating Combinations and Permutations with Repetitions, Enumerating Permutations with Constrained Repetitions. Binomial Coefficients – Pascal's Identity, Pascal's Triangle. Multinominal Theorem, The Principle of Inclusion–Exclusion and its Applications. (2.1 *to* 2.8 *of* [2])

Unit- III

Recurrence Relations – Generating Functions of Sequences, Generating Function Models, Calculating Coefficients of Generating Functions. Solutions of Recurrence Relations, the Fibonacci Relation. Solving Recurrence Relations by Substitution and by Generating Functions, Method of Characteristic Roots. Solution of Inhomogeneous Linear Recurrence Relations, the Method of Undetermined Coefficients: Solving Nonlinear Recurrence Relations. (3.1 *to* 3.6 *of* [2])

Unit- IV

Graphs – Graphs and Graph Models, Graph Terminology and Special Types of Graphs, The Hand shaking Theorem, Representing Graphs and Graph Isomorphism. Connectivity, Euler and Hamiltonian Paths and Circuits,Shortest Path Problems, Dijkstra's Algorithm,Planar Graphs,Euler formula. Trees – Introduction to Trees, Tree Traversal. Spanning Trees, DFS, BFS Algorithms, Minimum Spanning Trees. Prim's and Kruskal's Algorithms. (8.1 *to* 8.7, 9.1, 9.3, 9.5 *of* [1])

Text Book:

- **Discrete Mathematics and its Applications** by Kenneth HRosen, Seventh Edition, Mc GrawHill Education (India)Private Ltd, New Delhi.
- **Discrete Mathematics for Computer Scientists** & **Mathematicians** by JoeL.Mott, Abraham Kandel and Theodore P. Baker, Second Edition, Prentice Hall of India, Private Ltd, NewDelhi.

References:

1. **Elements of Discrete Mathematics** by C L Liu and D P Mohapatra, Third Edition, The McGraw-Hill Companies.
2. **Discrete and Combinatorial Mathematics** by Ralph P. Grimaldi and B. V. Ramana, 5th Edition,PEARSON education.

M. Sc. Mathematics

M 303(C) **Semester-III**

Paper-III(C): Mechanics

Unit- I

Dynamics of systems of Particles: Introduction - Centre of Mass and Linear Momentum of a system - Angular momentum and Kinetic Energy of a system, Centre of mass of Rigid body, symmetry considerations(Solid hemisphere,Hemispherical shell,Semicircle, Semicircular lamina), Rotation of a Rigid body about a fixed axis, Moment of Inertia, calculation of moment of Inertia, Perpendicular axis theorem for plane lamina,Parallel axis theorem for any rigid body, Radius of Gyration. (7.1, 7.2, 8.1, 8.2, 8.3 of [1])

Unit- II

Physical pendulum - Angular momentum Laminar Motion of a Rigid body in Laminar motion. Body rolling down an inclined plane. Motion of Rigid bodies in three dimension – Rotation of rigid body about an arbitrary axis,moments and products of inertia. (8.4, 8.5, 8.6, 9.1 of [1])

Unit- III

Angular momentum vector, Rotational kinetic energy of a rigid body, principles axes of a rigid body, Determination of the other two principal axes when one is known, Determining principal axes by diagonalizing the moment of inertia matrix, Dynamics of a particle in a rotating coordinate system. Euler's equation of motion of a Rigid body , Free rotation of a rigid body, Free rotation of a rigid body. (9.2, 5.2, 9.3, 9.4 of [1])

Unit- IV

Hamilton's variational principle-An example,Generalized Coordinates, Lagrange's Equations of motion for conservative systems, applications of Lagrange's equations, Generalized momenta,Ignorable coordinates, D'Alembert Principle-Generalised forces, Hamilton function - Hamilton's Equations. (10.1, 10.2, 10.4, 10.5, 10.6, 10.8, 10.9 of [1])

Text Book:

- **Analytical Mechanics** by G.R.Fowles G.L Cassiday, Cengage Learning , 7th edition.

References:

1. **Classical Mechanics** by Herbert Goldstein, Charles P.Poole and JhonSafko, Pearson pub.
2. **Principles Of Mechanics** by Synge J. L. and B.A. Griffith, McGraw Hill, 3rd edition.

M. Sc. Mathematics

M/AM/MCS 304(A) **Semester-III**

Paper-IV(A): Operations Research

Unit- I

Formulation of Linear Programming problems, Graphical solution of Linear Programming problem,Convex set,General formulation of Linear Programming problems, Standard and Matrix forms of Linear Programming problems,Simplex Method, Two-phase method, Big-M method, Method to resolve degeneracy in Linear Programming problem, Alternative optimal solutions.

Unit- II

Solution of simultaneous equations by Simplex Method, Inverse of a Matrix by Simplex Method,Revised Simplex Method,Concept of Duality in Linear Programming, Comparison of solutions of the Dual and its primal

Unit- III

Mathematical formulation of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, North West corner rule, Lowest cost entry method, Vogel's approximation method, Optimality test, Method of finding optimal solution, Degeneracy in transportation problem, Method to resolve degeneracy, Unbalanced transportation problem. Mathematical formulation of Assignment problem, Reduction theorem, Hungarian Assignment Method, Travelling salesman problem, Formulation of Travelling Salesman problem as an Assignment problem, Solution procedure

Unit- IV

Concept of Dynamic programming, Bellman's principle of optimality, characteristics of Dynamic programming problem,Backward and Forward recursive approach,Minimum path problem,Single Additive constraint and Multiplicatively separable return, Single Additive constraint and Additively separable return, Single Multiplicatively constraint and Additively separable return.

Text Book:

- **Operations Research** by S.D.Sharma, 18th Revised Edition 2017, KedarNath Ram Nath Publications.

References:

1. **Operations Research – An Introduction** by Hamdy A. Taha, 10th Edition.
2. **Linear Programming** by G.Hadley.

M. Sc. Mathematics

M 304(B) **Semester-III**

Paper-IV(B): Graph Theory

Unit- I

Basics of Graph Theory: Graphs, isomorphism, subgraphs, matrix representations, degree, operations on graphs, degree sequences.

Connected graphs and shortest paths: Walks, trails, paths, connected graphs, distance, cut-vertices, cut edges, blocks,connectivity, weighted graphs, shortest path algorithms.

Unit- II

Trees: Characterizations, number of trees, minimums panning trees.

Special classes of graphs: Bipartite graphs, line graphs, chordal graphs.

Eulerian graphs: Characterization, Fleury's algorithm, chinese - postman - problem.

Hamilton graphs: Necessary conditions and sufficient conditions

Unit- III

Independent sets, coverings, matchings: Basic equations, matchings in bipartite graphs, perfect matchings, greedy and approximation algorithms.

Vertex colorings: Chromatic number and cliques, greedy coloring algorithm, coloring of chordal graphs, Brook's theorem.

Edge colorings: Gupta - Vizing theorem, Class-1 graphs and class-2 graphs, equitable edge - coloring.

Unit- IV

Planar graphs: Basic concepts, Eulers formula, polyhedrons and planar graphs, characterizations, planarity testing, 5-color-theorem.

Directed graphs: Out-degree, in- degree, connectivity, orientation, Euleri and irected graphs, Hamiltondi - rected graphs, tournaments.

Text Book:

- **Graph Theory with Applications** by J.A.Bondy and U.S.R.Murty. (Freely downloadable from Bondy's web site; Google - Bondy).
- **Introduction to Graph Theory** by D.B. West, Prentice-Hall of India/Pearson, 2009 (latest impression).

References:

1. **Graph Theory** by J.A.Bondy and U.S.R.Murty, Springer, 2008.
2. **Graph Theory** by R.Diestel, Springer(low price edition), 2000.

M. Sc. Mathematics

M 304(C) **Semester-III**

Paper-IV(C): Finite Difference Methods

Unit- I

Partial Differential Equations: Introduction - Classification of Second order Partial Differential Equations PDE's - Difference Methods - Routh Hurwitz criterion - Domain of Dependence of Hyperbolic Equations. (1.1 to 1.4)

Unit- II

Difference Methods for Parabolic Partial Differential Equations : Introduction – One Space Dimension - Two Space Dimensions - Spherical and Cylindrical Coordinate System. (2.1 to 2.3, 2.5, 2.6).

Unit- III

Difference Methods for Hyperbolic Partial Differential Equations: Introduction - One Space Dimensions - Two Space Dimensions - System of First order equations.(3.1 to 3.5).

Unit- IV

Numerical Methods for Elliptic Partial Differential Equations: Introduction - Difference Methods for linear boundary value problems - General second order linear equation - Equation in polar coordinates.(4.1 to 4.5).

Text Book:

- **Computational Methods for Partial Differential Equations** by M.K.Jain, S.R.K.Iyengar, R.K.Jain, Wiley Eastern Limited, New Age International(P) Limited, New Delhi.

M. Sc. Mathematics

M/AM/MCS 401 **Semester-IV**

Paper-I: Integral Equations and Calculus of Variations

Unit- I

Volterra Integral Equations: Basic concepts - Relationship between Linear differential equations and Volterra Integral equations - Resolvent Kernel of Volterra Integral equation. Differentiation of some resolvent kernels - Solution of Integral equation by Resolvent Kernel - The method of successive approximations - Convolution type equations - Solution of Integro-differential equations with the aid of the Laplace Transformation – Volterra integral equation of the first kind-Euler integrals-Abel's problem-Abel's integral equation and its generalizations.

Unit- II

Fredholm Integral Equations : Fredholm integral equations of the second kind – Fundamentals – The Method of Fredholm Determinants - Iterated Kernels constructing the Resolvent Kernel with the aid of Iterated Kernels - Integral equations with Degenerated Kernels. Hammerstein type equation – Characteristic numbers and Eigen function and its properties.

Green's function :Construction of Green's function for ordinary differential equations-Special case of Green's function –Using Green's function in the solution of boundary value problem.

CALCULS OF VARIATIONS:

Unit- III

Introduction – The Method of Variations in Problems with fixed Boundaries: Definitions of Functionals –Variation and Its properties - Euler's'equation- Fundamental Lemma of Calculus of Variation – The problem of minimum surface of revolution - Minimum Energy Problem Brachistochrone Problem - Variational problems involving Several functions - Functional dependent on higher order derivatives - Euler Poisson equation.

Unit- IV

Functional dependent on the functions of several independent variables - Euler's equations in two dependent variables – Variational problems in parametric form-Applications of Calculus of Variation-Hamilton's principle - Lagrange's Equation,Hamilton's equations.

Text Book:

- **Problems and Exercises in Integral Equations** by M.KRASNOV, A.KISELEV, G.MAKARENKO, (1971).
- **Integral Equations** by S.Swarup, (2008).
- **Differential Equations and The Calculus of Variations** by L.ELSGOLTS, MIR Publishers, MOSCOW.
- **Analytical Mechanics** by Grant R. Fowles and George L. Cassiday, 7Th Edition.

M. Sc. Mathematics

M 402 **Semester-IV**

Paper-II: Partial Differential Equations

Unit- I

First order Nonlinear Equations, Cauchy's method of Characteristics, compatible systems of first order equations, Charpit's method, Special types of first order equations.

Unit- II

Higher order Linear Partial Differential Equations with constant coefficients, Homogeneous Partial Differential Equations with constant coefficients, Classification of second order Partial Differential Equations, Canonical forms, Canonical form for hyperbolic, parabolic and elliptic equations.

Unit- III

Fourier Transforms : Fourier Integral Representations, Fourier Transforms Pairs, Fourier Transform of Elementary Functions, Properties of Fourier Transform, Convolution theorem, Parseval's Relation,Transform of Dirac Delta Function, Finite Fourier Transforms.

Unit- IV

Solution of diffusion, wave and Laplace equations by using Fourier transforms and Separation of Variables Methods, D'Alembert's solution of wave equation, Dirichlet problem and Neumann problem.

Text Book:

- **Introdction to Partial Differential Equations** by K. Shankar Rao, PHI, Third Edition.

References:

1. **Elements of Partial Differential Equations** by Ian Sneddon, Mc.Graw-Hill International Edition.
2. **Partial Differential Equations** by Lawrence C. Evans, American Mathematical Society.

M. Sc. Mathematics

M 403(A) **Semester-IV**

Paper-III(A): Elementary Operator Theory

Unit- I

Spectral theory in finite dimensional normed spaces - Basic concepts of spectrum - Spectral properties of bounded linear operators –Further properties of resolvent and spectrum. (Sections7.1, 7.2, 7.3 and 7.4 of [1]).

Unit- II

Compact linear operators on normed spaces - Further properties of compact linear operators - Spectral properties of compact linear operators on normed spaces-Operator equations involving compact linear operators. (Sections 8.1, 8.2, 8.3 and 8.5 of [1]).

Unit- III

Spectral properties of bounded self adjoint linear operators - Further spectral properties of bounded linear operators – Positive operators –Square root of a positive operator. (Sections 9.1, 9.2, 9.3 and 9.4 of [1])

Unit- IV

Projection operators - Properties of projection operators - Spectral family - Spectral family of a bounded self adjoint linear operator. (Sections 9.5, 9.6, 9.7 and 9.8 of [1])

Text Book:

- **Introductory Functional Analysis** by E.Kreyszig, John Wiley and Sons, New York, 1978.

References:

1. **Elements of Functional Analysis** by Brown and Page, D.V.N. Comp.
2. **Functional Analysis** by B.V. Limaye, Wiley Eastern Limited,(2nd Edition).
3. **A Hilbert Space Problem Book** by P.R.Halmos, D.VanNostrand Company,Inc.1967.

M. Sc. Mathematics

M 403(B) **Semester-IV**

Paper-III(B): Analytical Number Theory

Unit- I

Averages of arithmetical function : The big oh notation- Asymptotic equality of functions- Euler summation formula- Some asymptotic formulas- The average order of $d(n)$- The average order of the divisor functions $\sigma(n)$ – The average order of $\phi(n)$ - An application to the distribution of lattice points visibletr on a the origin-The average order of $\mu(n)$ and $\Lambda(n)$ - The partial sums of dirichlet product- Applications to $\mu(n)$ and $\Lambda(n)$ - Another identity for the partial sums of a dirichlet product.(Sections 3.1 to 3.12).

Unit- II

Some elementary theorems on the distribution of prime numbers- Introduction chebyshev's functions - $\chi(x)$ and $\theta(x)$ - Relation connecting $\theta(n)$ and $\pi(n)$ - Some equivalent forms of the prime number theorem - Inequalities for $\pi(n)$ and p_n. (Sections 4.1 to 4.5)

Unit- III

Shapiro's Tauberian theorem – Applications of shapiro's theorem Anasymptotic formula for the partial sums $1/p$ - The partial sums of the mobins function - Selberg Asymptotic formula.(Sections 4.6 to 4.11 except 4.10)

Unit- IV

Finite Abelian groups and their character: Construction of sub groups - Characters of finite abelian group-The character group- The orthogonality relations for characters Dirichlet characters- Sums involving dirichelt characters the non vanishing of $L(1, \chi)$ for real non principal χ. (Sections 6.4 to 6.10)

Text Book:

- **An Introduction to Analytic Number Theory** by Tom M.Apostol - Springer.

M.Sc. Mathematics

M 403(C) **Semester-IV**

Paper-III(C): Numerical Analysis

Unit- I

Transcendental and Polynomial Equations: Introduction, Bisection Method - Iteration Methods Based on First Degree Equation: Secant Method, RegulaFalsi Method, Newton-Raphson Method - Iteration Methods Based on Second Degree Equation: Muller's Method, Chebyshev Method, Multipoint Iteration Methods, Rate of convergence - Iteration Methods.

Unit- II

System of Linear Algebraic Equations: Introduction - Direct Methods: Gauss Elimination Method, Gauss Jordan Elimination Method, Triangularization Method, Cholesky Method, Partition Method - Iteration Methods: Jacobi Iteration Method, Gauss Seidel Iteration Method, SOR Method, Convergence Analysis for iterative Methods.

Unit- III

Interpolation and Approximation: Interpolation: Introduction - Lagrange and Newton Interpolations, Finite Difference Operators - Interpolating Polynomials using Finite Differences - Hermite Interpolations, Piecewise and Spline Interpolations. Approximation: Least Squares Approximation.
Differentiation : Methods based on interpolation, Methods based on finite differences.

Unit- IV

Numerical Integration: Methods Based on Interpolation: Newton- Cotes Methods - Methods Based on Undetermined Coefficients: Guass- Legendre Integration Methods - Composite Integration Methods.
Numerical Solution of ODEs: Introduction - Numerical Methods: Euler Methods-Mid point Method Single Step Methods: Taylor series method, Runge-Kutta Method (2nd and 4th orders). Multistep Methods: Adams Bashforth Method - Adams Moulton Method, Milne-Simpson Method - Predictor Corrector Methods.

Text Book:

- **Numerical Methods for Scientific and Engineering computation** by M.K. Jain, S.R.K. Iyengar, R.K. Jain, 7th Edition, *New Age International Publishers,2019.*

M. Sc. Mathematics

M 403(D) **Semester-IV**

Paper-III(D): Cryptography

Unit- I

Simple substitution ciphers; Divisibility and greatest common divisors Modular arithmetic; Prime numbers, unique factorisation, and finite fields; Powers and primitive roots in finite fields; Cryptography before the computer age; Symmetric and asymmetric ciphers.

Unit- II

The birth of public key cryptography, The discrete logarithm problem Diffie – Hell mankey exchange, The ElGamal public key crypto system, An overview of the theory of groups, How hard is the discrete logarithm problem?, A collision algorithm for the DLP.

Unit- III

The Chinese remainder theorem, The Pohlig-Hellman algorithm, Rings, quotients, polynomials, and finite fields, Euler's formula and roots modulo pq, Primality testing.

Unit- IV

Elliptic curves, Elliptic curves over finite fields, The elliptic curve discrete logarithm problem, Elliptic curve cryptography.

Text Book:

- **Mathematical Cryptography** by Jeffrey Hoffstein, JillPipher, JosephH.Silverman.

References:

1. **Fundamental Principles and Applications** by Everyday Cryptography, Keith Martin.
2. **Cryptography: An Introduction** by N.P.Smart.

M. Sc. Mathematics

M 404 **Semester-IV**

PROJECT

DEPARTMENT OF MATHEMATICS

OSMANIA UNIVERSITY

M.Sc. Applied Mathematics Syllabus

Semester – III & IV

(Choice Based Credit System)
(w.e.f. the academic year 2024-2025)

M.Sc. Applied Mathematics Course Structure

(Choice Based Credit System)
(w.e.f. the academic year 2024-2025)

SEMESTER – III

Subjects	Code	Paper Title	THPW	T	Credits	IA	ESE	Total
Core	AM 301	**Viscous Flows**	4	1	5	30	70	100
Core	AM 302	**Linear Algebra**	4	1	5	30	70	100
Elective	AM 303(A)	**Mathematical Statistics**	4	1	5	30	70	100
	AM 303(B)	**Discrete Mathematics**						
	AM 303(C)	**Compressible Flows**						
Elective	AM 304(A)	**Operations Research**	4	1	5	30	70	100
	AM 304(B)	**Topology**						
	AM 304(C)	**Bio-Fluid Mechanics**						
			16	4	20			400

SEMESTER – IV

Subjects	Code	Paper Title	THPW	T	Credits	IA	ESE	Total
Core	AM 401	**Integral Equations and Calculus of Variations**	4	1	5	30	70	100
Core	AM 402	**Finite Difference Methods**	4	1	5	30	70	100
Elective	AM 403(A)	**Mechanics**	4	1	5	30	70	100
	AM 403(B)	**Functional Analysis**						
	AM 403(C)	**Finite Element Methods**						
	AM 403(D)	**Cryptography**						
Project	AM 404	**Project**	5		5			100
			17	3	20			400

T – Tutorial class: Each batch consists of 20 students and will be allotted to a teacher (Demonstrating the theory through a numerical example and practicing through mathematical software)
THPW = Teaching Hours Per Week.
IA = Internal Assessment (IA Test 20 Marks + Assignment 10 Marks).
ESE = End-Semester Examination.
End-Semester Examination Duration - 3 Hrs.

M. Sc. Applied Mathematics

AM 301 **Semester-III**

Paper-I: Viscous Flows

Unit- I

Viscosity - Body forces, Surface forces - Stress components in a Real fluid – Relations between Cartesian components of Stress – Translational Motion of fluid element – The rate of Strain Quadric and Principal Stresses – Properties of the rate of Strain Quadric – Stress analysis in fluid motion – Relations between Stress and rate of Strain – The coefficient of Viscosity and Laminar flow – The Navier - Stokes equations of Motion of a viscous fluid.

Unit- II

Dynamic Similarity and Inspection and Dimensionless Analysis – Dimensions and Unit systems - Dimensional homogeneity - Dimensional Matrix – Similitude: - Dynamical Similarity - Inspection Analysis of visocus fluid flow - Reynold's principle of similarity - Significance of Reynold's number - Non-dimensional parameters: Signification of common Non-dimensional parameters – Non - dimensionalization of the Governing Equations - Dimensionless Coefficients: Local skin-friction coefficient - Lift and drag coefficient - Nusselt number - Shrewood number. **Dimensional Analysis**: Techniques of Dimensional Analysis - Rayleigh's technique - Buckingham π- theorem - Applications of π-theorem.

Unit- III

Exact solution of the Navier-Stokes equations: Steady motion between two parallel plates – Plane Couette flow – Fully developed Plane Poiseuille flow –Plane Poiseuille flow with slip – Plane Couette-Poiseuille flow - Poiseuille flow between inclined plates - Couette flows between two parallel plates – Flow through a circular pipe (The Hagen Poiseuille flow) - Uniqueness Theorem - Steady motion in Tubes of uniform cross section of Elliptical and Equilateral triangle – Unsteady flow over a flat plate.

Unit- IV

Boundary Layer Theory – Boundary layer approximation – Separation of Boundary layer Thickness - Different measures of boundary layer thickness - Displacement thickness – Momentum thickness-Energy thickness. Boundary Layer equations in two dimensions- Boundary layer on a flat plate (Blasius Solution) – Falkner-Skan Solution of the Laminar Boundary layer Equations - Approximate solutions of Boundary Layer Equations - Von Karman's Integral relation - Von Karman Integral relation by momentum law.

Text Book:

1. FRANK CHORLTON, **Textbook of Fluid Dynamics** , CBS-Publishers, New Delhi, India.
2. J.L.BANSAL, **Viscous Fluid Dynamics**, Oxford & IBH Publishers Co.Ltd.,New Delhi
3. TASOS C. PAPANASTASIOU, GEORGIOS C. GEORGIOU, ANDREAS N. ALEXANDROU; **Viscous Fluid Flow**, CRC Pub., New Delhi.
4. M.D.RAISINGHANIA, **Fluid Dynamics**, S.Chand & Company, NewDelhi.

M. Sc. Applied Mathematics

AM 302 **Semester-III**

Paper-II: Linear Algebra

Unit- I

Elementary Canonical forms - Introduction,Characteristic Values,Annihilating Polynomials, Invariant Sub-spaces, Simultaneous Triangulation and Simultaneous Diagonalization (Ch6, Sec6.1 - 6.5).

Unit- II

Direct sum Decomposition, Invariant Direct sums, The Primary Decomposition Theorem (Ch6, Sec 6.6 - 6.8). The Rational and Jordan Forms: Cyclic Subspaces and Annihilators (Ch7, Sec 7.1)

Unit- III

Cyclic Decompositions and the Rational Form, The Jordan Form, Computation of Invariant Factors, Semi Simple Operators (Ch7, Sec 7.2 - 7.5)

Unit- IV

Bilinear Forms: Bilinear Forms, Symmetric Bilinear Forms, Skew-Symmetric Bilinear Forms,Groups Preserving Bilinear Forms (Ch10, Sec 10.1 - 10.4)

Text Book:

- **Linear Algebra** by Kenneth Hoffman and Ray Kunze,(2e), PHI.

References:

1. **Advanced Linear Algebra** by Steven Roman(3e).
2. **Linear Algebra** by David C Lay.
3. **Linear Algebra** by Kuldeep Singh.

M. Sc. Applied Mathematics

M/AM 303(A) **Semester-III**

Paper-III(A): Mathematical Statistics

Unit- I

Probability: Sample space and events of an experiment, Properties of Probability experiments, Equally likely out comes, Conditional probability and independence, Bayes' Theorem. **Discrete Random Variables**: Random variables, Expected value, Properties of expected values, variance of random variables, Properties of variances, Binomial random variables and its Expected value and variance, Hyper-geometric random variables, Poisson random variables.[ch4, 5]

Unit- II

Normal Random Variables: Continuous random variables, Normal random variables, Probabilities associated with a standard Normal random variable, Finding Normal probabilities. Problems on related. **Distributions of Sampling Statistics**: Sample Mean, Central Limit Theorem, Distribution of the sample mean, Sample size needed, Sampling proportions from a finite population; Probabilities associated with sample proportions. **Estimation** : Point estimator of a population mean, population proportion, Estimating a population variance,.(Ch.6, 7, 8)

Unit- III

Testing Statistical Hypotheses: Hypothesis tests and Significance levels, Tests concerning the mean of a Normal population: Case of known variance, One-sided tests; the t-test for the mean of a Normal population: Case of unknown variance, Hypothesis Tests Concerning Population Proportions. Two-Sided Tests of p. **Hypothesis Tests Concerning Two Populations**:Testing equality of means of two Normal populations: Case of known and unknown variances and large Sample sizes, Testing equality of means: Small - sample tests when the unknown population variances are equal, Paired-sample t-test, Testing equality of population proportions. Problems on related.(Ch.9, 10)

Unit- IV

Chi-Squared Goodness of Fit Tests: Chi-Squared Goodness of fit Tests, Testing for independence in Populations classified according to two characteristics, Testing for independence in contingency tables with fixed marginal totals. Analysis of Variance: Introduction,One-factor and two factor Analysis of Variances, Parameter estimation, Degrees of freedom, Testing hypotheses.(ch11, 12)

Text Book:

- **Introductory Statistics** by Sheldon M.Ross(2010), Academic Press, Elsevier, 3rd Edition.(chapters 4 to 12).

References:

1. **Introduction to Probability Models** by Sheldon M.Ross(2010), Academic Press, Elsevier, 10th Edition. (chapters 4 to 13).

M. Sc. Applied Mathematics

M/AM/MCS 303(B) **Semester-III**

Paper-III(B) : Discrete Mathematics

Unit- I

Propositional logic, Propositional Equivalences, Predicates and Quantifiers, Rules of Inference– Valid Arguments in Propositional Logic.Rules of Inference for Quantified Statements.Introduction to Proofs – Direct Proofs, Proofs by Contraposition, Proofs by Contradiction.NormalForms–Disjunctive Normal Form, Conjunctive Normal Forms, Principal Disjunctive Normal Form, Principal Conjunctive Normal Form. Boolean Algebra – Boolean Functions and Boolean Expressions, Identities of Boolean Algebra, Representing Boolean Functions. Logic Gates, Minimization of Circuits–K-maps. (1.1 *to* 1.3, 1.5 *to* 1.7, 10.1 *to* 10.4 *of* [1])

Unit- II

Elementary Combinatorics – Basics of Counting, Two Basic Counting Principles, IndirectCounting.Combinations and Permutations – Enumeration of Combinations and Permutations, Enumerating Combinations and Permutations with Repetitions, Enumerating Permutations with Constrained Repetitions. Binomial Coefficients – Pascal's Identity, Pascal's Triangle. Multinominal Theorem, The Principle of Inclusion–Exclusion and its Applications. (2.1 *to* 2.8 *of* [2])

Unit- III

Recurrence Relations – Generating Functions of Sequences, Generating Function Models, Calculating Coefficients of Generating Functions. Solutions of Recurrence Relations, the Fibonacci Relation. Solving Recurrence Relations by Substitution and by Generating Functions, Method of Characteristic Roots. Solution of Inhomogeneous Linear Recurrence Relations, the Method of Undetermined Coefficients: Solving Nonlinear Recurrence Relations. (3.1 *to* 3.6 *of* [2])

Unit- IV

Graphs – Graphs and Graph Models, Graph Terminology and Special Types of Graphs, The Hand shaking Theorem, Representing Graphs and Graph Isomorphism. Connectivity, Euler and Hamiltonian Paths and Circuits,Shortest Path Problems,Dijkstra's Algorithm,Planar Graphs,Euler formula. Trees – Introduction to Trees, Tree Traversal. Spanning Trees, DFS, BFS Algorithms, Minimum Spanning Trees. Prim's and Kruskal's Algorithms. (8.1 *to* 8.7, 9.1, 9.3, 9.5 *of* [1])

Text Book:

- **Discrete Mathematics and its Applications** by Kenneth HRosen, Seventh Edition, Mc GrawHill Education (India)Private Ltd, New Delhi.
- **Discrete Mathematics for Computer Scientists** & **Mathematicians** by JoeL.Mott, Abraham Kandel and Theodore P. Baker, Second Edition, Prentice Hall of India, Private Ltd, NewDelhi.

References:

1. **Elements of Discrete Mathematics** by C L Liu and D P Mohapatra, Third Edition, The McGraw-Hill Companies.
2. **Discrete and Combinatorial Mathematics** by Ralph P. Grimaldi and B. V. Ramana, 5th Edition,PEARSON education.

M. Sc. Applied Mathematics

AM 303(C) **Semester-III**

Paper - III(C): Compressible Flows

Unit- I

Thermodynamics and Physical properties of Gases: Introduction to equation of state – Perfect gas – First law of Thermodynamic – Internal Energy and Enthalpy, Specific Heats – Entropy and Second law of Thermodynamics and perfect gas mixture – Dissociation and Ionization – Real gases – Physical properties of gases.

Unit- II

Fundamental Equations of the Aerodynamics of a Compressible Inviscid and non-heat conducting fluid: Equation of State – Equation of Continuity – Equation of motion – Equation of energy – Maxwell's Thermodynamics Relations – Isothermal, Adiabatic and Isentropic processes – Kelvin's Theorem – Irrotational Motion – Vortex Motion – Helmholtz's Theorem.

Unit- III

One dimensional flow of an inviscid compressible Fluid: Energy Equation – Velocity of sound and Mach number – Subsonic, Sonic and Supersonic Flows – Pressure Coefficient - Steady flow in a Nozzle – Non-steady one dimensional flow – Sound wave with finite amplitude – Formation of a Shock – The elements of wave motion - wave equations in two and three dimensions.

Unit- IV

Flow of Viscous Compressible Fluids: One dimensional flow of a Compressible Viscous fluid – Plane Couette flow of a Compressible viscous fluid. Boundary Layer Theory of Viscous Compressible Fluid: Introduction – Mathematical structure for Boundary Layer Theory – Two dimensional Boundary Layer Theory for a Compressible fluid – Laminar Boundary Layer equations in Compressible flow.

Text Book:

- **Introduction to Theory of Compressible Flow** by S.I,Pai, Van Nostrand Reinhold Company.
- **Text Book of Fluid Dynamics** F.Chorlton, CBS Publications and Distributors, New Delhi.

M. Sc. Applied Mathematics

M/AM/MCS 304(A) **Semester-III**

Paper-IV(A): Operations Research

Unit- I

Formulation of Linear Programming problems, Graphical solution of Linear Programming problem,Convex set,General formulation of Linear Programming problems, Standard and Matrix forms of Linear Programming problems,Simplex Method, Two-phase method, Big-M method, Method to resolve degeneracy in Linear Programming problem, Alternative optimal solutions.

Unit- II

Solution of simultaneous equations by Simplex Method, Inverse of a Matrix by Simplex Method,Revised Simplex Method,Concept of Duality in Linear Programming, Comparison of solutions of the Dual and its primal

Unit- III

Mathematical formulation of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, North West corner rule, Lowest cost entry method, Vogel's approximation method, Optimality test, Method of finding optimal solution, Degeneracy in transportation problem, Method to resolve degeneracy, Unbalanced transportation problem. Mathematical formulation of Assignment problem, Reduction theorem, Hungarian Assignment Method, Travelling salesman problem, Formulation of Travelling Salesman problem as an Assignment problem, Solution procedure

Unit- IV

Concept of Dynamic programming, Bellman's principle of optimality, characteristics of Dynamic programming problem,Backward and Forward recursive approach,Minimum path problem,Single Additive constraint and Multiplicatively separable return, Single Additive constraint and Additively separable return, Single Multiplicatively constraint and Additively separable return.

Text Book:

- **Operations Research** by S.D.Sharma, 18th Revised Edition 2017, KedarNath Ram Nath Publications.

References:

1. **Operations Research – An Introduction** by Hamdy A. Taha, 10th Edition.
2. **Linear Programming** by G.Hadley.

M. Sc. Applied Mathematics

AM 304(B) **Semester-III**

Paper - IV(B): Topology

Unit- I

Topological Spaces: The Definition and examples - Elementary concepts - Open bases and open subbases- Weak topologies.
(Page No. 91-106)

Unit- II

Compactness: Compact spaces - Products of spaces - Tychonoff's theorem and locally compact spaces - Compactness for metric spaces - Ascoli's theorem.
(Page No. 110-128)

Unit- III

Separation: T_1 - spaces and Hausdorff spaces - Completely regular spaces and normal spaces - Urysohn's lemma and the Tietze extension theorem - The Urysohn imbedding theorem.
(Page No. 129-141)

Unit- IV

Connectedness: Connected spaces - The components of a spaces - Totally disconnected spaces - Locally connected spaces.
(Page No. 142-152)

Text Book:

- **Introduction to Topology and Modern Analysis** By G.F. Simmon's. *Tata Mc Graw Hill Edition.*

References:

1. **Introductory Topology** by Mohammed H. Mortad.
2. **Explorations in Topology** by David Gay.
3. **Encyclopedia of General Topology** by Hart, Nagata, Vanghan.
4. **Elementary Topology** by Michael C. Gemignani.

M. Sc. Applied Mathematics

AM 304(C) **Semester-III**

Paper-IV(C): Bio-Fluid mechanics

Unit- I

Introduction - Continuum Approach - **Blood Flow in Heart, Lung, Arteries and Veins**: Introduction - The geometry of the circulation system - Field equations and Boundary conditions - Coupling of Left Ventricle to Aorta and Right Ventricle to Pulmonary Artery - Pulsatile Flow in Arteries - Progressive waves superposed on a Steady flow - Reflection and Transmission of Waves at Junctions - Velocity profile of a steady flow in a Tube - Steady Laminar Flow in Elastic Tube. Velocity Profile of Pulsatile flow. (1.1, 1.7, 5.1, 5.2, 5.4, 5.6 – 5.12 of [1]).

Unit- II

The Reynolds Number, Stokes Number, and Womersley Number - Equations of Balance of Energy and Work - Systemic Blood Pressure - Flow in a Collapsible Tubes - **Micro and Macro Circulation**: Introduction - Major Feature of Microcirculation - The Rheological Properties of Blood - Pulmonary Blood Flow - Waterfall Phenomenon in Zone 2 - (5.13-5.17, 6.1, 6.3, 6.4, 6.7-6.8 of [1]).

Unit- III

Respiratory Gas Flow: Introduction - Gas flow in the airway - Interaction between Convection and Diffusion - Exchange between Alveolar Gas and Erythrocytes (7.1 to 7.4 of]1]).

Unit- IV

Basic Transport Equations According to Thermodynamics - Molecular Diffusion - Mechanisms in Membranes and Multiphasic Structure: Introduction - The laws of Thermodynamics - The Gibbs and Gibbs-Duhem Equations - Chemical Potential - Entropy in a system with Heat and Mass transfer - Diffusion, filtration, and Fluid movement in Interstitial Space from the point of view of Thermodynamics - Diffusion from the Molecular Point of view (8.1 - 8.7).

Text Book:

- **Biomechanics** by Y.C.Fung, Springer- Verlag, New York Inc., 1990.

M. Sc. Applied Mathematics

M/AM/MCS 401 **Semester-IV**

Paper-I: Integral Equations and Calculus of Variations

Unit- I

Volterra Integral Equations: Basic concepts - Relationship between Linear differential equations and Volterra Integral equations - Resolvent Kernel of Volterra Integral equation. Differentiation of some resolvent kernels - Solution of Integral equation by Resolvent Kernel - The method of successive approximations - Convolution type equations - Solution of Integro-differential equations with the aid of the Laplace Transformation – Volterra integral equation of the first kind-Euler integrals-Abel's problem-Abel's integral equation and its generalizations.

Unit- II

Fredholm Integral Equations : Fredholm integral equations of the second kind – Fundamentals – The Method of Fredholm Determinants - Iterated Kernels constructing the Resolvent Kernel with the aid of Iterated Kernels - Integral equations with Degenerated Kernels. Hammerstein type equation – Characteristic numbers and Eigen function and its properties.

Green's function :Construction of Green's function for ordinary differential equations-Special case of Green's function –Using Green's function in the solution of boundary value problem.

CALCULS OF VARIATIONS:

Unit- III

Introduction – The Method of Variations in Problems with fixed Boundaries: Definitions of Functionals –Variation and Its properties - Euler's'equation- Fundamental Lemma of Calculus of Variation – The problem of minimum surface of revolution - Minimum Energy Problem Brachistochrone Problem - Variational problems involving Several functions - Functional dependent on higher order derivatives - Euler Poisson equation.

Unit- IV

Functional dependent on the functions of several independent variables - Euler's equations in two dependent variables – Variational problems in parametric form-Applications of Calculus of Variation-Hamilton's principle - Lagrange's Equation,Hamilton's equations.

Text Book:

- **Problems and Exercises in Integral Equations** by M.KRASNOV, A.KISELEV, G.MAKARENKO, (1971).
- **Integral Equations** by S.Swarup, (2008).
- **Differential Equations and The Calculus of Variations** by L.ELSGOLTS, MIR Publishers, MOSCOW.
- **Analytical Mechanics** by Grant R. Fowles and George L. Cassiday, 7Th Edition.

M. Sc. Applied Mathematics

AM 402 **Semester-IV**

Paper-II: Finite Difference Methods

Unit- I

Partial Differential Equations: Introduction - Classification of Second order Partial Differential Equations - Difference Methods- Routh Hurwitz criterion - Domain of Dependence of Hyperbolic Equations – Errors in Difference methods and Rate of convergence of Numerical solution. (1.1 to 1.5)

Unit- II

Difference Methods for Parabolic Partial Differential Equations : Introduction – One Space Dimension –One dimensional Convection-Diffusion Parabolic Equation - Two Space Dimensions –Alternative Direct Implicit (ADI) methods - Cylindrical and Spherical Coordinate Systems – Keller Box Method – One dimensional Quasi linear Parabolic equations (second order method) (2.1 to 2.4, 2.6, 2.7).

Unit- III

Difference Methods for Hyperbolic Partial Differential Equations: Introduction - One Space Dimension - Two Space Dimensions - Alternative Direct Implicit (ADI) methods – First order Equations - System of First order equations. (3.1 to 3.5).

Unit- IV

Numerical Methods for Elliptic Partial Differential Equations: Introduction - Difference Methods for linear boundary value problems - General second order linear equation - Equation in polar coordinates – Quasi linear Elliptic Equations (Second order method) – Convection Diffusion Equation (4.1 to 4.6).

Text Book:

- **Computational Methods for Partial Differential Equations** by M.K.Jain, S.R.K.Iyengar, R.K.Jain, Wiley Eastern Limited, New Age International(P) Limited, New Delhi, 2nd Edition.

M. Sc. Applied Mathematics

AM 403(A) **Semester-IV**

Paper-III(A): Mechanics

Unit- I

Dynamics of systems of Particles: Introduction - Centre of Mass and Linear Momentum of a system - Angular momentum and Kinetic Energy of a system, Centre of mass of Rigid body, symmetry considerations(Solid hemisphere,Hemispherical shell,Semicircle, Semicircular lamina), Rotation of a Rigid body about a fixed axis, Moment of Inertia, calculation of moment of Inertia, Perpendicular axis theorem for plane lamina,Parallel axis theorem for any rigid body, Radius of Gyration. (7.1, 7.2, 8.1, 8.2, 8.3 of [1])

Unit- II

Physical pendulum - Angular momentum Laminar Motion of a Rigid body in Laminar motion. Body rolling down an inclined plane. Motion of Rigid bodies in three dimension – Rotation of rigid body about an arbitrary axis,moments and products of inertia. (8.4, 8.5, 8.6, 9.1 of [1])

Unit- III

Angular momentum vector, Rotational kinetic energy of a rigid body, principles axes of a rigid body, Determination of the other two principal axes when one is known, Determining principal axes by diagonalizing the moment of inertia matrix, Dynamics of a particle in a rotating coordinate system. Euler's equation of motion of a Rigid body , Free rotation of a rigid body, Free rotation of a rigid body. (9.2, 5.2, 9.3, 9.4 of [1])

Unit- IV

Hamilton's variational principle-An example,Generalized Coordinates, Lagrange's Equations of motion for conservative systems, applications of Lagrange's equations, Generalized momenta,Ignorable coordinates, D'Alembert Principle-Generalised forces, Hamilton function - Hamilton's Equations. (10.1, 10.2, 10.4, 10.5, 10.6, 10.8, 10.9 of [1])

Text Book:

- **Analytical Mechanics** by G.R.Fowles G.L Cassiday, Cengage Learning , 7th edition.

References:

1. **Classical Mechanics** by Herbert Goldstein, Charles P.Poole and JhonSafko, Pearson pub.
2. **Principles Of Mechanics** by Synge J. L. and B.A. Griffith, McGraw Hill, 3rd edition.

M. Sc. Applied Mathematics

AM 403(B) **Semester-IV**

Paper-III(B): Functional Analysis

Unit- I

Normed Spaces - Banach Spaces - Further properties of normed spaces - Finite dimensional normed spaces and sub spaces - compactness and finite dimension - linear operators - Bounded and continuous linear operators. [2.2, 2.3, 2.4, 2.5, 2.6 *and* 2.7].

Unit- II

Linear functional – normed spaces of operators – Dual space – Inner product space-Hilbert Space – Further Properties of Inner product Spaces – Orthogonal complements and direct sums – Orthogonal sets and sequences. [2.8, 2.10, 3.1, 3.2, 3.3 *and* 3.4]

Unit- III

Series related to Orthonormal Sequences and sets – Total Orthonormal sets and sequences – Representation of Functions on Hilbert spaces – Hilbert – Adjoint Operator-Self-Adjoint,unitary and normal operators. [3.5, 3.6, 3.8, 3.9 *and* 3.10]

Unit- IV

Hahn-Banach Theorem - Hahn-Banach Theorem for Complex Vector Spaces and Normed Spaces –Adjoint Operator- Reflexive Spaces- Category Theorem - Uniform Boundedness Theorem - Open Mapping Theorem - Closed Linear Operators – Closed Graph Theorem.
[4.2, 4.3, 4.5, 4.6, 4.7, 4.12 *and* 4.13]

Text Book:

- **Introductory Functional Analysis with Applications** by Erwin Kreyszig, John Wiley and sons, NewYork.

References:

1. **Functional Analysis** by B.V.Limaye 2nd Edition..
2. **Introduction to Topology and Modern Analysis** by G.F.Sinmmons. Mc.Graw-Hill International Edition.

M. Sc. Applied Mathematics

AM 403(C) **Semester-IV**

Paper-III(C):Finite Element Methods

Unit- I

Introduction - **Weighted Residual Methods**: - Least Square Method - Partition Method - Galerkin Method- Moment Method - Collocation Method – problems. **Variational Methods**: Ritz Method - Examples.

Unit- II

Finite Elements: Line segment Element - Triangular Element - Rectangular Elements with examples -Numerical Integration over Finite Elements.

Unit- III

Finite Element Methods: Ritz Finite Element Method - Least Square Finite Element Method –Galerkin Finite Element Method - Boundary Value Problems in Ordinary Differential Equations - Assembly of Element Equations - Boundary Value Problem in Partial Differential Equations(with Linear triangular element) - Mixed boundary conditions - Boundary points - Examples.

Unit- IV

Finite Element Error Analysis: Approximation Errors - Various Measures of Error - Convergence ofsolution - Accuracy of the solution - Examples. Eigenvalue Problems: Introduction - Eigenvalue problems- Formulation of a Eigenvalue problems – Applications (5.1 to 5.4, 6.1) of [2]

Text Book:

- **Numerical Solution of Differential Equations** by M.K.Jain, New Age Int.(P).Ltd., New Delhi.(for Units I, II and III)
- **Finite Element Method** by J.N.Reddy, McGraw-Hill International Edition, Engineering Mechanics Series.(for Unit IV).

M. Sc. Applied Mathematics

AM 403(D) **Semester-IV**

Paper-III(D): Cryptography

Unit- I

Simple substitution ciphers; Divisibility and greatest common divisors Modular arithmetic; Prime numbers, unique factorisation, and finite fields; Powers and primitive roots in finite fields; Cryptography before the computer age; Symmetric and asymmetric ciphers.

Unit- II

The birth of public key cryptography, The discrete logarithm problem Diffie – Hell mankey exchange, The ElGamal public key crypto system, An overview of the theory of groups, How hard is the discrete logarithm problem?, A collision algorithm for the DLP.

Unit- III

The Chinese remainder theorem, The Pohlig-Hellman algorithm, Rings, quotients, polynomials, and finite fields, Euler's formula and roots modulo pq, Primality testing.

Unit- IV

Elliptic curves, Elliptic curves over finite fields, The elliptic curve discrete logarithm problem, Elliptic curve cryptography.

Text Book:

- **Mathematical Cryptography** by Jeffrey Hoffstein, JillPipher, JosephH.Silverman.

References:

1. **Fundamental Principles and Applications** by Everyday Cryptography, Keith Martin.
2. **Cryptography: An Introduction** by N.P.Smart.

M. Sc. Applied Mathematics

AM 404 **Semester-IV**

PROJECT

DEPARTMENT OF MATHEMATICS

OSMANIA UNIVERSITY

M.Sc. Mathematics with Computer Science Syllabus

Semester – III & IV

(Choice Based Credit System)
(w.e.f. the academic year 2024-2025)

M.Sc. Mathematics with Computer Science Course Structure

(Choice Based Credit System)
(w.e.f. the academic year 2024-2025)

SEMESTER – III

Subjects	Code	Paper Title	THPW	T	P	Credits	IA	ESE	Total
Core	MCS 301	**Differential Equations**	4	1		5	30	70	100
Core	MCS 302	**Advanced RDBMS**	4	0		4	30	70	100
Elective	MCS 303(A)	**Network Security**	4	1		5	30	70	100
	MCS 303(B)	**Data Science with R**							
	MCS 303(C)	**Block Chain and Crypto currency technologies**							
Elective	MCS 304(A)	**Operations Research**	4	1		5	30	70	100
	MCS 304(B)	**Discrete Mathematics**							
	MCS 304(C)	**Elementary Number Theory**							
Lab	MCS302 L	**Advanced RDBMS Lab**			2	1		25	25
			16	3	2	20			425

SEMESTER – IV

Subjects	Code	Paper Title	THPW	T	P	Credits	IA	ESE	Total
Core	MCS 401	**Integral Equations and Calculus of Variations**	4	1		5	30	70	100
Core	MCS 402	**Computer Organization**	4	0		4	30	70	100
Elective	MCS 403(A)	**Cloud Computing**	4	1		5	30	70	100
	MCS 403(B)	**Natural Language Processing**							
	MCS 403(C)	**Internet of Things**							
Lab	MCS 402 L	**Computer Organization Lab**			2	1		25	25
Project	MSC 404	**Project**	5			5			100
			17	2	2	20			425

T – Tutorial class: Each batch consists of 20 students and will be allotted to a teacher (Demonstrating the theory through a numerical example and practicing through mathematical software)
P - Practical
THPW = Teaching Hours Per Week.
IA = Internal Assessment (IA Test 20 Marks + Assignment 10 Marks).
ESE = End-Semester Examination.
End-Semester Examination Duration - 3 Hrs.

M. Sc. Mathematics with Computer Science

MCS 301 **Semester-III**

Paper-I: Differential Equations

Unit- I

Existence and Uniqueness of Solution: Picard's method of successive approximations - Picard's theorem.

Power Series Solution of O.D.E.: Ordinary and singular points - Series solution about an ordinary point - Series solution about singular point - Frobenius method.

Unit- II

Lagendre's Polynomials: Lengendre's equation and its solution - Lengendre's function of the first kind and its properties - Generating function - Orthogonal properties - Recurrance relations - Laplace's definite integrals for $P_n(x)$, Rodrigue's formula.

Bessel's Functions: Bessel's equation and its solution – Bessel's function of the first kind and its properties – Recurrence relations - Generating function- Orthogonality.

Boundary Value Problems: Sturm – Liouville problem.

Unit- III

Non-Linear PDE of Order One:Charpit's method-Cauchy's method of characteristics for solving nonlinear partial differential equations -Higher order linear partial differential equations with constant coefficients.

Unit- IV

Partial Differential Equations of order two with variable coefficients - Canonical forms - Classification of second order partial differential equations - Separation of variables method of solving the one dimensional heat equation, wave equation and Laplace equation.

Text Book:

- **Ordinary and Partial Differential Equations** by M.D. Raisingania, S. Chand Company Ltd., NewDelhi, 19th edition.

References:

1. **Differential Equations with Application and Historical Notes** by George F Simmons 2nd edition, Tata Mc.Graw-Hill Edition.
2. **Textbook of Ordinary Differential Equations** by S.G.Deo, V.LakshmiKantham, V.Raghavendra, TataMc.Graw Hill Pub. Company Ltd.
3. **Elements of Partial Differential Equations** by Ian Sneddon, Mc.Graw-Hill International Edition.

M. Sc. Mathematics with Computer Science

MCS 302 **Semester-III**

Paper-II: Advanced RDBMS

Unit- I Introduction: Database System Applications, Purpose of database systems, View of Data, Database Languages,Relational Databases, Database Design, Database Architecture, Database Users and Administrators, Structure of Relational Databases, Database Schema, Keys, Schema Diagrams, Relational Query Languages, The Relational Algebra, The Tuple Relational Calculus, The Domain Relational Calculus.
Unit- II Overview of the SQL Query Language, SQLData Definition, Basic Structure of SQLQueries, SQLAdditional Basic Operations, Set Operations, Null Values,SQL Aggregate Functions, Nested Sub - queries, Modification of the Database. The Entity - Relationship Model, Constraints, Removing Redundant Attributes in Entity Sets, Entity - Relationship Diagrams, Reduction to Relational Schemas, Entity - Relationship Design Issues, Extended E - R Features.
Unit- III Features of Good Relational Designs – Atomic Domains and First Normal Form, Decomposition Using Functional Dependencies, 2NF, 3NF, BCNF, 4NF, 5NF. SQL, views, Integrity constraints, Functions and Procedures, Triggers. File Organization, Organization of Records in Files, Data - Dictionary Storage, Indexing and Hashing, Basic Concepts, Ordered Indices, B+ - Tree Index, Files, B+ - Tree Extensions, Static Hashing, Dynamic Hashing, Bitmaps Indices.
Unit- IV Transaction Concept, a Simple Transaction Model, Transaction Atomicity and Durability, Transaction Iso- lation, Serializabitlity, Transaction Isolation and Atomicity, Transaction Isolation Levels, Implementation of Isolation Levels.Concurrency Control, Lock based Protocols, Deadlock Handling, Multiple Granularity, Time - stamp based protocols, Validation based protocol, Multiversion Schemes. Recovery System, Failure Classification, Storage, Recovery and Atomicity, Recovery Algorithm, Buffer Management.
NoSQL: Need for NoSQL, aggregate data models, more details on data models, distribution models, consistency, version stamps, map-reduce, key-value databases, document databases, column-family stores, graph databases, Schema Migrations.
Text Book:

- **Database System Concepts** by Abraham Silberschatz, HenryF. Korth, S.Sudarshan.
- **Professional NoSQL** by Shashank Tiwari, 1 st Edition , Wiley publishers, 2011.

References:

1. **Database Management Systems** by Raghu Ramakrishnan, Johannes Gehrke.
2. **Fundamentals of Database Systems** by Ramez Elmasri, Shamkant B.Navathe.
3. **Modern Database Management** by Jeffrey A.Hoffer, V.Ramesh, HeikkiTopi.
4. **Database Systems - A Practical Approach to Design, Implementation and Management** by Thomas M. Connolly, Carolyn E. Begg.

MCS 303(A) **Semester-III**

Paper-III(A): Network Security

Unit- I Overview of Network Security: Computer Security Concepts, the OSI Security Architecture, Security Attacks, Security Services, Security Mechanisms, a Model for Network Security. Classical Encryption Techniques: Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Rotor Machines, Steganography. Block Ciphers and the Data Encryption Standard: Traditional Block Cipher Structure, the Data Encryption Standard (DES), A DES Example, Strength of DES.Block Cipher Operation: Double DES, Triple DES, Electronic Code Book, Cipher Block Chaining Mode, Cipher Feedback Mode, Output Feedback Mode, Counter Mode.
Unit- II Advanced Encryption Standard (AES): The Origins AES, AES Structure, AES Round Functions, AES Key Expansion, an AES Example AES Implementation. Pseudo random Number Generation and Stream Ciphers: Principles of Pseudo random Number Generation, Pseudo random Number Generators, Pseudo random Number Generation using Block Cipher, Stream Ciphers-RC4. Public-Key Cryptography and RSA: Principles of Public-Key Crypto systems, the RSA Algorithm. Key Management and Distribution: Symmetric Key Distribution Using Symmetric Encryption and Asymmetric Encryption, Distribution of Public Keys, X.509 Certificates, DiffieHellman Key Exchange.
Unit- III Cryptographic Hash Functions: Applications of Cryptographic Hash Functions, Two Simple Hash Functions, Secure Hash Algorithm (SHA) & MD5 Algorithm. Message Authentication Codes: Message Authentication Requirements, Message Authentication Functions, Requirements for Message Authentication Codes, Security of MACs, MACs Based on Hash Functions: HMAC, MACs Based on Block Ciphers:DAA and CMAC. Digital Signatures: Digital Signatures, NIST Digital Signatures Algorithm.
Unit- IV Transport-Level Security: Web Security Considerations, Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, Secure Shell (SSH), E-Mail Security: Pretty Good Privacy, S/MIME. IP Security: IP Security Overview, IP Security Architecture, Encapsulating Security Payload, Combining Security Associations, Internet Key Exchange. Intruders, Virus and Firewalls: Intruders, Intrusion Detection, Password Management, Virus and Related Threats, Countermeasures, Firewall Design Principles, Types of Firewalls.

Text Book:

- **Cryptography and Network Security – Principles and Practice** by William Stallings, (6e).

References:

1. Zhenfu Cao, New Directions of Modern Cryptography
2. Douglas R. Stinson, Cryptography Theory and Practices
3. Tom St Denis, Simon Johnson, Cryptography for Developers
4. Joseph MiggaKizza, A Guide to Computer Network Security
5. A. Menezes, P. Van Oorschot, S. Vanstone, Handbook of Applied Cryptograph
6. Henk C.A. van Tilborg, SushilJajodia, Encyclopedia of Cryptography and Security

M. Sc. Mathematics with Computer Science

MCS 303(B) **Semester-III**

Paper-III(B): Data Science with R

Unit- I

Data Science: Introduction to Data Science – Digital Universe – Sources of Data – Information Commons – Data Science Project Life Cycle: OSEMN Framework Data Preprocessing: Introduction to Data Preprocessing – Reading, Selecting, Filtering Data – Filtering Missing Values – Manipulating, Sorting, Grouping, Rearranging, Ranking Data.

Unit- II

Concept Learning:Formulation of Hypothesis – Probabilistic Approximately Correct Learning - VC Dimension –Hypothesis elimination – Candidate Elimination Algorithm Essentials Of R:R Basics - data types and objects - control structures – data frame -Feature Engineering - scaling, Label Encoding and One Hot Encoding, Reduction.

Unit- III

Model Fit Using R:Regression Models- Linear and Logistic Model, Classification Models – Decision Tree, Naïve Bayes, SVM and Random Forest, Clustering Models – K Means and Hierarchical clustering. Visualization:Data visualization: Box plot, histogram, scatter plot, heat map – Working with Tableau – Outlier detection – Data Balancing.

Unit- IV

Performance Evaluation: Loss Function and Error: Mean Squared Error, Root Mean Squared Error – Model Selection and Evaluation criteria: Accuracy, Precision, F1 score, Recall Score – Binary Predictive Classification –Sensitivity – Specificity. Recent Trends And Challenges In Data Science.

Text Book:

- **Introduction to Machine Learning** by Ethem Alpaydin, Fourth Edition, MIT Press, 2020.
- Hadley Wickham, Garrett Grolemund, R for data science : Import, Tidy, Transform, Visualize, And Model Data Paperback, 2017.

References:

1. Han, J., Kamber, M., Pei, J. Data mining concepts and techniques. Morgan Kaufmann. 2011.
2. Carl Shan, Henry Wang, William Chen, Max Song. The Data Science Handbook: Advice and Insight from 25 Amazing Data Scientists. The Data Science Bookshelf. 2016.
3. James, G., Witten, D., T., Tibshirani, R. An Introduction to statistical learning with applications in R. Springer. 2013.

M. Sc. Mathematics with Computer Science

MCS 303(C) **Semester-III**

Paper-III(C): Block Chain and Crypto Currency Technologies

Unit- I

Introduction to Cryptography and Cryptocurrencies: Foundations of Cryptography and security: Ciphers and secret messages, security attacks and services. Mathematical tools for cryptography: substitution techniques, modular arithmetic, Euclid's algorithm, finite fields, polynomial arithmetic. Design Principles of Block Ciphers: Theory of Block Cipher Design, Feistel cipher network structure, DES and Triple DES, modes of operation (ECB, CBC, OFB,CFB), strength of DES.

Unit- II

Block chain Achieves: Decentralization - Centralizations. Decentralization- Distributed consensus, Consensus with - out identity using a block chain, Incentives and proof of work. Simple Local Storage, Hot and Cold Storage, Splitting and Sharing Keys, Online Wallets and Exchanges, Payment Services, Transaction Fees, Currency Exchange Markets.

Unit- III

Mechanics of Bitcoin: Bitcoin transactions, Bitcoin Scripts, Applications of Bitcoin scripts, Bitcoin blocks, The Bit- coin network, Limitations and improvements. BitcoinMining :The task of Bitcoinminers, Mining Hardware, Energy consumption and ecology, Mining pools, Mining incentives and strategies. Bitcoin and Anonymity: Anonymity Basics, How to De-anonymize Bitcoin, Mixing, Decentralized Mixing, Zerocoin and Zerocash.

Unit- IV

Community, Politics, and Regulation:Consensus in Bitcoin, Bitcoin Core Software, Stakeholders: Who sinCharge, Roots of Bitcoin, Governments Notice on Bitcoin, Anti Money Laundering Regulation, NewYork's BitLicense Proposal. Bitcoin as a Platform: Bitcoin as an Append only Log, Bitcoins as Smart Property, Secure MultiParty Lotteries in Bitcoin, Bitcoin as Public Randomness,Source-Prediction, Markets, and Real World Data Feeds.

Text Book:

1. Narayanan, A., Bonneau, J., Felten, E., Miller, A., and Goldfeder, S. (2016). Bitcoin and crypto currency technologies: a comprehensive introduction. Princeton University Press.
2. William Stallings, Cryptography and Network Security, Pearson 2004.

References:

1. Antonopoulos, A. M. (2014). Mastering Bitcoin: unlocking digital cryptocurrencies. OReilly Media, Inc.
2. Franco, P. (2014). Understanding Bitcoin: Cryptography, engineering and economics. John Wiley and Sons.

M. Sc. Mathematics with Computer Science

M/AM/MCS 304(A) **Semester-III**

Paper-IV(A): Operations Research

Unit- I

Formulation of Linear Programming problems, Graphical solution of Linear Programming problem,Convex set,General formulation of Linear Programming problems, Standard and Matrix forms of Linear Programming problems,Simplex Method, Two-phase method, Big-M method, Method to resolve degeneracy in Linear Programming problem, Alternative optimal solutions.

Unit- II

Solution of simultaneous equations by Simplex Method, Inverse of a Matrix by Simplex Method,Revised Simplex Method,Concept of Duality in Linear Programming, Comparison of solutions of the Dual and its primal

Unit- III

Mathematical formulation of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, North West corner rule, Lowest cost entry method, Vogel's approximation method, Optimality test, Method of finding optimal solution, Degeneracy in transportation problem, Method to resolve degeneracy, Unbalanced transportation problem. Mathematical formulation of Assignment problem, Reduction theorem, Hungarian Assignment Method, Travelling salesman problem, Formulation of Travelling Salesman problem as an Assignment problem, Solution procedure

Unit- IV

Concept of Dynamic programming, Bellman's principle of optimality, characteristics of Dynamic programming problem,Backward and Forward recursive approach,Minimum path problem,Single Additive constraint and Multiplicatively separable return, Single Additive constraint and Additively separable return, Single Multiplicatively constraint and Additively separable return.

Text Book:

- **Operations Research** by S.D.Sharma, 18th Revised Edition 2017, KedarNath Ram Nath Publications.

References:

1. **Operations Research – An Introduction** by Hamdy A. Taha, 10th Edition.
2. **Linear Programming** by G.Hadley.

M. Sc. Mathematics with Computer Science

MCS 304(B) **Semester-III**

Paper-IV(B) : Discrete Mathematics

Unit- I

Propositional logic, Propositional Equivalences, Predicates and Quantifiers, Rules of Inference– Valid Arguments in Propositional Logic.Rules of Inference for Quantified Statements.Introduction to Proofs – Direct Proofs, Proofs by Contraposition, Proofs by Contradiction.NormalForms–Disjunctive Normal Form, Conjunctive Normal Forms, Principal Disjunctive Normal Form, Principal Conjunctive Normal Form. Boolean Algebra – Boolean Functions and Boolean Expressions, Identities of Boolean Algebra, Representing Boolean Functions. Logic Gates, Minimization of Circuits–K-maps. (1.1 *to* 1.3, 1.5 *to* 1.7, 10.1 *to* 10.4 *of* [1])

Unit- II

Elementary Combinatorics – Basics of Counting, Two Basic Counting Principles, IndirectCounting.Combinations and Permutations – Enumeration of Combinations and Permutations, Enumerating Combinations and Permutations with Repetitions, Enumerating Permutations with Constrained Repetitions. Binomial Coefficients – Pascal's Identity, Pascal's Triangle. Multinominal Theorem, The Principle of Inclusion–Exclusion and its Applications. (2.1 *to* 2.8 *of* [2])

Unit- III

Recurrence Relations – Generating Functions of Sequences, Generating Function Models, Calculating Coefficients of Generating Functions. Solutions of Recurrence Relations, the Fibonacci Relation. Solving Recurrence Relations by Substitution and by Generating Functions, Method of Characteristic Roots. Solution of Inhomogeneous Linear Recurrence Relations, the Method of Undetermined Coefficients: Solving Nonlinear Recurrence Relations. (3.1 *to* 3.6 *of* [2])

Unit- IV

Graphs – Graphs and Graph Models, Graph Terminology and Special Types of Graphs, The Hand shaking Theorem, Representing Graphs and Graph Isomorphism. Connectivity, Euler and Hamiltonian Paths and Circuits,Shortest Path Problems,Dijkstra's Algorithm,Planar Graphs,Euler formula. Trees – Introduction to Trees, Tree Traversal. Spanning Trees, DFS, BFS Algorithms, Minimum Spanning Trees. Prim's and Kruskal's Algorithms. (8.1 *to* 8.7, 9.1, 9.3, 9.5 *of* [1])

Text Book:

- **Discrete Mathematics and its Applications** by Kenneth HRosen, Seventh Edition, Mc GrawHill Education (India)Private Ltd, New Delhi.
- **Discrete Mathematics for Computer Scientists** & **Mathematicians** by JoeL.Mott, Abraham Kandel and Theodore P. Baker, Second Edition, Prentice Hall of India, Private Ltd, NewDelhi.

References:

1. **Elements of Discrete Mathematics** by C L Liu and D P Mohapatra, Third Edition, The McGraw-Hill Companies.
2. **Discrete and Combinatorial Mathematics** by Ralph P. Grimaldi and B. V. Ramana, 5th Edition,PEARSON education.

M. Sc. Mathematics with Computer Science

MCS 304(C) **Semester-III**

Paper - IV(C): Elementary Number Theory

Unit- I

The Fundamental Theorem of Arithmetic: Divisibility- GCD- Prime numbers, Fundamental theorem of arithmetic- the series of reciprocal of the primes- The Euclidean algorithm.
(Page No. 13 - 23)

Unit- II

Arithmetical Functions and Dirichlet Multiplication: The functions $\phi(n)$, $\mu(n)$ and a relation connecting them- Product formula for $\phi(n)$ - Dirichlet product- Dirichlet inverse and Mobius inversion formula -The Mangoldt function $\wedge(n)$- Multiplicative functions and Dirichlet multiplication- The inverse of a completely multiplicative function- Liouville's function $\lambda(n)$- The divisor functions $\sigma_\alpha(n)$.
(Page No. 24-39 & 46-51)

Unit- III

Congruences: Properties of congruences- Residue classes and complete residue system- Linear congruences-Reduced residue systems and Euler-Fermat theorem- Polynomial congruence modulo p - Lagrange's theorem- Application of Lagrange's theorem- Chinese remainder theorem and its applications.
(Page No. 106-120 & 126-128)

Unit- IV

Quadratic Residues and The Quadratic Reciprocity Law: Quadratic residues- Legendre's symbol and its properties- Evaluation of $(-1|p)$ and $(2|p)$ - Gauss' lemma- The quadratic reciprocity law and its applications-The Jacobi symbol.
(Page No. 178-190 & 201-203)

Text Book:

- **Introduction to Analytic Number Theory** by Tom M. Apostol. *Narosa publishing house*

References:

1. **Number Theory** by Joseph H. Silverman.
2. **Theory of Numbers** by K.Ramchandra.
3. **Elementary Number Theory** by James K Strayer.
4. **Elementary Number Theory** by James Tattusall.

M. Sc. Mathematics with Computer Science

MCS 302 L **Semester-III**

Advanced RDBMS Lab

1. E-R Model: Analyze the problem with the entities which identify data persisted in the database which contains entities,attributes.
2. Concept design with E-R Model: Apply cardinalities for each relationship, identify strong entities and weak entities for relationships like generalization, aggregation, specialization.
3. Relation Model: Represent attributes as columns in tables and different types of attributes like Composite, Multi-valued, and Derived.
4. Installation of MySql/Oracle/MONGO DB
5. Practicing DDL commands
6. Practicing DML commands SELECT, INSERT, UPDATE, DELETE.
7. Queries using ANY, ALL, IN, INTERSECT, UNION
8. Querying Using aggregate functions COUNT, SUM using GROUPBY and HAVING.
9. TRIGGER
10. Procedures and Stored Procedures Creation, Execution and Modification of stored Procedure
11. DCL Commands
12. CASE STUDY 1 : Hospital Management System
13. CASE STUDY 2 :Railway Reservation System

Note :The aim of these case studies is to design and develop a database for the hospital/Railway to maintain the records of various departments, rooms, and doctors in the hospital or the rail reservations. It also maintains records of the regular patients, patients admitted in the hospital, the check up of patients done by the doctors, the patients that have been operated, and patients discharged from the hospital.

M. Sc. Mathematics with Computer Science

M/AM/MCS 401 **Semester-IV**

Paper-I: Integral Equations and Calculus of Variations

Unit- I

Volterra Integral Equations: Basic concepts - Relationship between Linear differential equations and Volterra Integral equations - Resolvent Kernel of Volterra Integral equation. Differentiation of some resolvent kernels - Solution of Integral equation by Resolvent Kernel - The method of successive approximations - Convolution type equations - Solution of Integro-differential equations with the aid of the Laplace Transformation – Volterra integral equation of the first kind-Euler integrals-Abel's problem-Abel's integral equation and its generalizations.

Unit- II

Fredholm Integral Equations : Fredholm integral equations of the second kind – Fundamentals – The Method of Fredholm Determinants - Iterated Kernels constructing the Resolvent Kernel with the aid of Iterated Kernels - Integral equations with Degenerated Kernels. Hammerstein type equation – Characteristic numbers and Eigen function and its properties.

Green's function :Construction of Green's function for ordinary differential equations-Special case of Green's function –Using Green's function in the solution of boundary value problem.

CALCULS OF VARIATIONS:

Unit- III

Introduction – The Method of Variations in Problems with fixed Boundaries: Definitions of Functionals –Variation and Its properties - Euler's'equation- Fundamental Lemma of Calculus of Variation – The problem of minimum surface of revolution - Minimum Energy Problem Brachistochrone Problem - Variational problems involving Several functions - Functional dependent on higher order derivatives - Euler Poisson equation.

Unit- IV

Functional dependent on the functions of several independent variables - Euler's equations in two dependent variables – Variational problems in parametric form-Applications of Calculus of Variation-Hamilton's principle - Lagrange's Equation,Hamilton's equations.

Text Book:

- **Problems and Exercises in Integral Equations** by M.KRASNOV, A.KISELEV, G.MAKARENKO, (1971).
- **Integral Equations** by S.Swarup, (2008).
- **Differential Equations and The Calculus of Variations** by L.ELSGOLTS, MIR Publishers, MOSCOW.
- **Analytical Mechanics** by Grant R. Fowles and George L. Cassiday, 7Th Edition.

Paper-II: Computer Organization

Unit- I

Digital Logic Circuits: Digital Computers, Logic Gates, Boolean algebra, Map Simplification, Combinational Circuits,Flip-Flops,Sequential Circuits.

Digital Components: Integrated Circuits, Decoders, Multiplexers, Registers, Shift Registers, Binary Counters, Memory Unit.

Data Representation: Data Types, Complements, Fixed Point Representations, Floating Point Representation, Binary Codes, and Error Detection Codes.

Unit- II

Register Transfer and Micro operations: Register Transfer Language, Register Transfer, Bus and Memory Transfers, Arithmetic Micro operations, Logic Micro operations, and Shift Micro operations.

Basic Computer Organization and Design: Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Memory Reference Instructions, Input - Output and Interrupt, Design of Accumulator Logic.

Unit- III

Programming the Basic Computer: Machine Language, Assembly Language, The Assembler Program Loops, Programming Arithmetic and Logic Operations, Subroutines, Input - Output Programming.

Central Processing Unit: Introduction, General Register Organization, Stack Organization, Instruction Formats, Addressing Modes, Data Transfer and Manipulation, Program Control, Reduced Instruction Set Computer.

Computer Arithmetic: Addition and Subtraction, Multiplication Algorithms, Division Algorithms, and Floating Point Arithmetic Operations, Decimal Arithmetic Unit, Decimal Arithmetic Operations.

Unit- IV

Input - Output Organization: Peripheral Devices, Input - Output Interface,Asynchronous Data Transfer,Modes of Transfer, Priority Interrupt, Direct Memory Access (DMA), Input - Output Processor, Serial Communication. **Pipeline and Vector Processing**: Parallel Processing, Pipelining, Arithmetic Pipelines, Instruction Pipelines and RISC Pipelines, Vector Processing.

Text Book:

- **Computer System Architecture (3e)** by M.MorrisMano.

References:

1. Andrew S.Tanenbaum, Structured Computer Organization.
2. William Stallings, Computer Organization and Architecture.
3. ZviKohavi, NirajK.Jha, Switching and Finite Automata Theory.

M. Sc. Mathematics with Computer Science

MCS 402 L **Semester-IV**

Computer Organization Lab

1. Implementation of various logic gates using NAND gate.
2. Implementationofthehalfadderandfulladder.
3. Implementation of the sub - tractor.
4. Demonstrate of the RS flip - flop, D flip - flop, T flip - flop and JK flip - flop.
5. Implementation of the shift registers.
6. Implementation of the decoders and encoders
7. Implementation of the multiplexers and de-multiplexers
8. Design of counters.
9. Implementation of the addition algorithm
10. Implementation of the subtraction algorithm
11. Implementation of the multiplication algorithm
12. Implementation of the booths multiplication algorithm
13. Implementation of the division algorithm
14. Implementation of the simple ALU.
15. Simulation of direct memory access technique
16. Simulation of associative memory technique

Note : Using any simulator perform the following functions

MCS 403(A) **Semester-IV**

Paper-III(A): Cloud Computing

Unit- I Era of Cloud Computing (CC): Introduction, cloud and other similar configurations, CC vs. peer-to-peer architecture, CC vs client-server architecture, CC vs GC, components of CC, impact of CC on businesses. **Virtualization**: Introduction, virtualization benefits, implementation levels of virtualization, virtualization at the OS level, virtualization structure, open source virtualization technology, Xen virtualization architecture, binary translation with full virtualization, para-virtualization with compiler support, virtualization of CPU, memory, I/O devices, hardware support for virtualization, virtualization in multicore processors. **Cloud Computing Services**: IaaS, PaaS, leveraging PaaS for productivity, guidelines for selecting a PaaS provider, concerns with PaaS, languages and PaaS, SaaS, DBaaS. **Cloud Computing and Business Value**: key drivers for CC, CC and out sourcing, types of scalability, use of load balancers to enhance scalability, variable operating costs using CC, time-to-market benefits of CC, distribution over the internet, levels of business values from CC. **Cloud Types and Models**: private cloud, public cloud, hybrid cloud.
Unit- II Adoption and Use of Cloud by Small and Medium Businesses: place of adoption, benefits, adoption phases, vendor roles and responsibilities, selection phases, provider liability, provider capabilities, success factors for CC Adoption process of public clouds by enterprises. Cloud migration techniques, Phases during the migration of an application to the cloud. **IT Service Management for Cloud Computing**: ITIL based service management, service strategy, service design, service transition, service operations, continual service improvement. **SLA with Cloud Service Providers**: concept, aspects and requirements of SLA, credit calculation, samples 1 and 3. Risks, Consequences and **Costs for Cloud Computing**: Introduction, risk assessment and management, risk of vendor lock-in, loss of control, not meeting regulatory compliances, resource scarcity, multitenant environment, failure, inadequate SLA, malware and internet attacks, management of cloud resources, network outages, in fracture, legal, licensing, TCO, cloud costs, cost allocations, chargeback models and methodology, billable items.
Unit- III REST-style Web Services: What is REST? HTTP methods, Java API for RESTful Web Services (JAX-RS), JAX-RS with Jersey, CRUD RESTful Web Service, SOAP and REST in Harmony, Interpretability between the Java Platform and WCF, WSIT, Web Services Security, Wire-Level Security, WS-Security.
Unit- IV AAA Administration for Cloud: AAA model, single sign on for clouds, industry implementation for AAA, authentication management in the cloud, SAML, authentication for resource utilization. **Security as a Service**: Benefits of security as a service, concerns with security as a service, security service providers, IdMaaS, attributes of IdMaaS providers. **Cloud Certifications and Audits**: certifications, cloud audit framework, cloud auditing requirements. **Application Security in the Cloud**: cloud application SDLC, cloud service reports by providers, application security in IaaS, PaaS and SaaS environments.
Mobile Cloud Computing (MCC): Architecture of MCC, benefits of MCC, MCC challenges.
Text Book: 1. RajkumarBuyya, Cloud Computing: Principles and Paradigms.
2. ArshdeepBahga, Vijay Madisetti, Cloud Computing – A Hands-On Approach.
3. David E.Y. Sarna, Implementing and Developing Cloud Computing Applications.
4. Kai Hwang, Distributed and Cloud Computing From Parallel Processing to Internet of Things

MCS 403(B) **Semester-IV**

Paper-III(B): Natural Language Processing

Unit- I

Language Processing and Python: Computing with Language: Texts and Words, A Closer Look at Python: Texts as Lists of Words, Computing with Language: Simple Statistics, Back to Python: Making Decisions and Taking Control, Automatic Natural Language Understanding Accessing Text Corpora and Lexical Resources: Accessing Text Corpora, Conditional Frequency Distributions, Lexical Resources, WordNet.

Unit- II

Processing Raw Text: Accessing Text from the Web and from Disk, Strings: Text Processing at the Lowest Level, Text Processing with Unicode, Regular Expressions for Detecting Word Patterns, Useful Applications of Regular Expressions, Normalizing Text, Regular Expressions for Tokenizing Text, Segmentation, Formatting:From Lists to Strings.
Categorizing and Tagging Words: Using a Tagger, Tagged Corpora, Mapping Words to Properties Using Python Dictionaries, Automatic Tagging, N-Gram Tagging, Transformation- Based Tagging, How to Determine the Category of a Word.

Unit- III

Learning to Classify Text: Supervised Classification, Evaluation, Naive Bayes Classifiers Deep Learning for NLP: Introduction to Deep Learning, Convolutional Neural Networks, Recurrent Neural Networks, Classifying Text with Deep Learning

Unit- IV

Extracting Information from Text: Information Extraction, Chunking, Developing and Evaluating Chunkers, Recursion in Linguistic Structure, Named Entity Recognition, Relation Extraction. Analyzing Sentence Structure: Some Grammatical Dilemmas, What's the Use of Syntax. Context-Free Grammar, Parsing with Context-Free Grammar.
NLP applications: Topic modeling, Text classification, Sentiment analysis, Word sense disambiguation, Speech recognition and speech to text, Text to speech, Language detection and translation.

Text Book:

1. Steven Bird, Ewan Klein, and Edward Lope, Natural Language Processing with Python.OReily, 2009.

2. Akshay Kulkarni, Adarsha Shivananda, Natural Language Processing Recipes: Unlocking Text Data with Machine Learning and Deep Learning using Python. Apress, 2019

3. Allen James, Natural Language Understanding, Benjamin/Cumming,1995. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993.

4. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993.

Paper-III(C): Internet of Things

Unit- I

Introduction to IoT: Internet of Things - Physical Design - Logical Design - IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NET CONF - YANG - IoT Platforms Design Methodology.

Unit- II

IoT Architecture: M2M high - level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - in formation model - functional model - communication model - IoT reference architecture. IoT Protocols: Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA andR FID Protocols – Unified Data Standards.

Unit- III

Protocols – IEEE 802.15.4 – BACnet Protocol – Modbus– Zigbee Architecture – Network layer –6 LowPAN - CoAP – Security. Building IoT with RASPBERRY PI & ARDUINO: Building IOT with RASPERRY PI-IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints -IoT Device - Building blocks - Raspberry Pi - Board - Linuxon Raspberry Pi - Raspberry Pi Interfaces.

Unit- IV

Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.Case Studies and Real-World Applications : Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT – Software & Management Tools for IoT Cloud Storage Models & Communication APIs - Cloud for IoT - Amazon Web Services for IoT.

Text Book:

1. Arshdeep Bahga, Vijay Madisetti — Internet of Things – Ahands - on approach, Universities Press, 2015.
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian(Eds) — Architecting the Internet of Things, Springer, 2011.
3. Honbo Zhou — The Internet of Things in the Cloud: A Middle ware Perspective, CRC Press, 2012.
4. Jan Ho ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand.David Boyle, From Machine-to-Machine to the Internet of Things -Introduction to a New Age of Intelligence, Elsevier, 2014.
5. Olivier Hersent, David Boswar thick, Omar Elloumi — The Internet of Things – Key applications and Protocols, Wiley, 2012.

M. Sc. Mathematics with Computer Science

MCS 404 **Semester-IV**

PROJECT
